AIR QUALITY AND METEOROLOGY TECHNICAL DATA REPORT

Sukunka Coal Mine Project

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Final

123110482

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NOTE:

Development of the baseline Technical Data Reports (TDRs) for the Project took place over a 20-month period. During this time the mine plan went through several iterations. Because of this, the mine plan shown in the TDR may be different then the plan in the environmental assessment Application. The key features that changed from the preliminary design include:

- The underground mine from the environmental assessment was removed but appears in some TDRs.
- The life of mine and initial tailings storage facilities were removed and tailings will be co-disposed with the waste rock in stockpiles.
- Three new transport options were added near Tumbler Ridge. The three options have alternative load-out locations. Option C is no longer considered in the environmental assessment but appears in some of the TDRs.
- Three transmission line options were added.
- The waste rock stockpiles and open pits were refined.
- Water management features were added including a discharge and water collection pipe and collection and diversion ditches.
- A second location option for the coal handling and processing plant was added.

AUTHORSHIP

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Executive Summary

Air quality has been selected as a valued component for environmental assessment of the Sukunka Coal Mine Project. To assess potential cumulative effects of the Project with other existing sources of air pollutants, representative background air quality values need to be developed. An understanding of the local meteorology is also required due to the importance of meteorological conditions on dispersion of air contaminants. To this end, a baseline ambient air quality and meteorology study was conducted for the Project area. This study incorporates historical and existing data and reports with results of a field data collection program that began in August 2012. The historical data available for the Sukunka project area are primarily from the 1970s when the mineral tenures were being explored by the Coal Division of BP Exploration Canada Limited.

Information from regional weather stations is supplemented by data from an automated meteorological station in the Sukunka local study area (LSA) that was installed in September 2012. The station measures and records hourly observations of air temperature, relative humidity, wind speed and direction, total precipitation, snow depth, solar radiation, and atmospheric pressure.

As particulate matter (PM) from fugitive dust is typically the contaminant of greatest concern for coal mining, the air quality baseline monitoring program focused on measurement of PM concentrations and dustfall (PM deposition). Two PM monitoring instruments in the Sukunka regional study area (RSA) recorded ambient concentration of respirable particulate matter ($PM_{2.5}$). A network of six dustfall stations monitored deposition at various elevations in the study area where future infrastructure is proposed or along proposed mine access or coal hauling corridors. The dustfall containers are changed out monthly and sent to a certified lab for analysis.

Preliminary results indicate that weather conditions in the study area are highly variable, with large day-to-day temperature swings being common, particularly in winter. This is due largely to the influence of the Rocky Mountains, which often form a boundary between disparate air masses. Temperatures at the Sukunka meteorological station show less diurnal range than those of the Chetwynd Airport and precipitation amounts are higher. These differences likely arise from the elevation difference between the two stations and the closer proximity to the mountains for the Sukunka site.

Particulate monitoring data recorded at a site in the District of Chetwynd near the airport since November 2012 show that winter $PM_{2.5}$ concentrations are generally low, with no readings in excess of BC Ambient Air Quality Objectives or Canada-Wide Standards for air quality. Temporal variability in PM concentrations can be explained by changing weather (and thus dispersion) conditions and variations in emissions from nearby industrial sources. Dustfall amounts are also low for the study period, with monthly results for all stations remaining well within the BC Pollution Control Objectives.

Air quality and meteorology baseline data collection will continue until at least one year's worth of valid data have been recorded. In addition, to comply with recommendations from the British Columbia Ministry of Environment (BC MOE), baseline data collected up to three months prior to the submission of the Environmental Assessment Certificate Application should be included.

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Abbreviations

$\mu g/m^3$	micrograms per cubic metre
BC	British Columbia
cm	centimetre
km	kilometre
LSA	local study area
m	metre
m/s	metre per second
mb	millibar
$mg/dm^2/day$	milligrams per square decimetre per day
MOE	Ministry of Environment
PM	particulate matter
PM_{10}	inhalable particulate matter less than 10 micrometres in diameter
$PM_{2.5}$	respirable particulate matter less than 2.5 micrometres in diameter
QA/QC	quality assurance/quality control
RSA	regional study area
TSP	total suspended particulate
W/m^2	watts per meter squared

1.0 Introduction

Mining activities can release fugitive dust and gaseous emissions from combustion to the atmosphere. The atmosphere is an important environmental pathway for the transport of contaminants from emissions sources to receptors. The level of contaminants in the air or the "quality" of the air can affect the health and well-being of humans, wildlife, vegetation, and other biota. Therefore, air quality has been selected as a valued component for this assessment.

The air contaminant of greatest concern associated with a coal mining is usually particulate matter (PM), which is defined in terms of size fractions. Particulate of all size classes is referred to as total suspended particulate (TSP), while particulate less than 10 micrometres (µm) in diameter is PM10, and particulate with diameters less than 2.5 µm is PM2.5. The smaller particles are generally thought to be of greater concern to human health than the larger particles because of their ability to penetrate further into the lungs. Dustfall refers to the amount of TSP that is deposited onto a collection surface in a given amount of time. Dustfall has the potential to negatively impact water bodies by increasing the sediment load and also causes accumulation of dust that can be a nuisance.

Other air emissions of concern from mines includes nitrogen dioxide and sulphur dioxide, which have the potential to affect human and wildlife health, as well as vegetation. Emissions of greenhouse gases are also of concern for their potential contribution to global climate change.

Meteorological conditions greatly affect the extent to which air pollutants are dispersed after leaving their source locations. Therefore, an understanding of the local meteorology of the study area is important to the assessment of potential air quality effects.

Baseline ambient air quality conditions are characterized by collecting meteorological and air quality observations for approximately one year to develop representative background air quality values and determine seasonal variations. The background values take into account existing sources of air pollutants in the airshed and thus represent one component of a cumulative effects assessment.

2.0 Regional Setting

The Sukunka property is located in the Rocky Mountain Inner Foothills physiographic region and is characterized by relatively low, rounded, northwest-southeast trending ridges and valleys, ranging from approximately 1,000 to 2,000 metres (m) in elevation. The property is predominantly forested with stands of lodgepole pine and occasional spruce, with stands of balsam poplar occurring in the lower and wetter areas of the tenure area.

The climate of the region is classified as northern temperate. Daily mean temperatures at the Chetwynd Airport range from −10.7°C in January to 15.3°C in July. Extreme air temperatures range from −52 to 34°C. The average annual precipitation at Chetwynd is 448 millimetres (mm), which includes the rainfall equivalent of a mean snowfall of 170 centimetres (cm). The region does not have distinct wet and dry seasons, although the summer months usually have more precipitation than the winter months. February is normally the driest month of the year and July is the wettest month.

Local air flow is strongly influenced by valleys and other terrain features, and by larger terrain influences on the upper level wind patterns. Strong temperature differences may occur between valley floors and nearby elevated terrain features. The local terrain influences will affect the transport and dispersion of contaminants emitted into the atmosphere. In addition, local ground cover will also have an effect on the dispersion and deposition of these emissions.

There has been forestry, oil and gas, and some mining activity in the area of the Sukunka Project; however, there are no known, currently operating, large sources of emissions within 10 km of the Sukunka project tenure area. There are also no known residences within 10 km of the proposed mine site.

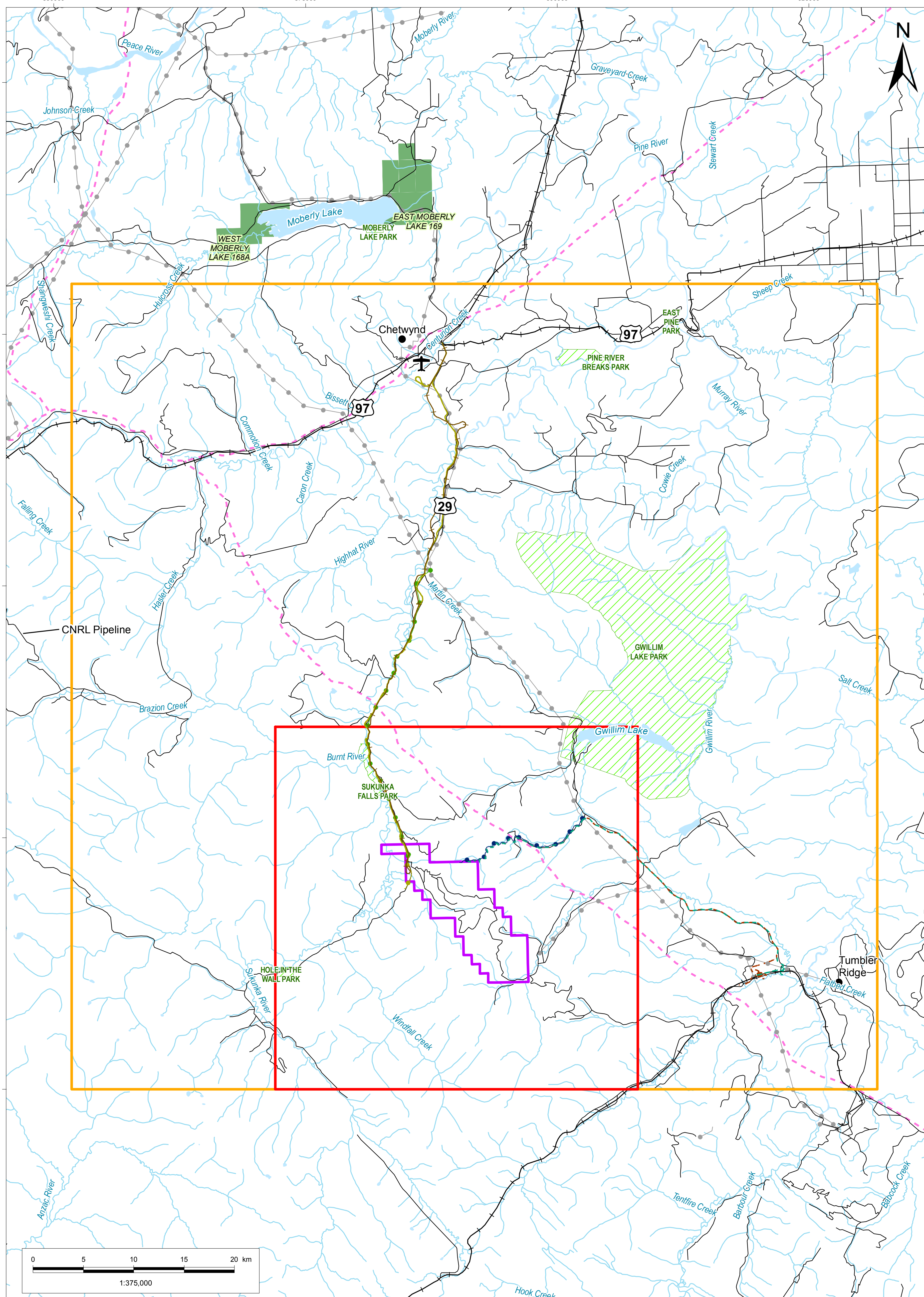
3.0 Study Areas

3.1 REGIONAL STUDY AREA

The Sukunka air quality regional study area (RSA) is an 80 by 80 km area, as illustrated Figure 3.1-1. It encompasses the Sukunka air quality local study area (LSA) as well as a minimum 5 km buffer around all rail, conveyor and road options for transporting the washed coal to the nearest existing infrastructure location. The air quality RSA will be used as the basis for the criteria air contaminant and greenhouse gas emission inventory for all project components and it will be used to assess cumulative effects in the Environmental Assessment Certificate Application.

3.2 LOCAL STUDY AREA

The air quality LSA is a 36 by 36-km area centered on the Sukunka project tenure area, as shown in Figure 3.1-1. This area includes a 10-km buffer on all sides of the Sukunka tenure. This size of study area should be sufficient to delineate potential project effects down to background levels. The air quality LSA will be used to conduct dispersion modelling of the main sources of emissions from the proposed Sukunka Project including the open pit(s), underground mine, coal handling and preparation plant, and the load-out.



Legend

- Airport
- City / Town / Village
- Road
- Railway
- Pipeline
- Transmission Line
- Watercourse

Transportation Options

- Option A
- Option B
- Option D
- Option E

Transmission Line Options

- Option 1
- Option 2
- Option 3

- First Nations Reserve
- Provincial Park
- Local Assessment Area
- Regional Assessment Area
- Sukunka Project Tenure Area

SUKUNKA COAL MINE PROJECT

AIR QUALITY LOCAL AND REGIONAL ASSESSMENT AREA

TECHNICAL DATA REPORT - AIR QUALITY

Data Sources: Glencore, Province of British Columbia, Government of Canada
Disclaimer: Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.
File Path: fig_10482_tdr_air_quality_03_01-01_air_quality_local_and_regional_assessment_areas

DATE:	15-AUG-14	PROJECTION:	UTM 10	DRAWN BY:	D. COOK
FIGURE ID:	123110482	DATUM:	NAD 83	CHECKED BY:	D. JARRETT

PREPARED BY: Stantec

PREPARED FOR: GLENCORE

FIGURE NO: **3.1-1**

4.0 Background and Methods

4.1 REVIEW OF EXISTING AIR QUALITY AND METEOROLOGICAL DATA SOURCES

A number of historical data sources describing the regional air quality and meteorological conditions are available. Appendix A contains the historical documents that are summarized in the following sections.

4.1.1 Preliminary Environmental Study of the Sukunka Coal Project (1975)

The report *Preliminary Environmental Study of the Sukunka Coal Project* (BC Research 1975) summarized meteorological data from 1971 to 1975. Air temperature and precipitation observations were recorded near the mine site at a weather station known as Chetwynd Sukunka. Only the years 1972–1974 had complete data records. These observations were supplemented by 1941–1970 Environment Canada climate data from Dawson Creek and Fort St. John.

During 1972–1974, the mean daily air temperature at the historical Chetwynd Sukunka site was –0.7°C, and ranged from –4.2°C (1974) to 1.5°C (1973). The average daily maximum over the 3-year period was 7.4°C and the average daily minimum was -5.0°C. Data from the Dawson Creek and Fort St. John stations indicated that during the 1941–1970 period the extreme minimum temperature was –48°C and the extreme maximum temperature was 33°C.

Annual precipitation at the Chetwynd Sukunka station averaged 689 mm during the three years with complete data. Annual snowfall ranged from 230 cm in 1973 to 487 cm in 1972.

Wind speed and direction were not measured at the weather station, but the prevailing wind was inferred by human observations to be from the southwest (down the Sukunka River Valley).

Relevant tables and figures from this report are included in Appendix A.

4.1.2 Sukunka-Bullmoose Environmental Studies (1977–1979)

The report *Sukunka-Bullmoose Stage I Environmental Study* (BP Exploration Canada 1977) included a section describing the climate of the study area, which was compiled based on data from long-term climatological stations at Dawson Creek, Fort St. John, and Prince George as well as shorter data records from Chetwynd Sukunka, Bullmoose, and several other stations in the region.

The report outlined regional temperature, precipitation, wind, and inversion characteristics. It was noted that insufficient data were available to evaluate air quality, but a relatively pristine condition was assumed due to the undeveloped state of the study area.

The Sukunka-Bullmoose Stage 1 study highlighted climatological differences between the study area and the long-term stations, which result from differences in elevation and proximity to the Rocky Mountains. The mean annual temperature at Chetwynd Sukunka (-0.7°C) was noted to be about 2°C colder than Dawson Creek and Fort St. John. Precipitation at Chetwynd Sukunka was found to be considerably higher than that of Dawson Creek and Fort St. John, with maximum daily amounts estimated to be about 80 mm. The mean total annual precipitation amounts for Chetwynd Sukunka, Dawson Creek and Fort St. John were 690, 425 and 450 mm, respectively. Temperature inversions in the Chetwynd area were observed on 60-80 percent of days year-round during the overnight and early morning hours, and on nearly half (45 percent) of winter days in the afternoon hours.

In 1979 the *Sukunka Coal Project Stage II Submission* was prepared for the BC Environment and Land Use Committee (BP Exploration Canada 1979). This report summarized the anticipated environmental effects of the proposed underground coal mine. A network of six dustfall stations and one particulate monitoring station in the Sukunka Valley was referred to in the Stage II report, but no results were presented. Dust control along the Sukunka Forestry Road was cited as an issue of concern.

Relevant tables and figures from the Stage I report are included in Appendix A.

4.1.3 Chetwynd Windrem School Air Quality Data

Particulate matter (PM) monitoring was conducted by the British Columbia Ministry of Environment (BC MOE) at the Chetwynd Windrem Elementary School periodically from 2007 through 2009. Data gaps exist, but in general both inhalable (PM_{10}) and respirable ($PM_{2.5}$) particulate concentrations were sampled every three days. Months with less than three days of $PM_{2.5}$ data include September 2007, January 2008, February 2008 (no data), March 2008, May 2008, July 2008 (no data), and August 2008. All of the available months of PM_{10} data have more than four days with reliable data. The maximum $PM_{2.5}$ concentration was 21 micrograms per cubic metre (µg/m^3) and the maximum PM_{10} concentration was 80 µg/m^3 (both are 24-hour averages).

Table 4.1-1 and Table 4.1-2 compare the BC Ambient Air Quality Objectives (25 µg/m^3 for $PM_{2.5}$ and 50 µg/m^3 for PM_{10}) and the Canada-Wide Standards (30 µg/m^3 for $PM_{2.5}$). This comparison shows that none of the observed $PM_{2.5}$ concentrations exceeded the provincial objective or Canada-Wide Standard. Concentrations of $PM_{2.5}$ greater than half the provincial objective occurred 1.2 percent of the time.

Table 4.1-2 shows that 24-hour average PM_{10} concentrations exceeded the provincial objective 1.4 percent of the time and were more than half the provincial objective for 9.2 percent of observations.

Table 4.1-1 Analysis of Chetwynd Windrem School 24-Hour Average $PM_{2.5}$ Measurements (2007 to 2009) Relative to the BC Ambient Air Quality Objectives and Canada-Wide Standards

Parameter	$PM_{2.5}$
Total number of data records	171
Count of data records > 12.5 µg/m³ (half of BC Objective)	2
Frequency > 12.5 µg/m³	1.2%
Count of data records > 25 µg/m³ (BC Objective)	0
Frequency > 25 µg/m³	0.0%
Count of data records > 15 µg/m³ (half of Canada-Wide Standard)	2
Frequency > 15 µg/m³	1.2%
Count of data records > 30 µg/m³ (Canada-Wide Standard)	0

Table 4.1-2 Analysis of Chetwynd Windrem School 24-Hour AveragePM_{10} Measurements (2007 to 2009) Relative to the BC Ambient Air Quality Objectives and Canada-Wide Standards

Parameter	PM_{10}
Total number of data records	207
Count of data records > 25 µg/m³ (half of BC Objective)	19
Frequency > 25 µg/m³	9.2%
Count of data records > 50 µg/m³ (BC Objective)	3
Frequency > 50 µg/m³	1.4%

Box and whisker plots (Figure 4.1-1 and Figure 4.1-2) illustrate the monthly variation of the daily $PM_{2.5}$ and PM_{10} concentrations observed at the Windrem School in Chetwynd. The interquartile range (25th to 75th percentile) is illustrated by the box's bottom and top. The median is represented by the line through the centre of the box. The vertical lines (whiskers) indicate the maximum and minimum daily concentrations during that month. Months where there were three or less days with reliable data do not have whiskers extending from the boxes.

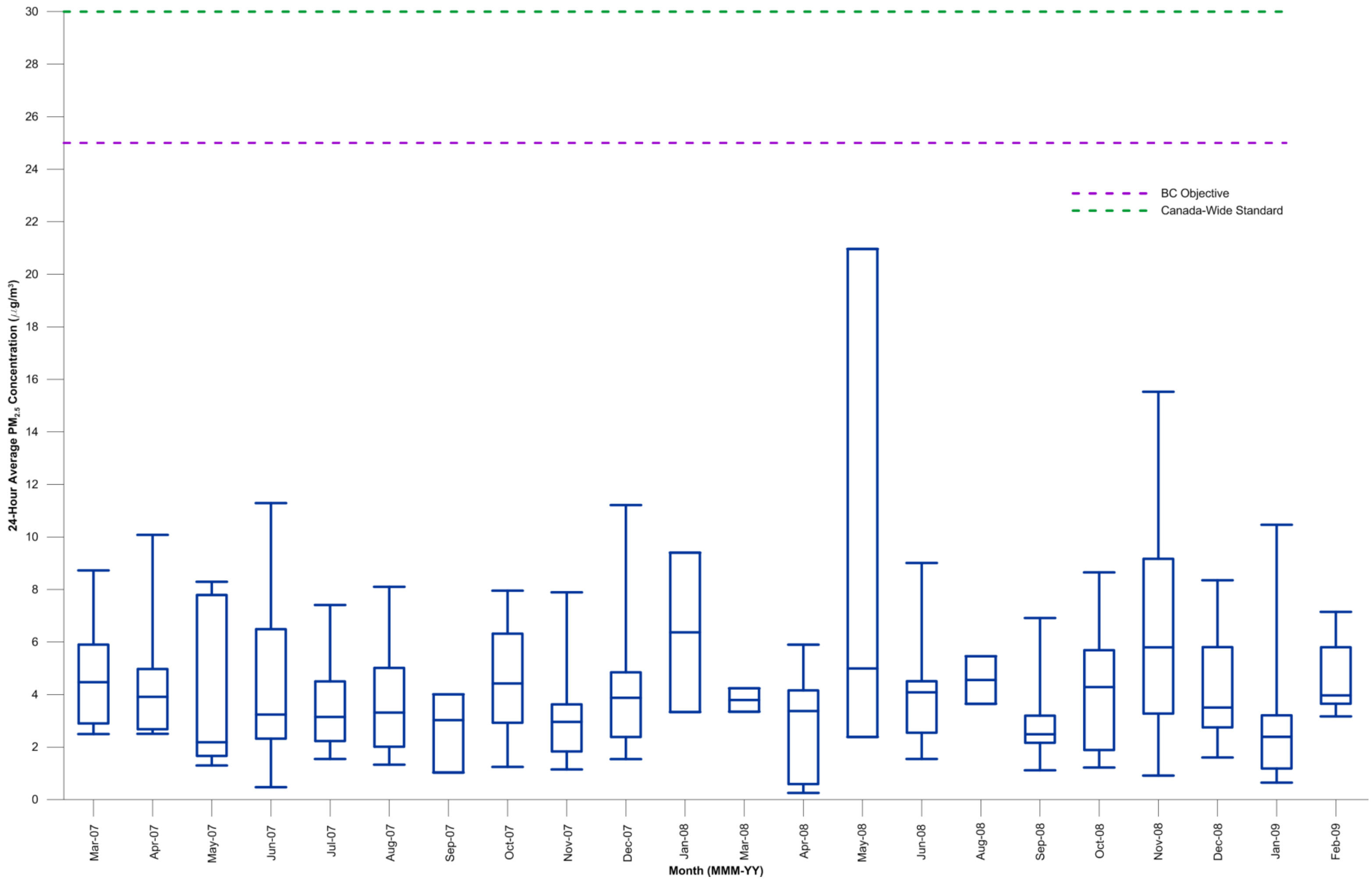


Figure 4.1-1 Variation in 24-Hour Average $PM_{2.5}$ Concentrations at the Chetwynd Windrem School

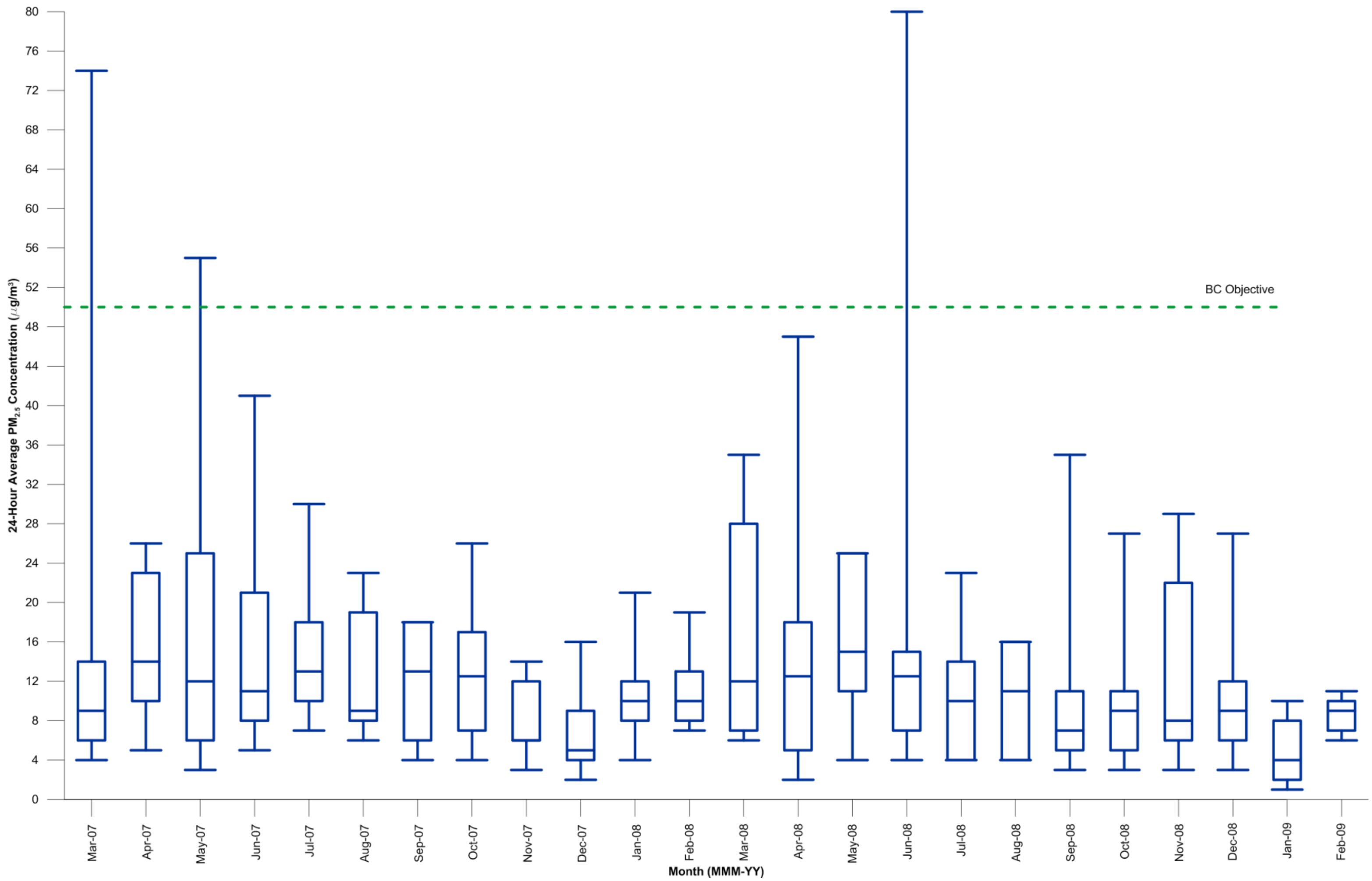


Figure 4.1-2 Variation in 24-Hour Average PM_{10} Concentrations at the Chetwynd Windrem School

4.2 FIELD SURVEYS

Due to the dated nature of previous environmental studies in the Sukunka Valley and limited data availability, a baseline monitoring program was implemented in 2012 with the deployment of new meteorological, particulate, and dustfall monitoring stations in the Sukunka LSA and RSA. The locations of these stations are shown in Figure 4.2-1. Details of the instruments and measured parameters are provided below.

Based on the remote location of the proposed Sukunka Project and a relatively low level of anthropogenic activities, it is not deemed necessary to carry out baseline monitoring of nitrogen dioxide and sulphur dioxide ambient concentrations. The monitoring program focused on particulate matter, including dustfall.

4.2.1 Meteorological Station

The Sukunka meteorological station is located near kilometre 32 of the Sukunka Forest Service Road, approximately 51 km south of Chetwynd (Figure 4.2-1, Table 4.2-1, Photo 4.2-1). The station consists of a 10-m aluminum tower, meteorological instruments, datalogger, high definition camera, satellite modem, and power system (solar and battery). The station measures and records wind speed and direction, air temperature, relative humidity, snow depth, total precipitation, solar radiation, and atmospheric pressure.

The location for the Sukunka automated meteorology station followed guidance provided in the *MSC Guidelines for Co-operative Climatological Autostations Version 3.0* (Environment Canada 2004) and the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008). A suitable site was confirmed during a reconnaissance field trip and after consultation with the Glencore mine planning engineers about the proposed locations for future mine infrastructure. Coordinates of the station are provided in Table 4.2-1. The station is situated in a nearly level clearing in the Sukunka Valley, just south of Skeeter Creek.

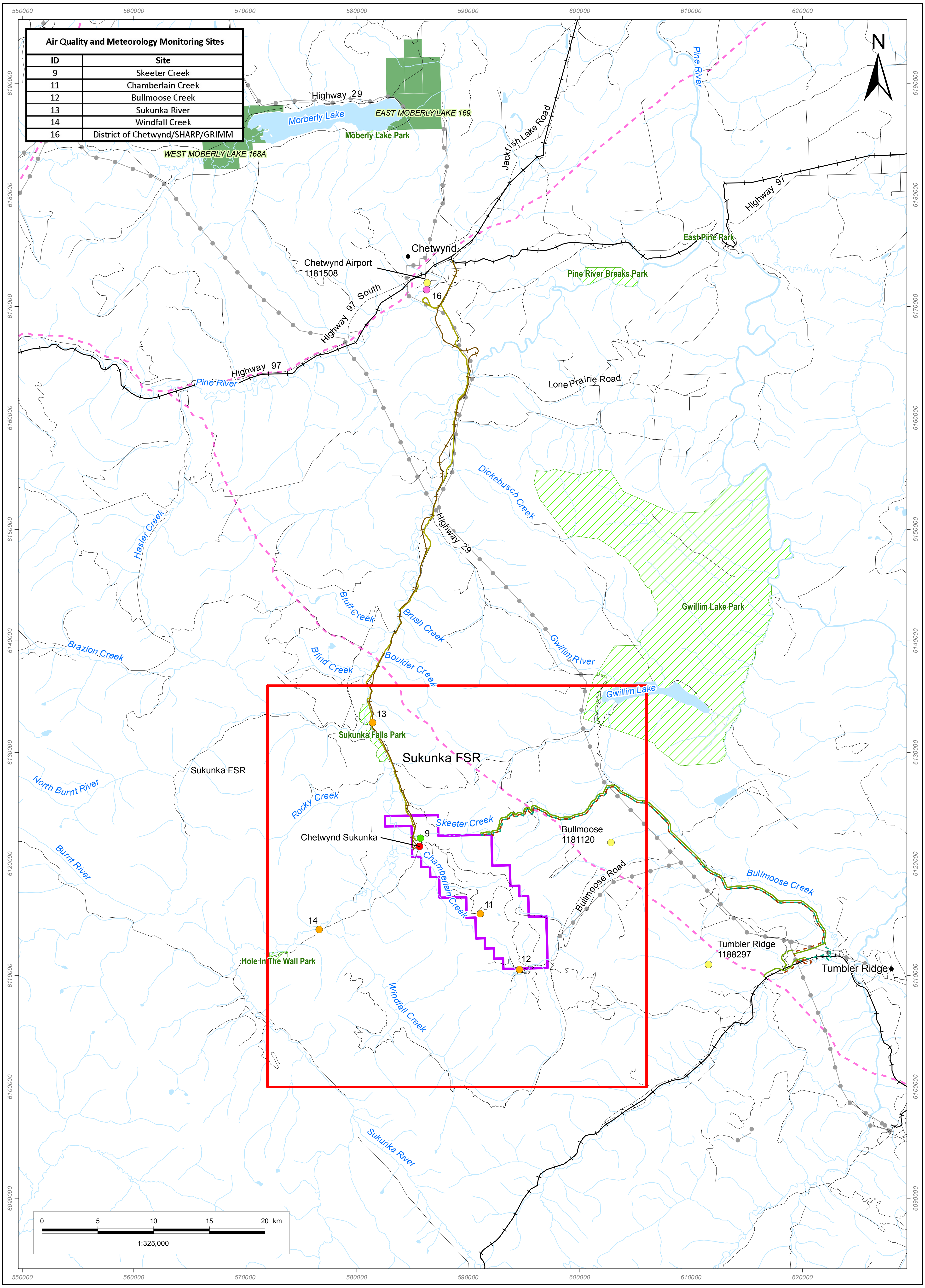
Table 4.2-1 Location of the Sukunka Meteorological Station

UTM (NAD 83 Zone 10)		Elevation (m)	Data Available
Easting (m)	Northing (m)		
585,734	6,122,327	757	September 19, 2012–present

Table 4.2-2 describes the sensors installed at the Sukunka meteorological station. The Campbell Scientific CR1000 datalogger records data on an hourly basis; these observations, including lower resolution photos from the digital camera, are automatically downloaded once per day via satellite modem. The high resolution photos are downloaded manually during site visits. Photo 4.2-1, Photo 4.2-2, and Photo 4.2-3 show the meteorological station, the datalogger enclosure, and the precipitation gauge.

Table 4.2-2 List of Sensors for the Sukunka Automated Meteorology Station

Parameter	Sensor	Manufacturer	Model Number	Serial Number	Mounting Height (m)
Datalogger	Measurement and Control Module with 4MB Ram Memory	Campbell Scientific	CR1000-55	50281	2
Solar Panel	50 Watt 12 Volt	Campbell Scientific	MSX50R-L	D31203059D755DD	5
Solar Radiation	Pyranometer Sensor w/ Integrated Leveling	Kipp & Zonen	CMP3-L	127273	6
Wind Speed Wind Direction	Wind Monitor-AQ	RM Young	05305-10-L	119478	10
Relative Humidity Air Temperature	Relative humidity Probe (0 to 100%) Temperature Probe (-50 to +50C)	Campbell Scientific	HC2-S3-L	60947447	3
Pressure	Barometric Pressure Sensor 500 –1100 millibars (mb)	Vaisala	PTB110	H1460091	1
Precipitation	Precipitation Gauge–1500 mm	GEONOR	T-200B-MD	30412	3 (12 m away from met tower)
Snow Depth	Sonic Ranger	Campbell Scientific	SR50A	4676	5



Legend

- Historical Meteorological Station
- Environment Canada Meteorology Station
- Dustfall Station
- Meteorology and Dustfall Station
- Particulate (TSP/PM10/PM2.5) and Dustfall Station
- City / Town / Village
- Railway
- Road
- Watercourse
- Pipeline
- Transmission Line
- Local Study Area
- Sukunka Project Tenure Area
- First Nations Reserve
- Provincial Park

Haulage Options

- Option A
- Option B
- Option C
- Option D
- Option E

SUKUNKA COAL MINE PROJECT

LOCATION OF AIR QUALITY AND METEOROLOGICAL MONITORING SITES

TECHNICAL DATA REPORT - AIR QUALITY

Data Sources: Glencore, Province of British Columbia, Government of Canada
Disclaimer: Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.
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FIGURE ID:	123110482	DATUM:	NAD 83	CHECKED BY:	D. JARRATT

PREPARED BY: Stantec

PREPARED FOR: GLENCORE

FIGURE NO: **4.2-1**

Photo 4.2-1 Sukunka Automated Meteorology Station

Photo 4.2-2 Campbell Scientific CR1000 Datalogger in a Fiberglass Weatherproof Enclosure

Photo 4.2-3 GEONOR Precipitation Gauge with a Capacity of 1,500 mm

Data downloaded from the station are assessed with a quality assurance and quality control (QA/QC) process. Methods for completing the QA/QC review of data are derived from the *MSC Guidelines for Co-operative Climatological Autostations Version 3.0* (Environment Canada 2004), as well as *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (US EPA 2000) and professional judgment. The raw hourly data are checked using the screening process outlined in Table 4.2-3. Observations that do not meet the screening criteria are flagged for removal from calculations of averages and extremes.

Data collection commenced on September 19, 2012 for all sensors except the GEONOR precipitation gauge, which was installed on October 23, 2012. For the current analysis, the period of valid data is from September 19, 2012 to April 2, 2013 for all sensors except the GEONOR precipitation gauge, which has valid data from October 23, 2012 to April 2, 2013.

Table 4.2-3 Meteorology Data Quality Assurance Screening Criteria

Parameter	Screening Criteria
Air Temperature	• If the same value is read for 10 or more consecutive hours • If minimum temperature is greater than maximum temperature

Table 4.2-3 Meteorology Data Quality Assurance Screening Criteria

Parameter	Screening Criteria
Precipitation	• If hourly accumulated liquid precipitation is greater than 89.9 mm • If hourly accumulated liquid precipitation is non-zero and if it is the same as that of the two preceding hours • If the hourly precipitation is negative • If the precipitation calculated from first principles (e.g., using the manufacturer's formula from the sensor calibration data sheet) does not match data
Wind Speed and Direction	• If wind direction and speed are both zero for 24 or more consecutive hours • If the same speed or direction value is read for 12 or more consecutive hours
Snow Depth	• Between December and April, if more than 500 cm • Between May and November, if more than 150 cm • If the Signal Quality for the sonic ranger sensor (SR50A) is greater than 230 or less than 152 • If the snow depth is negative
Solar Radiation	• If daytime or summertime radiation is greater than nighttime or winter • If nighttime solar radiation is greater than 0
Relative Humidity	• If greater than 100% or less than 5%

Since installation of the Sukunka meteorological station, there have been four datalogger program changes. The four changes are as follows:

- Header lines updated on October 4, 2012
- Signal quality, sample precipitation level, average precipitation frequency, sample precipitation frequency, and pressure added to the data output on October 23, 2012
- Sample precipitation level, average precipitation frequency, and sample precipitation frequency were removed and average five-minute precipitation level was added on January 7, 2013

4.2.2 Particulate Matter Monitoring

Ambient PM concentrations are being monitored by automated instrumentation at a District of Chetwynd site approximately 400 m south of the Chetwynd airport. These observations are for the purpose of recording baseline PM conditions near Chetwynd, which is part of the Sukunka air quality RSA. Two instruments are currently operating at the District of Chetwynd site: a Thermo Scientific SHARP Model 5030i particulate monitor and a GRIMM Aerosol Environ Check 365 unit. Location information for the instruments is provided in Figure 4.2-1 and Table 4.2-4. The GRIMM instrument will be moved to a location within the Sukunka air quality LSA when a suitable site with continuous AC power becomes available (the ongoing mineral exploration drilling program does not include an on-site camp with a power generator).

The SHARP 5030i PM monitor was installed at the District of Chetwynd site on October 7, 2012. Due to considerable noise in the data and instrument calibration during the first month of monitoring, valid SHARP readings are considered to range from November 4, 2012 to March 26,

2013. The SHARP unit is a hybrid instrument that uses both the light scattering photometry of a nephelometer and a beta attenuation mass sensor to provide accurate continuous PM monitoring. As only one size fraction can be sampled at a time, the instrument has been configured to measure $PM_{2.5}$, which is generally of greater concern from a human health perspective than larger size fractions, due to the respirable nature of very fine particulates.

The inlet flow rate of the SHARP monitor is 16.67 liters per minute as ambient air containing PM is drawn through a heated sample tube. The heating system is used to maintain the relative humidity at or below a threshold setting of 35 percent. The system combines the short-term sensitivity of a nephelometer with the time-averaged accuracy of a beta attenuation sensor. $PM_{2.5}$ concentrations are output as "NEPH", "PM", and "SHARP", which are the nephelometer, beta attenuation, and hybrid values, respectively (Thermo Fisher Scientific 2011). Data analysis focuses on the hybrid "SHARP" readings, which are expected to be the most accurate observations of 24-hour average $PM_{2.5}$ concentrations.

The SHARP instrument also measures and records both ambient and sample relative humidity, temperature, and pressure. Ambient readings are used for volumetric flow rate regulation.

A leak check and flow audit calibration were conducted during installation of the SHARP instrument. The following instrument quality assurance checks were also conducted during installation following the manufacturer's recommendations: a) ambient temperature, b) flow temperature, c) barometric pressure, d) mass calibration, and e) nephelometer calibration for temperature and source level. Appendix E contains leak check and flow audit information from the SHARP user's manual.

The GRIMM Environ Check 365 instrument was moved from the Suska Exploration Camp to the District of Chetwynd site on December 12, 2012 and monitoring resumed on December 13, 2012. As the Suska camp was being dismantled (resulting in loss of continuous AC power for the GRIMM), it was decided that the instrument should be co-located with the SHARP monitor for a period of time sufficient to perform a comparison of the two instruments before deploying the GRIMM monitor in the Sukunka air quality LSA. The GRIMM instrument was calibrated by the manufacturer on August 9, 2012 and the calibration certificate is in Appendix F.

Table 4.2-4 Location of the SHARP and GRIMM Particulate Monitoring Instruments

PM Monitor	UTM (NAD 83 Zone 10)		Elevation (m)	Valid Data Available
	Easting (m)	Northing (m)		
Thermo SHARP 5030i $PM_{2.5}$ monitor	586,286	6,171,480	615	November 4, 2012–present
GRIMM PM monitor	586,286	6,171,480	615	December 13, 2012–present

The GRIMM monitor is an aerosol spectrometer that uses a laser diode as a light source. The light scattering pulse of each particle passing through the detection chamber is counted and the intensity of the scattered signal is correlated to a certain particle size range (GRIMM Aerosol Technik 2009). Thus, the instrument is able to simultaneously measure $PM_{2.5}$, PM_{10}, and Total Suspended Particulate (TSP). Like the SHARP unit, the GRIMM also monitors temperature, relative humidity, and barometer pressure.

Photo 4.2-4 shows the SHARP and GRIMM instruments located next to each other at the District of Chetwynd monitoring site. The SHARP electronics are housed in the large white enclosure on the left, while the GRIMM is in the silver enclosure to the right.

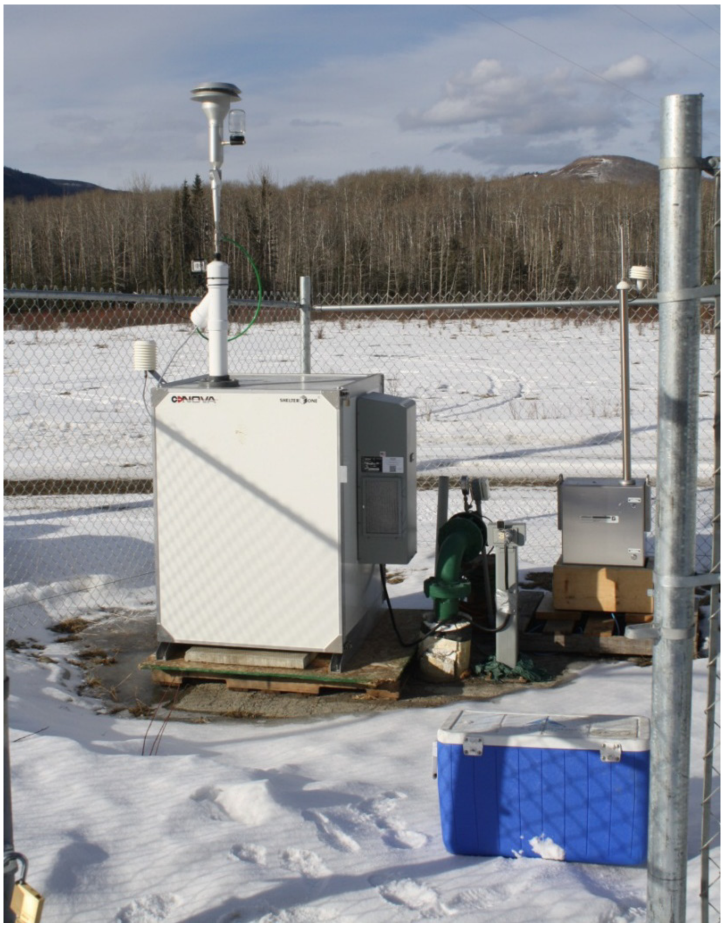


Photo 4.2-4 SHARP and GRIMM PM Monitors at the District of Chetwynd Monitoring Site

4.2.3 Dustfall Monitoring

Deposition of atmospheric PM is being measured by a network of dustfall canisters deployed throughout the study area. For the Sukunka baseline monitoring program, five dustfall stations were installed in the LSA and one additional dustfall station was installed at the District of Chetwynd site in the RSA. (Originally, a sixth station was installed at a high elevation site within the LSA, but this station was vandalized within one month of installation.) Locations of these stations are provided in Figure 4.2-1 and Table 4.2-5. The five dustfall stations in the LSA were installed in August 2012 and the District of Chetwynd station was installed in October 2012. Locations were chosen following guidance provided in the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012) and station configuration, equipment installation and siting followed the *Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter)* (ASTM 2004).

The dustfall stations each consist of two stands composed of metal poles topped by plastic wind screens to house the containers, which are open 12.5 cm diameter high density polyethylene plastic containers (Photo 4.2-5). Bird spikes are installed around the perimeter of the wind screen to prevent birds from fouling into the sample container.

Table 4.2-5 Sukunka Dustfall Station Locations

Station Name	UTM (NAD 83 Zone 10)		Elevation (m)
	Easting (m)	Northing (m)	
09 Skeeter Creek	585,733	6,122,328	752
11 Chamberlain Creek	591,096	6,115,555	1,658
12 Bullmoose Creek	594,604	6,110,538	1,205
13 Sukunka River	581,450	6,132,676	705
14 Windfall Creek	576,660	6,114,122	726
16 District Of Chetwynd	586,286	6,171,480	615

Photo 4.2-5 Dustfall Monitoring Station

Collection of the samples occurs monthly in order to obtain data that can be compared to the BC Pollution Control Objectives, which are based on monthly average deposition rates (BC MOE 1979). Actual container change-out dates are shown in Table 4.2-6. The dustfall containers at Site 11, Chamberlain Creek, were not collected during the late January/early February field trip due to site inaccessibility (unsafe helicopter flying conditions); therefore, data from the late February container change-out represent a two-month dustfall sample.

Monthly dustfall samples are shipped to a certified lab for analysis of total dustfall, soluble dustfall, and insoluble dustfall in units of milligrams per square decimetre per day ($mg/dm^2/day$). Additionally, a second dustfall canister is deployed at each station for metals analysis on a quarterly basis. The metals analysis provides the deposition rates ($mg/dm^2/day$) of 28 different elements, including those expected to be of greatest interest to ecological and human health risk assessments (e.g., aluminum, arsenic, cadmium, copper, lead, molybdenum, nickel, selenium, silver, vanadium and zinc).

Table 4.2-6 Dustfall Sample Container Change-Out Dates

Station Name	Sample Out Date (DD-MMM-YY)						
09 Skeeter Creek	17-Sep-12	21-Oct-12	23-Nov-12	03-Jan-13	31-Jan-13	01-Mar-13	26-Mar-13
11 Chamberlain Creek	19-Sep-12	23-Oct-12	24-Nov-12	05-Jan-13	–	27-Feb-13	27-Mar-13
12 Bullmoose Creek	19-Sep-12	21-Oct-12	24-Nov-12	05-Jan-13	01-Feb-13	27-Feb-13	27-Mar-13
13 Sukunka River	17-Sep-12	21-Oct-12	23-Nov-12	03-Jan-13	31-Jan-13	01-Mar-13	27-Mar-13
14 Windfall Creek	17-Sep-12	21-Oct-12	23-Nov-12	03-Jan-13	01-Feb-13	27-Feb-13	27-Mar-13
16 District Of Chetwynd	–	–	21-Nov-12	03-Jan-13	30-Jan-13	26-Feb-13	27-Mar-13

5.0 Results

The following sections describe meteorology and air quality data collected at the Sukunka meteorology station, the SHARP and GRIMM PM monitors, and the six dustfall stations. Meteorological data records from September 19, 2012 to April 2, 2013 are included in the analysis. (Precipitation and atmospheric pressure records began on October 23, 2012.) SHARP $PM_{2.5}$ concentration data range from November 4, 2012 to March 26, 2013. Project-relevant GRIMM PM concentration data are from December 2012 to March 2013.

5.1 METEOROLOGY

Hourly data have been collected and processed from the Sukunka automated meteorology station as described in Section 4.2.1. The following sections summarize air temperature, precipitation, wind speed and direction, solar radiation, snow depth, and atmospheric pressure data from the station. A comparison to data from the Chetwynd Airport weather station (operated by Environment Canada–Meteorological Services of Canada) is also included.

5.1.1 Air Temperature

Figure 5.1-1 shows daily average, minimum and maximum air temperatures for September 19, 2012 to April 2, 2013. Table 5.1-1 includes the overall maximum and minimum air temperatures during the sample period.

The extreme maximum temperature during the period was 28.5°C (hour 16 September 23, 2012) and the extreme minimum was –31.2°C (hour 7 December 27, 2012). The hourly average air temperature for the available data ranged from –30.6°C (December 26, 2012) to 27.9°C (September 23, 2012). The overall average temperature for the sample period was –4.6°C

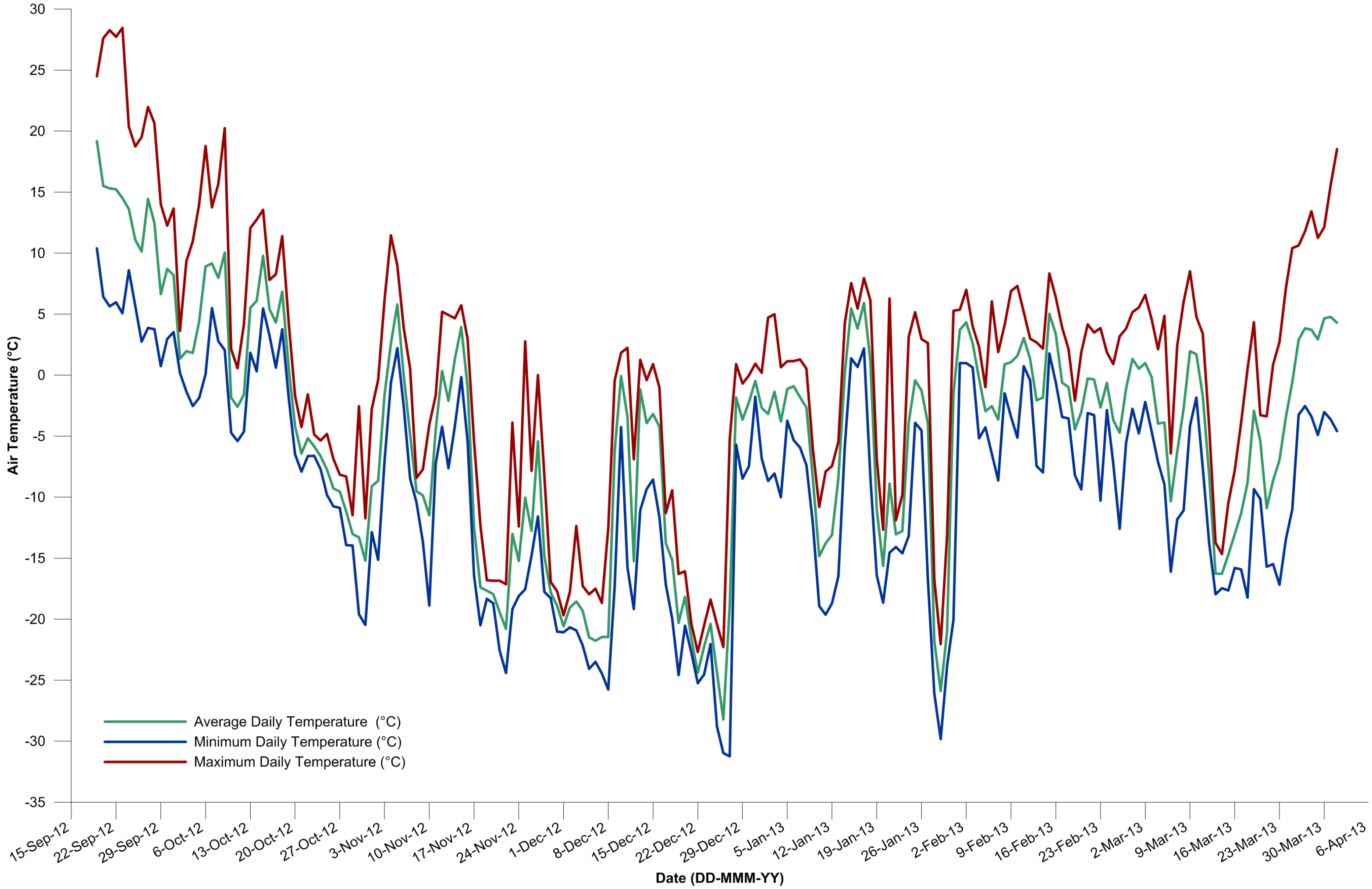


Figure 5.1-1 Daily Average, Minimum, and Maximum Air Temperatures at the Sukunka Meteorology Station for September 2012 to April 2013

Table 5.1-1 Monthly Temperatures at the Sukunka Meteorology Station for September 2012 to April 2013

Month	Average Air Temperature (°C)	Extreme Maximum Air Temperature (°C)	Extreme Minimum Air Temperature (°C)	Mean Maximum Air Temperature (°C)	Mean Minimum Air Temperature (°C)
September 2012	12.8	28.5	0.7	22.0	5.1
October 2012	–0.7	20.2	–20.5	4.0	–4.1
November 2012	–8.7	11.5	–24.4	–4.0	–12.5
December 2012	–14.1	2.2	–31.2	–10.3	–18.4
January 2013	–6.5	8.0	–29.8	–1.9	–11.9
February 2013	–0.3	8.3	–12.6	3.7	–4.2
March 2013	–4.1	15.6	–18.2	2.6	–10.0
April 2013	4.7	18.5	–4.6	18.5	–4.6

5.1.2 Precipitation

Figure 5.1-2 shows the total accumulated precipitation (line graph) and the total monthly precipitation (bar graph) for October 2012 to April 2013. The monthly total precipitation ranged from 10.9 mm (January 2013) to 54.8 mm (November 2012), while the total accumulated precipitation reached 184 mm by the end of March 2013. The average monthly precipitation over the sample period was 30.6 mm. These values include the water equivalent of melted snowfall. The maximum hourly precipitation amount was 2.3 mm on hour 11 of November 23, 2012. The maximum daily precipitation amount was 11.9 mm on March 13, 2013.

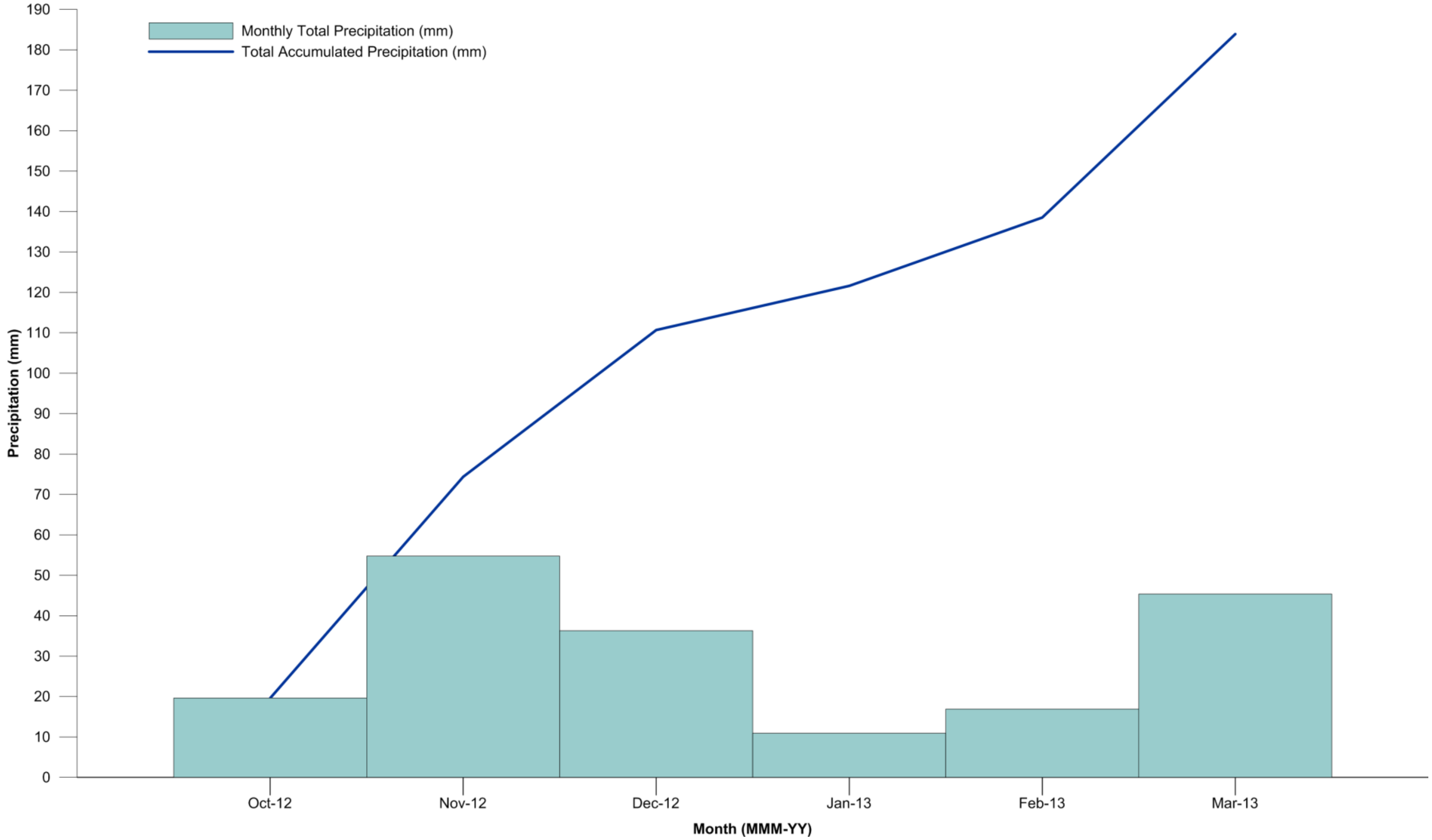


Figure 5.1-2 Total Accumulated Precipitation and Total Monthly Precipitation at the Sukunka Meteorology Station from October 2012 to March 2013

5.1.3 Wind Speed and Direction

Figure 5.1-3 shows winter and summer seasonal wind roses based on data from the Sukunka meteorology station from September 2012 to April 2013. The summer wind rose contains 13 days of data from September 19 to 30, 2012 and April 1 to 2, 2013; therefore, the wind rose does not fully represent typical summer wind patterns. The winter wind rose contains data from October 1, 2012 to March 31, 2013 (182 days). The wind roses are based on hourly average values from an air quality rated wind sensor manufactured by RM Young. All wind directions are referenced from True North.

From the available summer data (September and April), the winds were primarily from the northwest with speeds of 1–2 metres per second (m/s) occurring 57.7 percent of the time. Calm periods (winds less than 0.5 m/s, the starting threshold for the RM Young wind sensor) occurred 2.3 percent of the time.

The winter winds (October to March) were primarily light (1–3 m/s) from the north and west, while the stronger winds (3 to greater than 6 m/s) were primarily from the south and southeast. Wind speeds of 1–2 m/s occurred 42.0 percent of the time and calm winds occurred 10.5 percent of the time.

5.1.4 Solar Radiation

Figure 5.1-4 shows the daily average solar radiation at the Sukunka meteorology station for September 19, 2012 to April 2, 2013. The highest daily average solar radiation during this period was 211.8 W/m^2 on March 31, 2013. The maximum recorded hourly solar radiation of 668 W/m^2 was also on March 31, 2013 at hour 14. The average monthly solar radiation ranged from 11 W/m^2 (December 2012) to 120 W/m^2 (September 2012).

5.1.5 Snow Depth

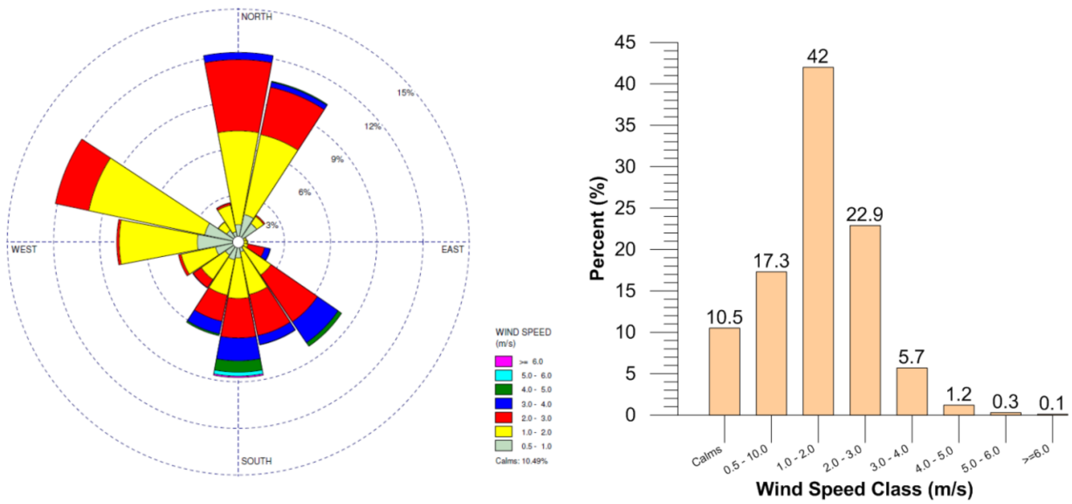
Figure 5.1-5 shows the daily average snow depth between September 2012 and April 2013. A maximum snow depth of 93 cm was recorded on March 14, 2013. Snow started accumulating at the station in mid-October 2012, and as of April 2, 2013 the snow depth at the station was 55 cm.

In addition to the automated snow depth measurements, manual snow surveys were conducted monthly beginning in January 2013 near the Sukunka meteorology station, near the Chamberlain Creek dustfall station, and at a site in the Bullmoose drainage. Results from the snow survey program are presented in a separate Sukunka baseline report for the snow and climate studies.

5.1.6 Atmospheric Pressure

Hourly atmospheric pressure readings, corrected to sea level, are presented in Figure 5.1-6. The maximum sea level pressure during the sample period was 1,037 millibar (mb) on January 19, 2013 and the minimum pressure was 989 mb on February 22, 2013.

Winter (October to March)



Summer (September and April)

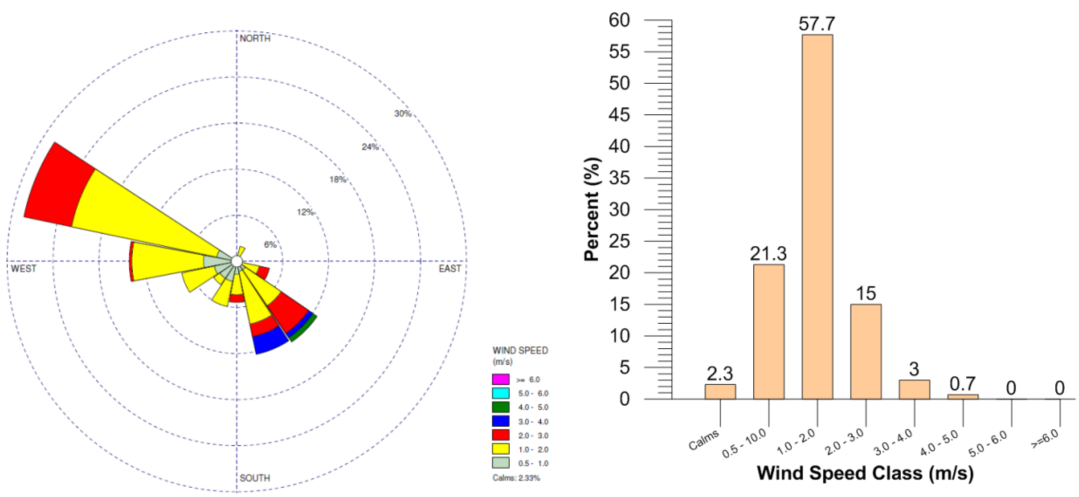


Figure 5.1-3 Wind Roses and Frequency Diagrams at the Sukunka Meteorology Station for Summer (September 2012 and April 2013) and Winter (October 2012 to March 2013)

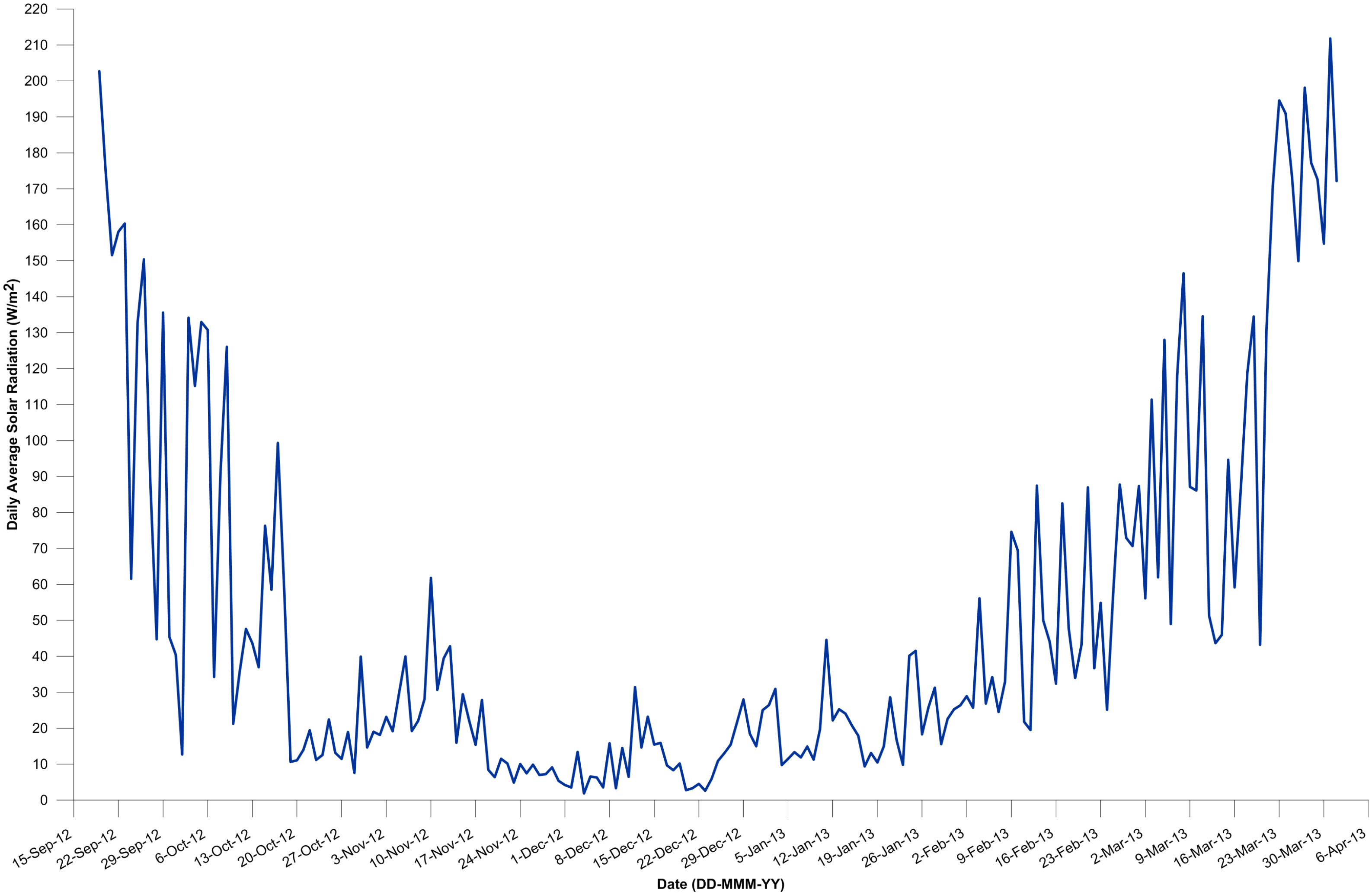


Figure 5.1-4 Daily Average Solar Radiation at the Sukunka Meteorology Station for September 2012 to March 2013

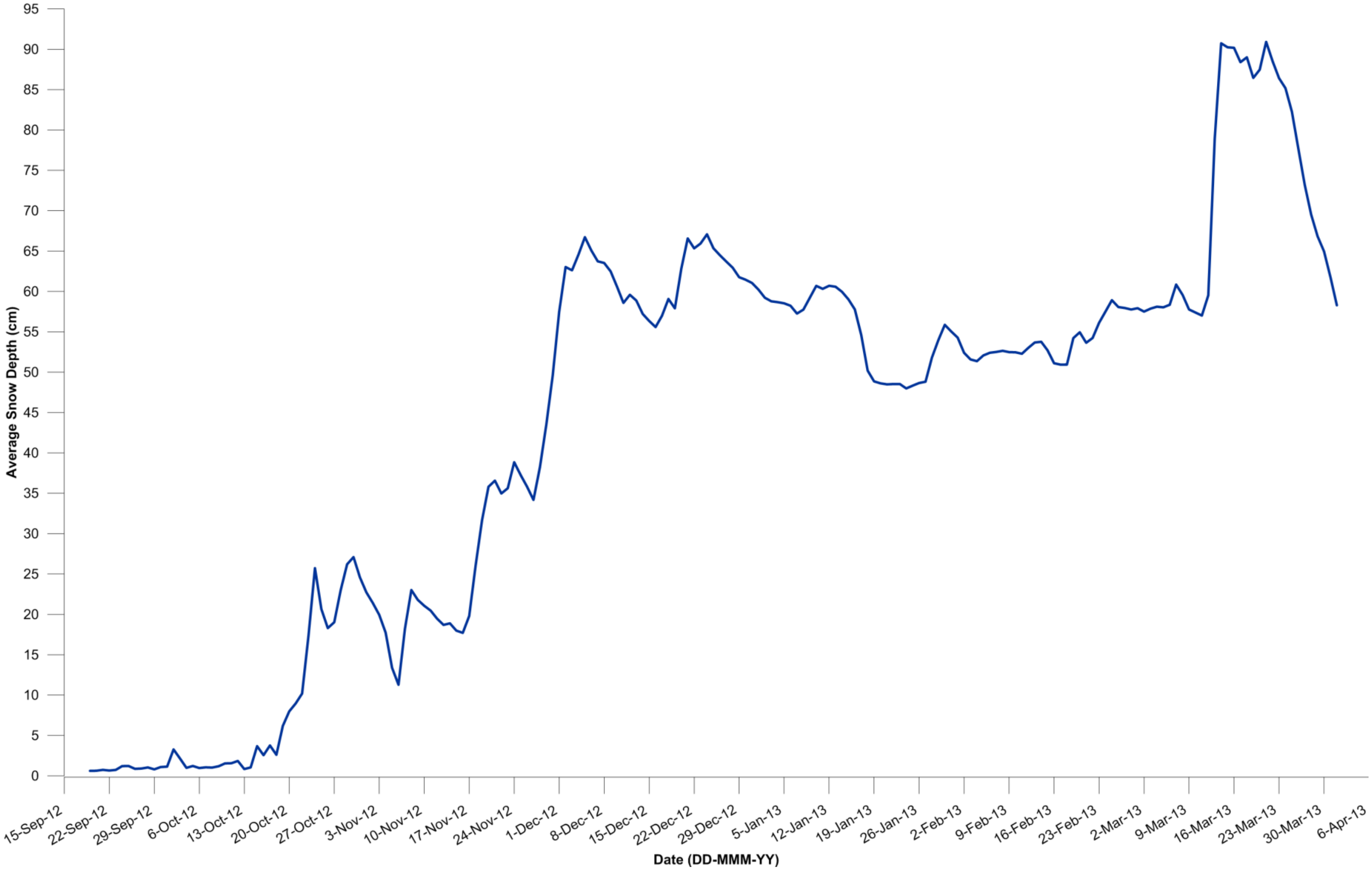


Figure 5.1-5 Daily Average Snow Depth at the Sukunka Meteorology Station for September 2012 to March 2013

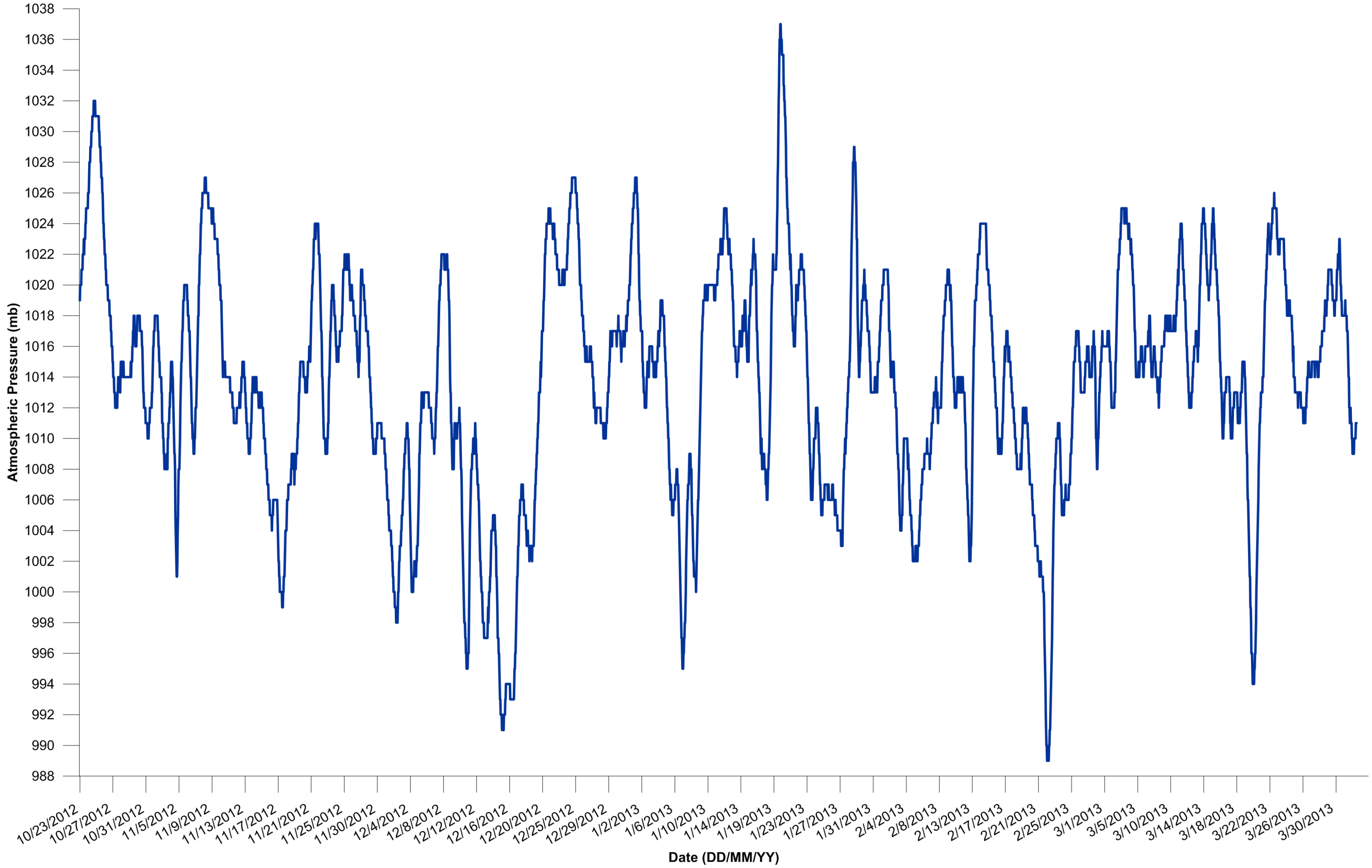


Figure 5.1-6 Hourly Atmospheric Pressure Corrected to Mean Sea Level Pressure at the Sukunka Meteorology Station for September 19, 2012 to April 2, 2013

5.2 PM CONCENTRATIONS

Concentrations of $PM_{2.5}$ are measured by the SHARP and GRIMM instruments at the District of Chetwynd site (Figure 4.2-1). The GRIMM unit also measures PM_{10} and TSP concentrations. The interval of valid SHARP readings for this analysis was from November 4, 2012 to March 26, 2013. The period of valid GRIMM readings for this analysis was from December 13, 2012 to March 26, 2013. Data were analyzed as 24-hour average concentrations.

5.2.1 SHARP PM Monitor

The maximum 24-hour average $PM_{2.5}$ concentration measured by the Thermo Scientific SHARP 5030i PM monitor during the sample period was 19.1 µg/m^3. The average $PM_{2.5}$ concentration over the sample period was 5.4 µg/m^3. Table 5.2-1 and Figure 5.2-1 provide a comparison of the $PM_{2.5}$ concentrations to the BC Ambient Air Quality Objective for $PM_{2.5}$ (25 µg/m^3) and the corresponding Canada-Wide Standard (30 µg/m^3). Table 5.2-1 indicates that during the sample period none of the $PM_{2.5}$ measurements were observed to be above the BC Objective or the Canada-Wide Standard. Concentrations greater than half of the BC Objective occurred 6.2 percent of the time and concentrations greater than half the Canada-Wide Standard occurred 2.1 percent of the time.

Table 5.2-1 Frequency of SHARP 24-hour average PM2.5 Measurements Relative to the Provincial Objectives and Canada-Wide Standards

Parameter	$PM_{2.5}$
Total number of data records	145
Count of data records > 12.5 µg/m^3 (half of BC objective)	9
Frequency > 12.5 µg/m^3	6.2%
Count of data records > 25 µg/m^3 (BC objective)	0
Frequency > 25 µg/m^3	0%
Count of data records > 15 µg/m^3 (half of Canada-Wide Standard)	3
Frequency > 15 µg/m^3	2.1%
Count of data records > 30 µg/m^3 (Canada-Wide Standard)	0
Frequency > 30 µg/m^3	0%

Figure 5.2-1 shows the variation in 24-hour average $PM_{2.5}$ concentrations from the SHARP PM monitor at the District of Chetwynd site as a box and whisker plot. The text on the figure indicates the maximum, minimum, mean, median, 95th percentile, and 98th percentile for the set of data. Box and whisker plots illustrate the monthly variation of the daily PM2.5 concentrations measured by the SHARP PM monitor. The interquartile range (25th to 75th percentile) is illustrated by the box's bottom and top. The median is represented by a line through the centre of the box. The

vertical lines (whiskers) indicate the maximum and minimum 24-hour average concentrations during that month.

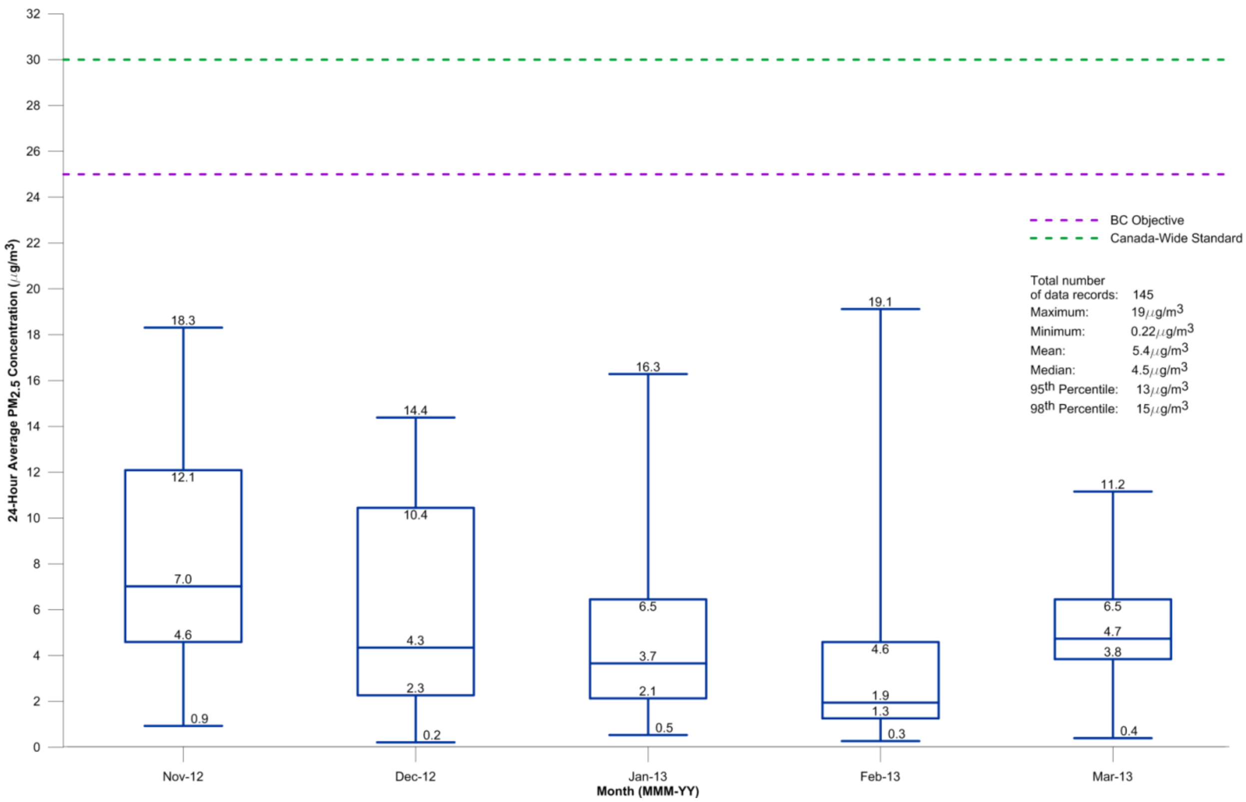


Figure 5.2-1 Variation in 24-Hour Average $PM_{2.5}$ Concentrations at the SHARP Particulate Monitor for November 2012 to March 2013 at District of Chetwynd

5.2.2 GRIMM PM Monitor

The GRIMM PM monitor simultaneously measures $PM_{2.5}$, PM_{10}, and TSP at the District of Chetwynd site. The maximum 24-hour average $PM_{2.5}$, PM_{10}, and TSP concentrations observed were 18.8, 23.7 and 45.2 µg/m^3, respectively. The daily mean $PM_{2.5}$, PM_{10}, and TSP concentrations observed were 4.4, 5.5 and 9.0 µg/m^3, respectively. Table 5.2-2 compares the GRIMM $PM_{2.5}$ measurements to the BC Ambient Air Quality Objective and the Canada-Wide Standard. Table 5.2-2 shows that during the sample period, none of the $PM_{2.5}$ measurements were observed to be above the BC Objective or the Canada-Wide Standard. Concentrations greater than half of the BC Objective and half the Canada-Wide Standard occurred 2.9 percent of the time.

There were no observed PM_{10} or TSP concentrations exceeding the relevant BC Ambient Air Quality Objectives (50 and 150 µg/m^3, respectively). All 24-hour average PM_{10} and TSP readings were less than half of the applicable objectives.

Table 5.2-2 Frequency of GRIMM $PM_{2.5}$ Measurements Relative to the Provincial Objectives and Canada-Wide Standards

Parameter	$PM_{2.5}$
Total number of data records	103
Count of data records > 12.5 µg/m^3 (half of BC objective)	3
Frequency > 12.5 µg/m^3	2.9%
Count of data records > 25 µg/m^3 (BC objective)	0
Frequency > 25 µg/m^3	0%
Count of data records > 15 µg/m^3 (half of Canada-Wide Standard)	3
Frequency > 15 µg/m^3	2.9%
Count of data records > 30 µg/m^3 (Canada-Wide Standard)	0
Frequency > 30 µg/m^3	0%

Figure 5.2-2, Figure 5.2-3, and Figure 5.2-4 show the variation in 24-hour average $PM_{2.5}$, PM_{10}, and TSP, respectively, as box and whisker plots. The text on the figures indicate the maximum, minimum, mean, median, 95th percentile, and 98th percentile for the data sets.

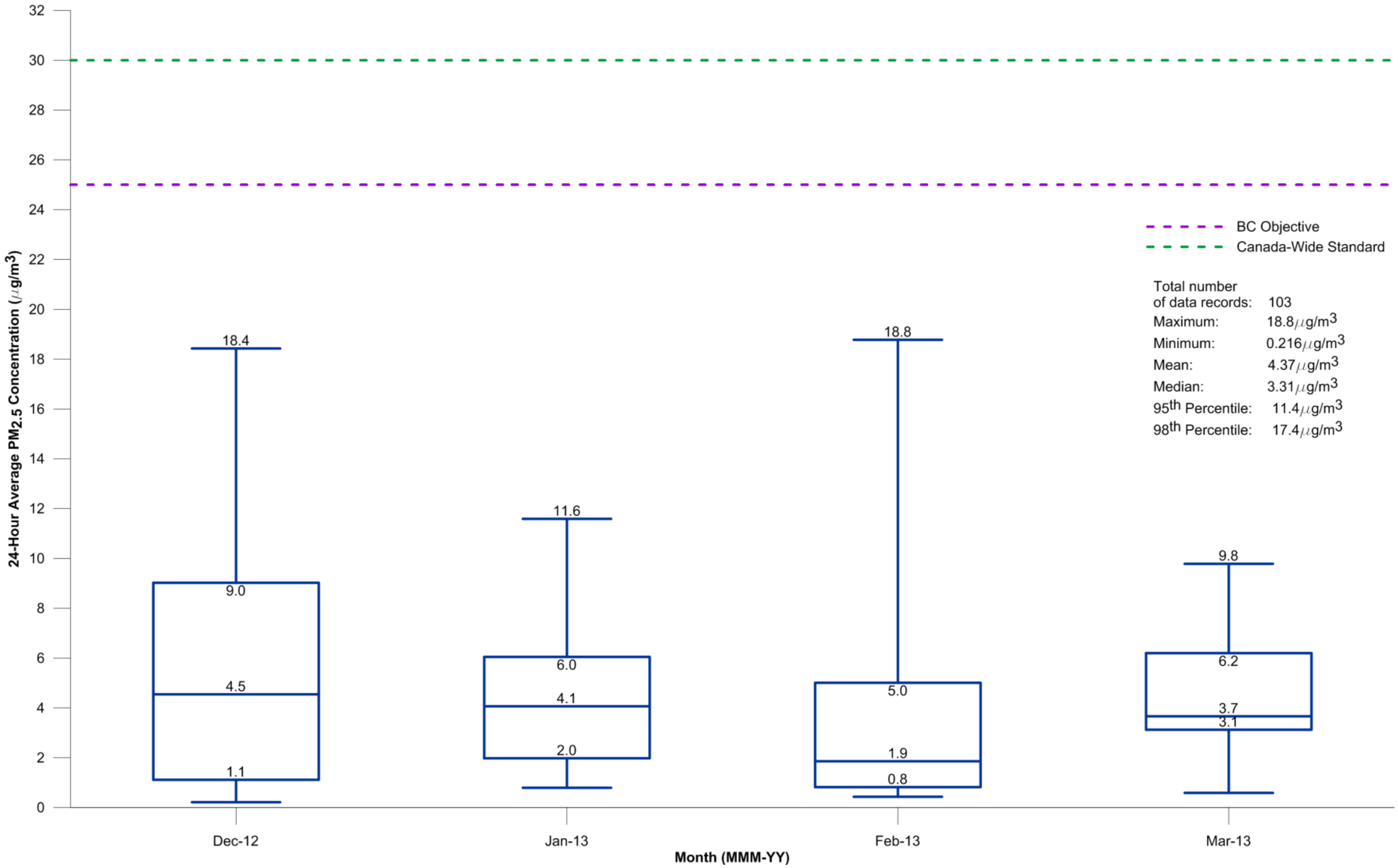


Figure 5.2-2 Variation in 24-Hour Average $PM_{2.5}$ Concentrations at the GRIMM Particulate Monitor for December 2012 to March 2013 at District of Chetwynd

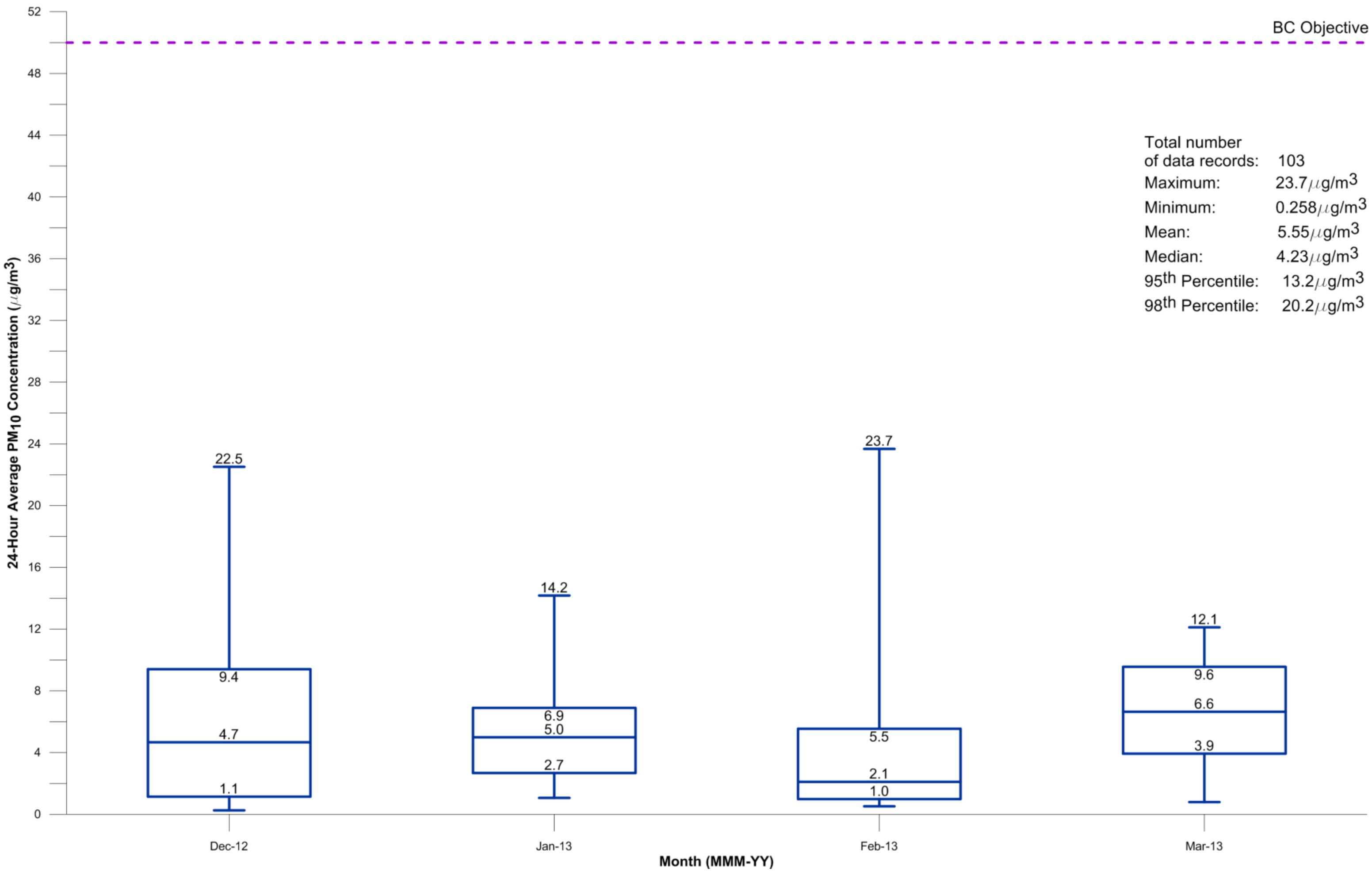


Figure 5.2-3 Variation in 24-Hour Average PM_{10} Concentrations at the GRIMM Particulate Monitor for December 2012 to March 2013 at District of Chetwynd

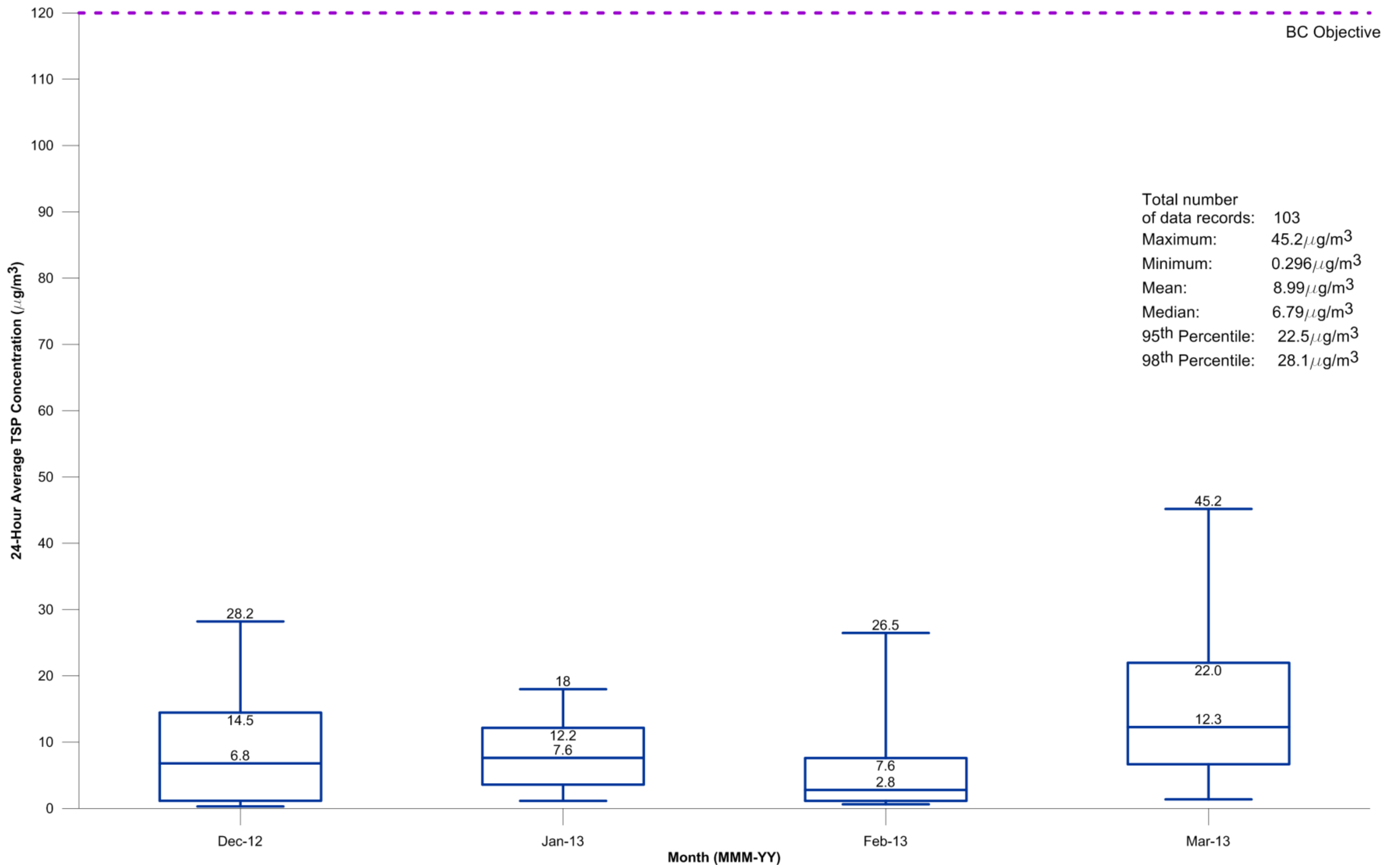


Figure 5.2-4 Variation in 24-Hour Average TSP Concentrations at the GRIMM Particulate Monitor for December 2012 to March 2013 at District of Chetwynd

5.3 DUSTFALL SAMPLES

Results from analysis of total dustfall at the six Sukunka dustfall stations are summarized in Table 5.3-1 and Figure 5.3-1. The detection limit ranged from 0.10 to 0.11 mg/dm^2/day. Values reported by the lab as less than the detection limit were taken to be at the detection limit for the purpose of calculating means. The highest observed monthly value was 1.4 mg/dm^2/day during September to October 2012 and occurred at Bullmoose Creek station, which is near the decommissioned Bullmoose mine. Figure 5.3-1 shows that none of the dustfall measurements exceeded the residential Pollution Control Objective of 1.75 mg/dm^2/day or the non-residential objective of 2.9 mg/dm^2/day (BC MOE 1979). The mean dustfall observations for each site are shown in Table 5.3-1. The mean dustfall over all stations was 0.3 mg/dm^2/day.

The total metals analysis was conducted for two of the sampling periods: September 17 to October 21, 2012 and January 3 to 29, 2013. Table 5.3-2 shows the concentrations of selected total metals observed at the six dustfall stations.

Table 5.3-1 Mean Total Dustfall at the Sukunka Dustfall Sites for August 2012 to April 2013

Station	Mean Total Dustfall (mg/dm^2/day)
09 Skeeter Creek	0.3
11 Chamberlain Creek	0.2
12 Bullmoose Creek	0.3
13 Sukunka River	0.3
14 Windfall Creek	0.2
16 District Of Chetwynd	0.4

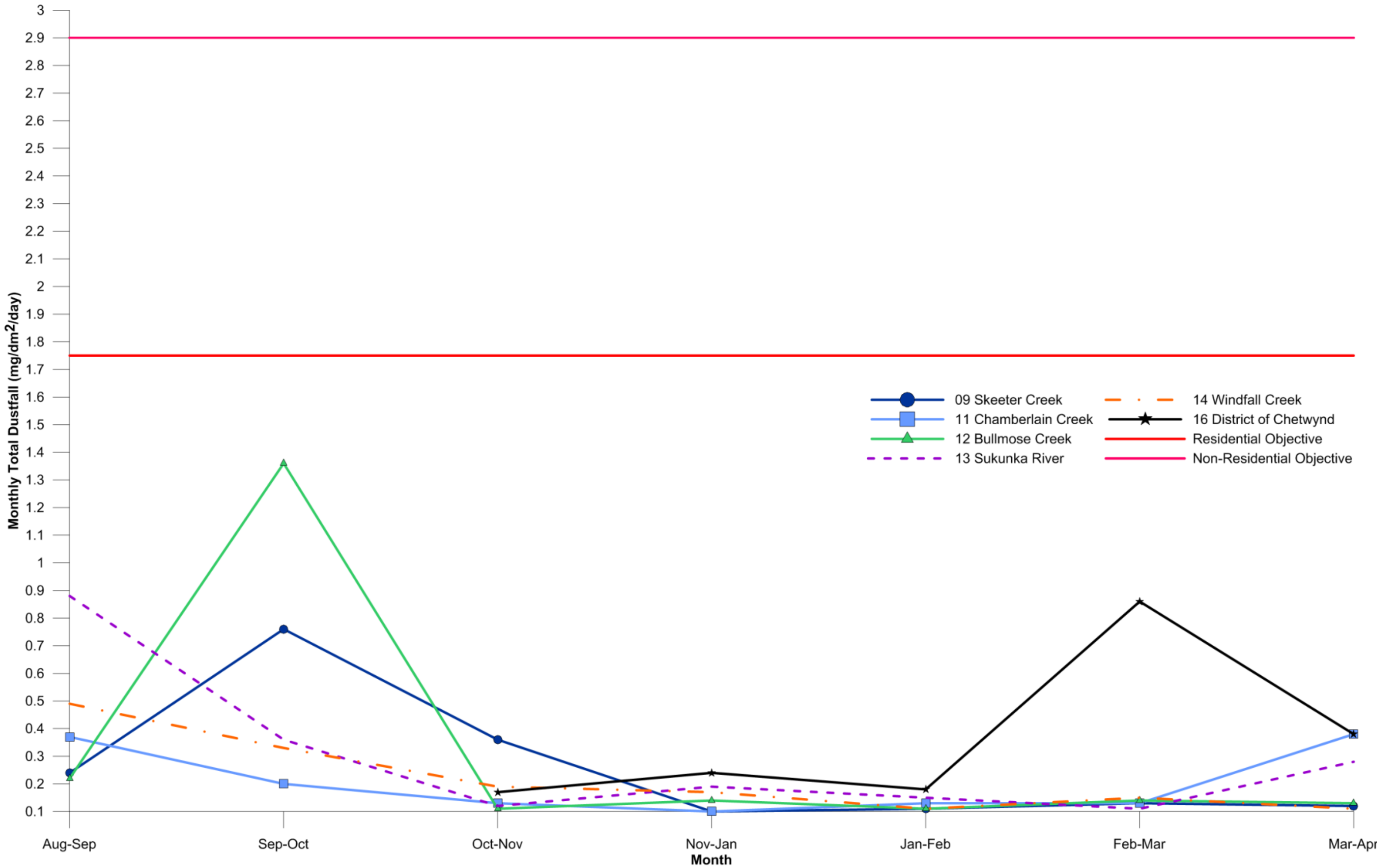


Figure 5.3-1 Total Monthly Dustfall at the Sukunka Dustfall Monitoring Stations for September 2012 to April 2013

Table 5.3-2 Total Metal Concentrations at the Sukunka Dustfall Monitoring Stations (mg/dm²/day)

Station	Month	Aluminum (Al) Total	Arsenic (As) Total	Cadmium (Cd) Total	Copper (Cu) Total	Lead (Pb) Total	Molybdenum (Mo) Total	Nickel (Ni) Total	Selenium (Se) Total	Silver (Ag) Total	Vanadium (V) Total	Zinc (Zn) Total
09 Skeeter Creek	Sep-Oct	0.000844	< 0.0000022	0.0000048	< 0.00012	0.0000034	< 0.0000011	< 0.000011	< 0.000022	< 0.00000022	< 0.000022	0.000092
	Jan-Feb	0.000467	0.0000038	< 0.00000079	0.000337	< 0.0000094	< 0.00000079	< 0.0000079	< 0.000016	< 0.00000016	< 0.000016	< 0.000047
11 Chamberlain Creek	Sep-Oct	0.00039	< 0.0000039	< 0.0000020	< 0.00043	0.0000029	< 0.0000020	< 0.000020	< 0.000039	< 0.00000039	< 0.000039	0.00019
	Jan-Mar	0.000526	< 0.0000020	< 0.0000010	0.000229	0.0000080	< 0.0000010	< 0.000010	< 0.000020	< 0.00000020	< 0.000020	< 0.000061
12 Bullmoose Creek	Sep-Oct	0.000513	< 0.0000028	< 0.0000014	< 0.00023	0.0000019	< 0.0000014	< 0.000014	< 0.000028	< 0.00000028	< 0.000028	< 0.000085
	Jan-Feb	0.000148	0.0000030	< 0.00000098	0.0000773	< 0.0000059	< 0.00000098	< 0.0000098	< 0.000020	< 0.00000020	< 0.000020	< 0.000059
13 Sukunka River	Sep-Oct	0.000876	< 0.0000019	< 0.00000097	< 0.00019	0.00000282	< 0.00000097	< 0.000029	< 0.000019	< 0.00000019	< 0.000019	0.000089
	Jan-Feb	0.00230	0.0000024	< 0.00000065	0.0000207	< 0.0000052	< 0.00000065	< 0.0000065	< 0.000013	< 0.00000013	< 0.000013	0.000040
14 Windfall Creek	Sep-Oct	0.000250	< 0.0000029	< 0.0000015	< 0.00018	0.0000020	< 0.0000015	< 0.000015	< 0.000029	< 0.00000029	< 0.000029	< 0.000088
	Jan-Feb	0.000221	0.0000017	< 0.00000064	0.0000219	< 0.0000038	< 0.00000064	< 0.0000064	< 0.000013	< 0.00000013	< 0.000013	0.000044
16 District Of Chetwynd	Oct-Nov	0.000895	0.0000052	< 0.0000014	0.000481	< 0.0000056	< 0.0000014	< 0.00026	< 0.000028	0.00000035	< 0.000028	< 0.00033
	Jan-Feb	0.00173	0.0000074	< 0.00000092	0.000341	< 0.0000073	0.00000161	< 0.0000092	< 0.000018	< 0.00000018	< 0.000018	0.000114

6.0 Discussion

6.1 METEOROLOGY

The daily temperature plot in Figure 5.1-1 reflects the highly variable conditions experienced in the Sukunka Valley, particularly during the winter months when large, rapid temperature swings occurred as different air masses affected the area. Very low temperatures were observed when Arctic air masses settle over the region and the coldest dense air drains to valley bottoms. The cold air can, however, be quickly displaced by westerly Chinook winds that descend from the Rockies, resulting in adiabatic warming and low relative humidity. In some cases, the day-to-day increase in average daily temperature exceeded 20°C. Figure 5.1-1 also illustrates that the diurnal temperature range was small during the winter months as compared to fall and spring; this is a result of the low amplitude of the daily solar radiation trend in winter.

Monthly precipitation totals shown in Figure 5.1-2 indicate that the mid-winter months of January and February were considerably drier than November, December, and March. There were several heavy snowfalls that contributed to the precipitation totals for November, December, and March; these snowfalls are evident in the snow depth trend shown in Figure 5.1-5. The snow depth plot also shows periodic losses of snow in excess of 10 cm, likely during times of Chinook wind flow.

6.1.1 Comparison to Chetwynd Airport

As an additional quality check and in order to gauge the degree of spatial variability in atmospheric conditions, data from the Sukunka meteorology station were compared to observations from the Chetwynd Airport, which are available from Environment Canada's National Climate Data and Information Archive (Environment Canada 2013). The Chetwynd Airport is the nearest weather station with both current data and 30-year normals available. Table 6.1-1 contains monthly temperature and precipitation data from the Sukunka station along with corresponding monthly data and the 1971–2000 climate normal from the Chetwynd Airport. Monthly mean air temperatures were generally colder at Sukunka during the fall, while Chetwynd was colder during the winter months. This trend is likely attributable to the slightly higher elevation of the Sukunka station. During winter, the lower Chetwynd Airport site experiences enhanced cold air pooling and strong temperature inversions.

Precipitation for the November–March period was 43 percent higher at Sukunka than Chetwynd, which is also likely due to the higher elevation of the Sukunka station and its proximity to the mountains, which cause orographic lift and enhanced precipitation. Both stations recorded precipitation above the 30-year normal for Chetwynd for the current period of record. The above-normal precipitation was mainly due to the large snowfalls that occurred early in the season and again in March. January and February had more days with Chinook winds, which led to relatively mild and drier than normal conditions.

Table 6.1-1 Sukunka Meteorology Station Data Compared to Observations and Climatological Normal from Chetwynd Airport

Parameter	Station	Month							
		Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13
Mean Air Temperature (°C)	Sukunka	12.8	–0.7	–8.7	–14.1	–6.5	–0.3	–4.1	4.7
	Chetwynd	13.2	–0.1	–9.6	–16.0	–7.6	–0.4	–3.7	–1.8
	Chetwynd–Normal	10.0	3.9	–5.9	–9.4	–10.7	–7.6	–2.4	4.7
Minimum Air Temperature (°C)	Sukunka	5.1	–4.1	–12.5	–18.4	–11.9	–4.2	–10.0	–4.6
	Chetwynd	4.5	–4.4	–13.7	–21.8	–12.4	–5.3	–9.7	–7.6
	Chetwynd–Normal	3.5	–1.3	–10.4	–14.3	–15.9	–13.5	–8.2	–2.0
Maximum Air Temperature (°C)	Sukunka	22.0	4.0	–4.0	–10.3	–1.9	3.7	2.6	18.5
	Chetwynd	21.8	4.2	–5.5	–10.1	–2.6	4.5	2.3	–4.1
	Chetwynd–Normal	16.5	9.2	–1.3	–4.4	–5.4	–1.7	3.4	11.4
Total Precipitation (mm)	Sukunka	–	19.6	54.8	36.3	10.9	16.9	45.4	–
	Chetwynd	17.2	59.0	37.0	37.7	3.6	5.8	30.8	4.9
	Chetwynd–Normal	44.4	30.7	29.6	20.5	21.6	16.0	19.5	18.7

6.2 PARTICULATE MATTER

Observations through the winter season at the District of Chetwynd site show that the Thermo Scientific SHARP Model 5030i and the GRIMM Aerosol Environ Check 365 instruments are in good agreement with their reported $PM_{2.5}$ concentrations. Table 6.2-1 summarizes the monthly mean 24-hour $PM_{2.5}$ concentrations for the two instruments. Overall the two instruments were within 1.0 µg/m^3 for the period of record for the 24-hour $PM_{2.5}$ monthly mean concentrations. Additional statistical comparisons for the $PM_{2.5}$ data were provided in Figure 5.2-1 and Figure 5.2-2.

Table 6.2-1 Comparison of SHARP and GRIMM Ambient Air Sampler Monthly Mean 24-Hour $PM_{2.5}$ Measurements (µg/m^3)

Month	SHARP 5030i	GRIMM 365
November 2012	7.0	Not available
December	4.3	4.5
January 2013	3.7	4.1
February	1.9	1.9
March	4.7	3.7
Period of Available Record	5.4	4.4

These observations also indicate that winter season fine particulate concentrations were generally low in the Chetwynd area, with monthly median $PM_{2.5}$ concentrations less than half of the BC Ambient Air Quality Objective of 25 µg/m^3. It is expected that PM concentrations are lower in the Sukunka LSA than in Chetwynd, except in the immediate areas of activities that produce fugitive dust, such as logging operations and vehicle traffic on unpaved roads.

Considerable temporal variation in the PM readings is likely due to changing weather conditions and the subsequent effect on dispersion. For example, February had the lowest median 24-hour $PM_{2.5}$ concentrations of the five months included (2.0 µg/m^3 for the SHARP and 1.9 µg/m^3 for the GRIMM), but also the highest reported daily readings of the period (19.1 µg/m^3 for the SHARP and 18.8 µg/m^3 for the GRIMM). The highest readings occurred on February 7, when the lowest temperature of the month
(-21.4°C) was observed at the Chetwynd Airport. The cold air was most likely associated with a strong surface-based temperature inversion and poor dispersion, trapping locally produced PM from vehicles, home heating, etc. near the surface. Two days later on February 9, the cold air had been flushed from the valley by westerly winds that warmed the air to a high of 8.4°C. By this time, the 24-hour average $PM_{2.5}$ concentration had dropped to below 1.0 µg/m^3 according to both instruments.

In addition to changing dispersion conditions, variable emissions within the airshed can also influence PM concentrations. As an example, during some of the baseline monitoring field trips, slash burning was observed in the active logging areas to the southwest of Chetwynd. Industrial emissions from facilities such as the CANFOR Chetwynd sawmill and the Pine River Hasler gas plant is also variable.

6.3 DUSTFALL

Monthly total dustfall values were generally low at all five Sukunka RSA stations. There was only one observation of total dustfall above 1.0 mg/dm^2/day during the period, which was 1.4 mg/dm^2/day for the September to October period at Bullmoose Creek. This station is within 100 m of an unpaved road that may have had logging truck traffic during that time. As expected, dustfall readings were generally higher in the late summer and fall than during the winter. During winter, snow cover and frozen ground limit fugitive dust production from surface disturbances. The highest average dustfall reading for the 7-month period occurred at the District of Chetwynd site (0.4 mg/dm^2/day). The Chetwynd site is closer to industrial sources of PM than any of the stations in the Sukunka LSA.

7.0 Recommended Monitoring and Data Collection

The Sukunka baseline air quality and meteorology monitoring programs that began in August 2012 are an integral part of the upcoming environmental assessment. To comply with the recommendations in the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012) the application for a mine development should contain a minimum of 12 months of quality assured environmental baseline data that adequately characterizes spatial and seasonal variability and must be suitable for use in impact prediction. An addendum to this report will be generated prior to submission of the Environmental Assessment Certificate Application. Baseline data collected up to three months prior to submission of the Application will be included. BC MOE also expects that the baseline monitoring continues throughout the application review period, and to be renegotiated, as necessary, prior to the mine construction phase and waste discharge permitting.

Monthly maintenance trips will ensure that the Sukunka meteorological station continues to collect high quality data and that PM and dustfall monitoring programs continue uninterrupted. The GRIMM PM monitor will be moved to a location within the Sukunka LSA when a suitable site with continuous 120 volt AC power becomes available. The data QA/QC program will continue on a regular basis throughout the monitoring period.

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9.0 Closing

Respectfully submitted,

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Appendix A Historical Documents

Project No. 1696

PRELIMINARY ENVIRONMENTAL STUDY OF THE SUKUNKA COAL PROJECT

Prepared For
Coalition Mining Limited

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PRELIMINARY ENVIRONMENTAL STUDY
OF THE SUKUNKA COAL PROJECT

Project No. 1696

May, 1975

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SUMMARY

The Coalition Mine lease area lies in the Rocky Mountain foothills, 37 miles south of Chetwynd. The lease area ranges from a low of 2300 ft in the Sukunka River Valley to a high of 6687 ft at the summit of Bullmoose Mountain. Skeeter and Chamberlain Creeks run east to west and drain the lease area, then join the northward flowing Sukunka River.

Climate is characterized by severe winters with moderate snowfall. Summers are mild and wet with a frost free period of between 74 to 93 days.

The lease area west of the mine development has been divided into four vegetation types: Shrub Communities, White Spruce and Cottonwood Forest, Aspen Forest and Coniferous Forest.

Shrub Communities occur extensively along the bottom of the Sukunka River Valley, White Spruce and Cottonwood Forests occur along both Chamberlain and Skeeter Creeks, and extensive stands of Aspen Forest occur on many of the well drained portions of alluvial fans. Coniferous Forest covers much of the lease area above the valley that will be affected by development.

Important big game animals within the lease area are moose, mule deer, caribou, mountain goat, black bear and grizzly bear.

Carnivorous mammals include wolves, coyote, foxes, and lynx. Species of furbearers are squirrel, beaver, muskrat, marten, fisher, short-tailed weasel, mink and otter. Beaver are abundant along the Sukunka River. Beaver and marten are the major species trapped.

The Sukunka River valley bottom is very important as winter range for moose. Moose browse activities in the valley were observed as follows: Shrub Communities most heavily browsed, Aspen Forest least browsed.

Coniferous forests above the valley bottoms provide habitat for caribou.

The alpine regions on Bullmoose Mountain are important both as winter areas for caribou and as year-round habitat for mountain goat.

The lease area offers very poor waterfowl habitat. Several species of grouse inhabit the area, including spruce grouse and ruffed grouse.

The two major drainages in the lease area are Chamberlain Creek and Skeeter Creek. Chamberlain Creek is larger and receives most of the run-off from the proposed open pit area. Both Chamberlain Creek and Skeeter Creek drain into the Sukunka River.

Surface drainages are alkaline and hard. Drainage from the proposed pit area is high in volatile particles which are presumed to be mainly fine coal particulates. Bioassay results indicated that coal leached in water releases chemicals toxic to fish, while leached bedrock material appears to be harmless.

No fish were observed in Chamberlain or Skeeter Creek, and the fish potential of the creeks in the region of proposed development appears to be low. Fish food organisms were not abundant except for a small region of Chamberlain Creek below the road crossing towards the Sukunka River.

Present land use of the lease area is extensive rather than intensive resource utilization. No logging or agricultural work is currently being carried out. Hunting and trapping occurs within the lease. Although Skeeter and Chamberlain Creeks are not fished, there is excellent fishing in the Sukunka River.

There are no known sites of historical or archaeological value in the immediate area of the proposed mine operation.

The impact of the mine development as outlined indicates that most of the effects of mining will occur outside of the most environmentally sensitive areas, alpine and valley bottom communities. However, future plans may call for development in sensitive zones.

A preliminary assessment of potential waste material using drill cores indicated no major chemical barriers to plant growth, although high pH values must be considered when choosing reclamation species. Weathering rates were adequate and should be of minor importance in waste rock placement.

Reclamation success will be influenced mainly by moisture availability and any treatment which will increase moisture will encourage plant growth.

The proposed mining development is expected to create about 300 permanent jobs and a payroll of the order of $4.5 million annually. This will add welcome diversity and stability to the area's economy.

Most of the related population increase of at least 1000 is expected to settle in Chetwynd or its immediate vicinity.

The village appears to have good expansion potential to take care of the increase, but planning and financial aspects will require careful attention.

A re-assessment of expected impacts will be required if this development and others further south and east give rise to rail extension and a new townsite.

INTRODUCTION

OBJECTIVE

To determine the major environmental sensitivities which may be affected through mine development.

BACKGROUND

Coalition Mining Limited is considering the feasibility of developing an open pit mine and associated coal washing plant near the Sukunka River. The coal lease area is situated in the Rocky Mountain foothills of northern British Columbia, 37 miles south of Chetwynd (Figure 1) and covers an area of 41 sq. mi. The summit of Bullmoose Mountain lies near the eastern edge of the lease area and the Sukunka River is near the western boundary. Access to the property is by gravel road along the Sukunka Valley from Chetwynd.

Although the company has made a positive effort to reclaim disturbances, extensive alteration of the environment has already occurred. At present, Coalition Mining Limited is operating an underground mine and extensive exploration activity has been conducted over the past few years. A relatively large corridor for coal transport was cleared from the current mine operation at 4000 ft. to the valley floor, and a large area in the valley bottom has been cleared for a wash plant installation (Figure 2). Both Skeeter and Chamberlain creeks, the two main drainages in the area, were rechannelled to contain freshet waters near the main Sukunka road. Current campsite facilities are located at the valley bottom adjacent to Skeeter Creek (Figure 2).

At present, mine plans call for development of an open pit excavation on the southern side of a plateau opposite the present underground mine site (Figure 3). Concomitant with this development will be the construction and improvement of access roads, coal washing and storage facilities, and transportation developments (road or rail) for shipping coal from the mine. The location of the proposed washing plant is not finalized, but tentatively will be located at the elevation of the underground mine near the presently cleared minesite. Locations of the roads and transport routes have not as yet been assigned.

This report is a preliminary environmental assessment only. It is based on a compilation of existing information and one short visit to the property during early May, 1975.

PERSONNEL

This study was undertaken in the Division of Applied Biology, headed by

Dr. C.C. Walden. Mr. I.V.F. Allen, Group Leader in Ecological Studies, was responsible for project supervision. Project design, data collection, processing and reporting were carried out by Mr. J.C. Errington and Mr. M. Zallen. Mr. C. Schmidt, Mr. G. Longworth, and Mr. M. Blazeka were involved in data processing and reporting.

METHODS

This report was compiled largely on the basis of existing information, although one short field survey during May 5 to May 8, 1975 was made to the property. Due to snow which remained in the upper elevations of the lease area, it was not possible to travel east of the present mine site.

The area between the open pit and the Sukunka River was surveyed. Chamberlain Creek was surveyed on foot from Tributary A to the junction with the Sukunka River, while Skeeter Creek was surveyed from one-quarter mile above the camp to its mouth.

TERRESTRIAL COMPONENTS

The vegetation was mapped using air photos in combination with field observations. During the field survey, preliminary observations of wildlife use were made within each map unit.

AQUATIC COMPONENTS

Stream Discharge

Stream velocity was measured by timing the passage of a floating object through a measured distance. The surface velocity, V_s, was converted to mean velocity, $\bar{V}$, through the approximate relation

$$\bar{V} = 0.75\ V_s$$ (Church and Kellerhals, 1970).

Discharge (Q) in cubic feet per second (f^3/s) and cubic metres per second (m^3/s) was computed by the following formula:

$$Q = \bar{V}\ (A_1 + A_2 + A_n)$$

where A_1 to n is the cross-sectional area of flow measured in subsections across the width of the stream.

Water Sampling and Analyses

Water samples from designated sites were collected in 1-litre polyethylene bottles and returned to B.C. Research laboratories for refrigeration. In the laboratory, organic and inorganic carbon was measured using a Beckman model 91S TOC analyzer. Other analyses included: turbidity, specific conductance, total dissolved and suspended solids, pH, hardness, alkalinity, sulfates, and color. All tests were performed according to methods in American Public Health Association (1971).

Invertebrate Sampling

Aquatic invertebrates were sampled using a Surber sampler with a modified fine plankton net. Collected samples preserved in 80% ethanol were returned to B.C. Research laboratories for sorting and identification.

Bioassays

Two separate bioassays were carried out on the coal and drill core samples of bedrock. Bioassay I consisted of leaching coal and core samples in water and subjecting fish to the mixture of coal and water or core and water. In Bioassay II, the leached materials were removed from the water and fish were subjected separately to both the filtrate and the leached coal and rock plus fresh water.

Drill core samples were crushed, using an Atlas crusher, until 90% of the material would pass through a 4.00 mm. Tyler standard mesh screen. A representative sample of material of less than 2.00 mm. was collected for the bioassay.

Coal samples were crushed by hand using a porcelain mortar and pestle, sieved (less than 2.00 mm.) and a representative sample was collected.

A 10% weight to volume of water ratio was used for coal, core and core mixture samples. All samples were stirred for a period of 24 h at 100 rpm using a rheostat controlled laboratory stirrer. Some samples in Bioassay I were leached in Sukunka River water obtained near the mine property.

The leachates for Bioassay II were obtained by suction filtration through Whatman filter paper and the remaining material re-suspended in water. All samples in Bioassay II were placed in laboratory dechlorinated water.

Samples were aerated at 11°C for 24 h. Initial pH was recorded after 24-h aeration. Bioassays were run in 3-litre glass jars using 10 x 0.25 g rainbow trout per sample. Fish mortality (% survival) was recorded every 24 h, for a 72-h period.

RECLAMATION FEASIBILITY

Analysis of Core Samples

Core samples obtained at various depths from drill hole 1-24 were received by B.C. Research for analysis. An Atlas crusher was used to reduce each sample to a point where 90% by weight would pass through a 13.3-mm Tyler screen. Analysis of drill core were similar to those outlined by Hodder et al 1971.

Physical analysis

Artificial weathering tests were conducted in a low temperature - high temperature humidity test chamber, model ELHH-27-MRLC-1. Temperatures were controlled using a metal cam, which varied the temperature from -12.2°C (10°F) to 15.6°C (60°F) every 3 h, giving four freeze-thaw cycles every 24 h. No humidity control was used. Crushed core samples were sieved to 4-mm to 13.5-mm size range, using Tyler standard mesh screens. Duplicate samples (approximately 100 g) were placed in plastic weighing trays and covered with distilled water. One hundred freeze-thaw cycles were run with the water level in each tray being maintained by additions of distilled water. At the end of the last freeze cycle, the samples were allowed to thaw at room temperature and evaporate to dryness at 100°C.

Particle size analysis of the dried samples, using the Wentworth-Udden scale, was determined down to the very fine sand range and results tabulated on a percent by weight basis.

Chemical analysis

Chemical analysis was carried out according to standard methods as set out in the revised edition of analytical methods by the Department of Soil Science, University of British Columbia.

Plant Growth Experiments

Tests were carried out in a plant growth chamber (Conviron model E7). Light was provided by a combination of fluorescent and incandescent sources to produce the complete spectral range required for plant growth. Light intensity produced was 12,900 lux at pot level. The day cycle (at 20°C and 75% R.H.) was set for 16 h, and night (15°C, 60% R.H.) for 8 h.

After sieving, soils were recombined comprising 80% by weight of particles less than 2.00 mm and 20% by weight of particles between 2.00 mm and 4.00 mm and placed in 3½ in. diameter plastic plant pots. Ten barley seeds were added to each pot.

Agricultural grade fertilizers used were granular urea (46 - 0 - 0), superphosphate (0 - 18 - 0) and sulfate of potash (0 - 0 - 50). Concentrations of 0, 25, 50 and 100 lb/ac were made up by dissolving appropriate weights of each fertilizer in distilled water. Fertilizer concentrations were duplicated for each core and the control. The plants were watered daily from below with distilled water. At the end of 28 days, the percentage germination and any abnormal growth symptoms were recorded. The average dry weight per plant was determined by oven drying the above ground portion of the plants at 100°C for 48 h and weighing the remaining plant material.

ENVIRONMENTAL DATA

PHYSICAL OVERVIEW

Topography

The mine area is located in the Rocky Mountain foothills and is characterized by rough, irregularly rolling upland. Elevations vary considerably from a low of 2,300 ft in the Sukunka River Valley to a high of 6,687 ft at Bullmoose Mountain (Figure 2).

The known coal deposits underlie a northwesterly trending ridge which drops sharply to a tributary of Skeeter Creek to the northeast. The area to the east of this ridge is a subalpine-alpine region extending as far as Bullmoose Mountain.

To the west, the Sukunka River flows north following a braided course through a broad U-shaped valley (Figure 1). In general, topography of the area is largely controlled by thrust faulting and the effects of Pleistocene glaciation.

Climate

Climatic data, including temperature and precipitation, have been recorded at the mine site since December, 1971 (Table 1). As these records were collected only for a short period, they have been augmented with observations from the two nearest stations: Dawson Creek (Table 2) and Fort St. John (Table 3). These data were taken from the Climate of British Columbia Extremes of Record 1941 - 1970, B.C. Department of Agriculture.

Temperature

Average mean daily temperature at Sukunka (over a 3 yr period) was -7.2°C (30.7°F) and varied from a high of 1.5°C (34.7°F) in 1973 to a low of -4.2°C (24.5°F) in 1974. Average mean daily maximums (3 yr period) were 7.4°C (45.4°F) and average mean daily minimums were -5.0°C (23.0°F). Both maximum and minimum were less variable between years.

The frost free period at Sukunka (3 yr period) has varied from 74 to 93 days and occurs between early June and early September.

Data from the two other stations indicated that the extreme maximum and minimum temperatures which could be expected at Sukunka would be 33°C (92°F) and -48°C (-55°F), respectively. The warmest months of the year are July and August, with average mean daily temperatures of 13.3°C (56°F) and 13.7°C (56°F), respectively.

Precipitation

Total annual precipitation at Sukunka is 27.13 in. with 48% occurring as rain. Precipitation during the growing season (May to August) averaged 7.0 in. and is spread evenly over these months.

Wind

Personnel at the mine site report that winds are generally from the southwest down the Sukunka River Valley.

Geology

Coal measures in the Sukunka-Bullmoose Mountain Region are found in lower Cretaceous strata, underlain by rocks of early Cretaceous to Triassic age. Coal seams of commercial importance are found within the Gething and Commotion formations; the main seam (Chamberlain) averaging 9 ft in thickness. Gething and Commotion strata are essentially flat lying to gently warped in the mine area, but become involved in complex northwesterly trending folds to the north and south of Bullmoose Mountain. Southwest sloping thrust faults tend to control the generally northwesterly trending topography.

Overburden samples received from DDH P1-24, located in the southeast area of the proposed pit, indicate a depth to coal of between 140 - 172 ft below the top of the formation. Depth of overburden will vary from natural coal outcrop to increased depth in a northeasterly direction. Overburden in this area is comprised of sandstone, interbedded sandstone and mudstone, carbonaceous sandstone, siltstone and mudstone.

TERRESTRIAL COMPONENTS

Vegetation

The lease area has a range in elevation from the Sukunka River at 2,300 ft to the summit of Bullmoose Mountain (6,687 ft) and covers three biogeoclimatic zones (Krajina, 1969). The Boreal White and Black Spruce Zone occupies the lower elevations below 2,800 ft. At higher elevations, the Englelmann Spruce Subalpine Fir Zone is present, to about 5,500 ft, above which the Alpine Tundra Zone occurs.

A preliminary map of the vegetation has been prepared, covering the immediate area of development (Figure 3). The following vegetation map units have been named according to their dominant overstory component: Shrub Communities, White Spruce and Cottonwood Forest, Aspen Forest and Coniferous Forest. The map unit descriptions are preliminary and were checked with a limited field reconnaissance. They will serve as a general framework for discussion of relative environmental sensitivity.

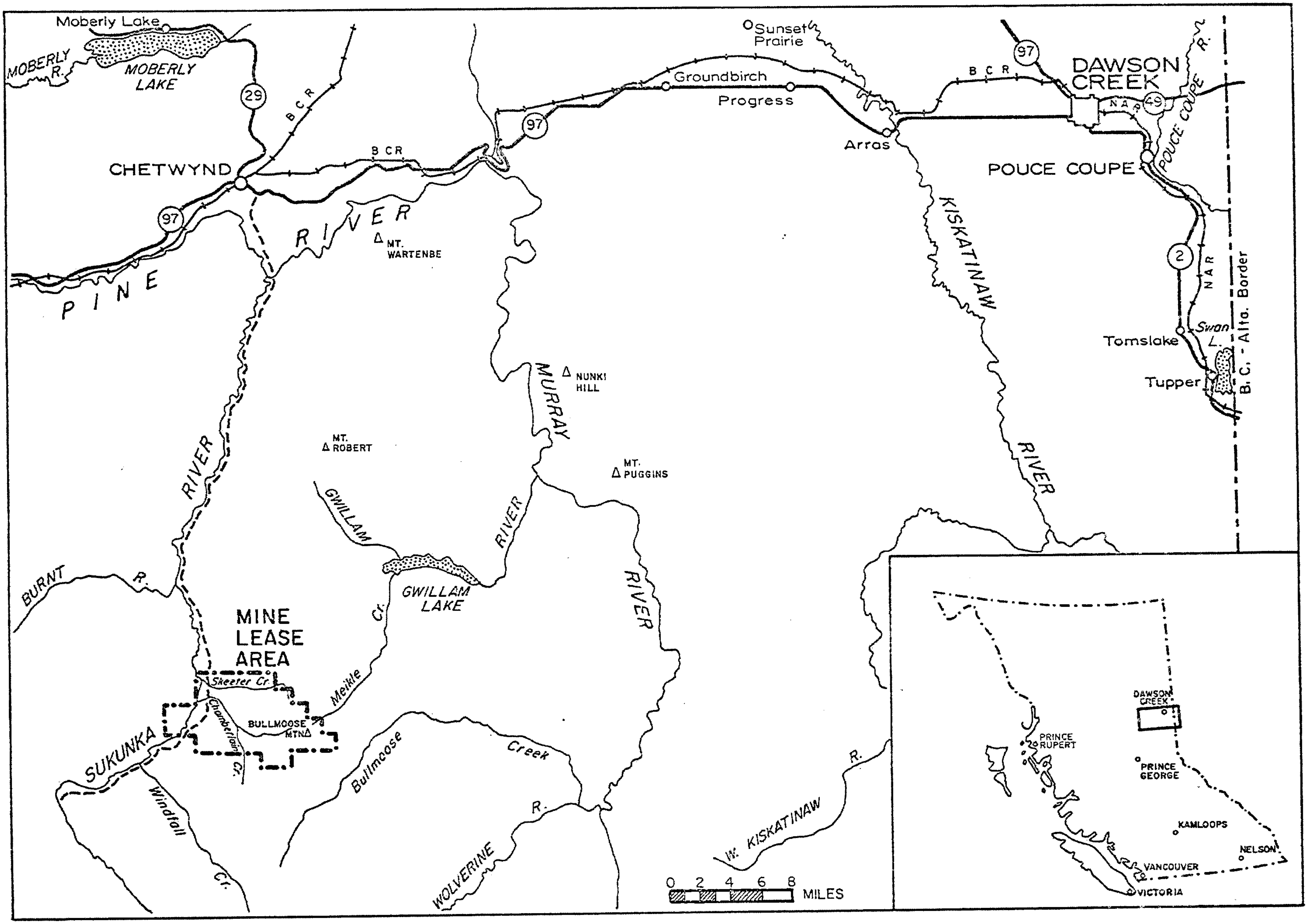


Figure 1
LOCATION OF COALITION COAL LEASE AREA

TABLE 1

RELEVANT CLIMATIC DATA FROM STATION: CHETWYND, SUKUNKA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	
Temperature (°F)														
Mean Daily														
1971												11.6		
1972	3.5	5.7	24.8	35.1	48.2	55.2	57.3	56.8	41.2	37.4	26.2	4.0	33.0	
1973	13.4	16.4	28.0	39.0	46.7	52.9	57.0	53.3	48.5	36.0	6.4	18.4	34.7	
1974	3.5	18.5	14.1	35.8	41.6	52.4	53.7	57.0	41.8	38.4	29.6	24.6	24.5	
1975	14.2	7.0	19.2											
													30.7	Avg
Mean Daily Maximums														
1971												15.1		
1972	13.0	15.4	36.1	48.4	64.7	72.5	70.9	69.6	49.7	48.0	33.3	15.0	44.7	
1973	26.5	25.6	37.7	50.9	60.8	65.3	71.5	67.7	58.5	43.0	11.9	27.1	45.5	
1974	16.9	29.6	24.6	47.0	51.0	66.3	66.2	69.0	59.3	52.2	37.5	33.1	46.1	
1975	21.7	16.8	31.5											
													45.4	Avg
Mean Daily Minimums														
1971												-3.5		
1972	-6.0	-3.9	13.5	21.7	31.6	38.0	43.7	44.0	32.7	26.8	19.1	-7.0	21.2	
1973	0.3	7.3	18.3	27.2	32.5	40.6	42.4	39.0	38.4	29.1	0.9	9.7	23.8	
1974	-9.8	7.4	3.7	24.6	32.1	38.6	41.2	45.0	34.4	34.5	21.8	16.0	24.1	
1975	6.6	-2.8	7.0											
													23.0	Avg
Precipitation (in)														
Rain														
1971												1.53	-	
1972	0.0		0.52	0.09	0.60	4.50	2.49	1.27	1.59	3.54	0.36	0.0	14.96	
1973	0.27	0.16	0.0	0.75	0.77	2.57	0.75	2.20	3.75	1.79	0.0	0.0	13.01	
1974	0.0	0.01	0.0	0.26	1.93	0.48	1.89	1.34	1.77	1.64	0.52	1.08	10.92	
1975	0.0	0.4	0.0											
													12.96	Avg
Snow														
1971												14.9	-	
1972	11.5	46.3	16.6	15.8	0.0	0.0	0.0	0.0	23.9	20.0	16.7	41.0	191.8	
1973	31.3	12.4	1.9	4.2	0.0	0.0	0.0	2.1	0.0	7.4	20.4	10.9	90.6	
1974	52.9	18.0	35.6	4.3	0.0	0.0	0.0	0.0	4.9	2.0	15.3	9.7	142.7	
1975	12.7	6.3	15.8											
													141.7	Avg
Total														
1971												3.02	-	
1972	1.15	4.63	2.18	1.67	0.60	4.50	2.49	1.27	3.98	5.54	2.03	4.10	34.14	
1973	3.40	1.40	0.19	1.17	0.77	2.57	0.75	2.41	3.75	2.53	2.04	1.09	22.07	
1974	5.29	1.81	3.56	0.69	1.93	0.48	1.89	1.34	2.26	1.84	2.05	2.05	25.19	
1975	1.27	1.03	1.58											
													27.13	Avg

Frost-free period: 1974 June 13 to September 1 (80 days)
1973 June 3 to August 16 (74 days)
1972 June 5 to September 6 (93 days)

TABLE 2

CLIMATIC DATA FROM DAWSON CREEK
(1941-1970)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (°F)													
Mean Daily	2.0	10.3	20.1	36.6	48.5	55.5	59.5	57.6	49.4	39.9	20.9	8.6	34.1
Mean Daily Maximum	13.2	22.5	32.1	47.3	61.2	67.9	72.5	70.7	61.7	50.8	30.8	19.2	45.8
Mean Daily Minimum	-9.2	-2.0	8.0	25.9	35.8	43.1	46.5	44.4	37.0	28.9	11.0	-2.0	22.3
Extreme Maximum	52	60	57	71	86	89	90	90	83	80	64	52	90
Extreme Minimum	-55	-53	-45	-37	11	28	30	29	14	-13	-43	-48	-55
Precipitation (in.)													
Rain	T	0.05	0.02	0.20	1.46	2.25	1.89	1.47	1.54	0.78	0.28	0.02	9.96
Snow	11.7	11.9	9.6	3.6	2.1	T	0.0	T	0.5	6.0	9.8	10.6	65.8
Total	1.25	1.24	1.08	0.56	1.67	2.25	1.89	1.47	1.59	1.38	1.26	1.08	16.72

TABLE 3

CLIMATIC DATA FROM FORT ST. JOHN
(1941-1970)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (°F)													
Mean Daily	1.0	10.5	20.4	36.5	49.7	56.5	60.6	58.4	49.9	39.5	20.3	8.1	34.3
Mean Daily Maximum	8.7	18.8	29.2	45.9	60.6	67.0	71.2	69.0	59.7	47.5	27.0	15.4	43.3
Mean Daily Minimum	-6.8	2.2	11.6	27.0	38.8	46.0	50.0	47.8	40.0	31.4	13.6	0.8	25.2
Extreme Maximum	51	55	57	71	86	89	92	92	86	78	65	48	92
Extreme Minimum	-53	-44	-34	-20	13	31	37	30	14	-5	-33	-41	-53
Precipitation (in.)													
Rain	0.02	0.01	0.03	0.25	0.99	2.41	2.47	2.05	1.15	0.47	0.11	0.01	9.97
Snow	13.8	11.4	11.1	6.9	3.1	0.2	0.0	0.6	1.3	7.1	12.0	13.7	81.2
Total	1.31	1.10	1.07	0.92	1.30	2.43	2.47	2.11	1.28	1.17	1.26	1.29	17.71

TABLE 5.2.1-1

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY[1]
STATION - BULLMOOSE

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^oF)													
Mean Daily	1976						42.4[1]	46.2	47.2	44.9	32.6	28.3	16.3
	1977	14.8	25.2	17.9	32.3								
Daily Max	1976						48.0[1]	53.6	52.4	51.5	37.5	33.3	22.2
	1977	19.3	29.6	23.6	39.1								
Daily Min	1976						36.7[1]	38.7	42.0	38.2	27.9	23.4	10.4
	1977	10.3	20.9	12.2	25.5								
Precipitation (in.)													
Total Rain & Snow (Recording Rain Gauge)	1976						2.95	4.13	11.32	1.70	2.31	1.20	M
	1977	4.17	0.74	2.91	0.66								
Predominant Wind Direction	1976						S[1]	S	S	S	S	S	S
	1977	S	S	S	S								
Mean Wind Speed (mph)	1976						8.9[1]	11.3	9.2	11.5	13.0	13.0	11.0
	1977	10.4	15.1	11.4	12.7								

M - data missing

[1] Data courtesy of Climatology Section, Resource Analysis Branch, Victoria, B.C.

[2] station operative 23 June, 1976.

TABLE 5.2.1-2

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY[1]
STATION - LOWER MOOSE

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^{o}F)													
Mean Daily	1976					43.9	47.2	51.1	52.2	48.1	37.8	28.3	19.2
	1977	17.9	31.7	24.3									
Daily Max	1976					57.7	58.9	63.8	61.4	62.1	48.0	40.3	27.5
	1977	29.6	42.2	34.7									
Daily Min	1976					30.1	35.5	38.3	43.0	34.0	27.7	16.2	11.1
	1977	6.2	21.3	14.0									
Precipitation (in.)													
Total Rain & Snow (Recording Rain Gauge)	1976					M	4.07[1]	3.36[1]	3.60	1.06	0.68	1.37[1]	0.86[1]
	1977	0.53	0.39	1.60[1]	0.35[1]								
Predominant Wind Direction	1976						W	W	W	W	W	W	W
	1977	W	W	W	W								
Mean Wind Speed (mph)	1976						5.8	5.8	4.7	5.3	4.7	5.2	5.2
	1977	5.2	6.2	5.8	6.9								

M - data missing

[1] Data courtesy of Climatology Section, Resource Analysis Branch, Victoria

[2] at least one day's data missing

TABLE 5.2.1-3

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY[1]
STATION - COALITION UPPER

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^{o}F)													
Mean Daily	1976								49.5	48.2	35.7	27.8	10.8
	1977	14.2	29.5	23.0	38.2								
Daily Max	1976								56.0	56.9	40.8	33.1	17.3
	1977	20.1	34.7	29.6	46.9								
Daily Min	1976								43.1	39.4	30.5	22.6	3.7
	1977	8.4	24.3	16.4	29.5								
Precipitation (in.)													
Total Rain & Snow	1976								6.00	0.70	1.40	M	1.15
(Storage Gauge)	1977	2.40	2.10	2.98	2.08								

M - data missing

[1] Data courtesy of Climatology Section, Resource Analysis Branch, Victoria, B.C.

TABLE 5.2.1-4

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY [1]
STATION - CANFOR

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^{o}F)													
Mean Daily	1976			30.3[1]	38.2	46.1	49.2	53.5	55.9	M	M	27.2	18.8
	1977	17.3	32.2	26.6	40.7								
Daily Max	1976			38.5[1]	51.2	57.7	60.3	65.4	64.1	M	M	37.1	26.9
	1977	26.4	40.9	35.2	53.1								
Daily Min	1976			22.5[1]	25.4	34.4	38.0	41.5	47.5	M	M	17.5	10.7
	1977	8.2	23.6	18.1	28.4								
Precipitation (in.)													
Total Rain & Snow (Storage Gauge)	1976			M		0.0	3.74	3.24	4.75	1.27	1.56	M	0.77
	1977	1.97	1.00	0.98	1.33								
Predominant Wind Direction	1976				SE	SE	SE	SE	SE	SE	SE	SE	SE
	1977	SE	SE	SE	SE								
Mean Wind Speed (mph)	1976				5.5	6.7	5.3	5.7	4.7	5.4	6.7	6.3	6.3
	1977	5.9	6.4	6.5	6.6								

M - data missing

[1] Data courtesy of Climatology Section, Resource Analysis Branch, Victoria, B.C.

[2] station operative 23 March, 1976

TABLE 5.2.1-5

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY [1]
STATION - COALITION MID

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^oF)													
Mean Daily	1976								51.4	53.0	38.9	34.1	18.8
	1977	19.0	31.5	25.1	44.1								
Daily Max	1976								57.4	61.2	44.4	39.2	24.8
	1977	24.1	36.3	31.0	54.6								
Daily Min	1976								44.8	44.4	33.4	29.1	12.9
	1977	14.0	26.6	19.3	33.4								
Precipitation (in.)													
Total Rain & Snow (Storage Gauge)	1976								5.80	0.63	1.36	0.0	0.91
	1977	1.98	1.70	2.11	0.60								

[1] Data courtesy of Climatology Section, Resource Analysis Branch, Victoria, B.C.

TABLE 5.2.1-6

RELEVANT CLIMATIC DATA FROM SUKUNKA - BULLMOOSE AREA OF THE NORTHEAST COAL STUDY[1]
STATION - COALITION LOW

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (^{o}F)													
Mean Daily	1976								57.1	53.9	42.0	32.6	18.4
	1977	21.0	34.9	29.0	45.4								
Daily Max	1976								65.4	66.1	49.5	40.2	24.9
	1977	28.2	41.8	36.0	57.2								
Daily Min	1976								48.8	41.5	34.5	25.1	12.1
	1977	14.0	28.1	22.0	33.6								
Precipitation (in.)													
Total Rain & Snow	1976								5.59	0.54	M	0.0	0.87
(Storage Gauge)	1977	1.38	0.80	0.70	0.0								

M - data missing

[1]Data courtesy of Climatology Section, Resource Analysis Branch, Victoria, B.C.

TABLE 5.2.1-7

RELEVANT CLIMATIC DATA FROM STATIONS AT CHETWYND-SUKUNKA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (^{o}F)													
Mean Daily													
1972	3.5	5.7	24.8	35.1	48.2	55.2	57.3	56.8	41.2	37.4	26.2	4.0	33.0
1973	13.4	16.4	28.0	39.0	46.7	52.9	57.0	53.3	48.5	36.0	6.4	18.4	34.7
1974	3.5	18.5	14.1	35.8	41.6	52.4	53.7	57.0	41.8	38.4	29.6	24.6	24.5
Average 30.7													
Mean Daily Maximums													
1972	13.0	15.4	36.1	48.4	64.7	72.5	70.9	69.6	49.7	48.0	33.3	15.0	44.7
1973	26.5	25.6	37.7	50.9	60.8	65.3	71.5	67.7	58.5	43.0	11.9	27.1	45.5
1974	16.9	29.6	24.6	47.0	51.0	66.3	66.2	69.0	59.3	52.2	37.5	33.1	46.1
Average 45.4													
Main Daily Minimums													
1972	-6.0	-3.9	13.5	21.7	31.6	38.0	43.7	44.0	32.7	26.8	19.1	-7.0	21.2
1973	0.3	7.3	18.3	27.2	32.5	40.6	42.4	39.0	38.4	29.1	0.9	9.7	23.8
1974	-9.8	7.4	3.7	24.6	32.1	38.6	41.2	45.0	34.3	34.5	21.8	16.0	
Average 23.0													
Precipitation (in.)													
Rain: 1972	0.0		0.52	0.09	0.60	4.50	2.49	1.27	1.59	3.54	0.36	0.0	14.96
1973	0.27	0.16	0.0	0.75	0.77	2.57	0.75	2.20	3.75	1.79	0.0	0.0	13.01
1974	0.0	0.01	0.0	0.26	1.93	0.48	1.89	1.34	1.77	1.64	0.52	1.08	10.92
Average 12.96													
Snow: 1972	11.5	46.3	16.6	15.8	0.0	0.0	0.0	0.0	23.9	20.0	16.7	41.0	191.8
1973	31.3	12.4	1.9	4.2	0.0	0.0	0.0	2.1	0.0	7.4	20.4	10.9	90.6
1974	52.9	18.0	35.6	4.3	0.0	0.0	0.0	0.0	4.9	2.0	15.3	9.7	142.7
Average 141.7													
Total: 1972	1.15	4.63	2.18	1.67	0.60	4.50	2.49	1.27	3.98	5.54	2.03	4.10	34.14
1973	3.40	1.40	0.19	1.17	0.77	2.57	0.75	2.41	3.75	2.53	2.04	1.09	22.07
1974	5.29	1.81	3.56	0.69	1.93	0.48	1.89	1.34	2.26	1.84	2.05	2.05	25.19
Average 27.13													

Source: Atmospheric Environment Service

TABLE 5.2.1-8

CLIMATIC DATA FROM DAWSON CREEK (Extremes of Record 1941 - 1970)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (°F)													
Mean Daily	2.0	10.3	20.1	36.6	48.5	55.5	59.5	57.6	49.4	39.9	20.9	8.6	34.1
Mean Daily Maximum	13.2	22.5	32.1	47.3	61.2	67.9	72.5	70.7	61.7	50.8	30.8	19.2	45.8
Mean Daily Minimum	-9.2	-2.0	8.0	25.9	35.8	43.1	46.5	44.4	37.0	28.9	11.0	-2.0	22.3
Extreme Maximum	52	60	57	71	86	89	90	90	83	80	64	52	90
Extreme Minimum	-55	-53	-45	-37	11	28	30	29	14	-13	-43	-48	-55
Precipitation (in.)													
Rain	T	0.05	0.02	0.20	1.46	2.25	1.89	1.47	1.54	0.78	0.28	0.02	9.96
Snow	11.7	11.9	9.6	3.6	2.1	T	0.0	T	0.5	6.0	9.8	10.6	65.8
TOTAL	1.25	1.24	1.08	0.56	1.67	2.25	1.89	1.47	1.59	1.38	1.26	1.08	16.72

Source: Atmospheric Environment Service

TABLE 5.2.1-9

CLIMATIC DATA FROM FORT ST. JOHN (Extremes of Record 1941 - 1970)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature (^{o}F)													
Mean Daily	1.0	10.5	20.4	36.5	49.7	56.5	60.6	58.4	49.9	39.5	20.3	8.1	34.3
Mean Daily Maximum	8.7	18.8	29.2	45.9	60.6	67.0	71.2	69.0	59.7	47.5	27.0	15.4	43.3
Mean Daily Minimum	-6.8	2.2	11.6	27.0	38.8	46.0	50.0	47.8	40.0	31.4	13.6	0.8	25.2
Extreme Maximum	51	55	57	71	86	89	92	92	86	78	65	48	92
Extreme Minimum	-53	-44	-34	-20	13	31	37	30	14	-5	-33	-41	-53
Precipitation (in.)													
Rain	0.02	0.01	0.03	0.25	0.99	2.41	2.47	2.05	1.15	0.47	0.11	0.01	9.97
Snow	13.8	11.4	11.1	6.9	3.1	0.2	0.0	0.6	1.3	7.1	12.0	13.7	81.2
TOTAL	1.31	1.10	1.07	0.92	1.30	2.43	2.47	2.11	1.28	1.17	1.26	1.29	17.71

Source: Atmospheric Environment Service

	J	F	M	A	M	J	J	A	S	O	N	D
N	9.6	10.1	10.1	10.4	10.5	9.6	9.6	9.8	9.7	12.1	8.8	10.2
NE	5.2	6.0	6.6	8.6	9.2	8.5	7.7	7.9	7.3	9.0	5.3	5.6
E	8.4	9.1	9.9	11.0	10.8	10.3	8.9	8.9	9.3	10.1	8.3	8.5
SE	7.7	8.3	8.0	9.2	9.1	8.6	7.9	8.1	8.3	9.4	8.7	8.7
S	8.6	10.5	10.7	11.2	10.0	9.9	8.8	9.4	9.9	11.8	11.1	10.6
SW	15.2	16.6	15.2	16.0	14.7	13.6	12.3	13.0	14.0	17.2	16.9	16.2
W	9.0	10.2	10.4	11.0	11.9	10.8	9.7	9.5	10.9	10.5	8.8	9.3
NW	9.8	9.6	10.0	9.7	10.6	10.6	9.5	9.6	9.3	11.0	10.1	10.1

FIGURE 5.2.1.1-1

FORT ST. JOHN, B.C. - MEAN WIND SPEED (MPH) BY DIRECTION AND MONTH

	J	F	M	A	M	J	J	A	S	O	N	D
N	24	26	25	17	15	12	11	10	13	9	19	20
NE	3	3	5	5	5	5	3	3	3	3	2	2
E	9	11	18	15	11	10	7	6	8	9	9	10
SE	12	10	9	11	9	8	9	9	10	13	11	13
S	7	8	7	8	9	12	12	12	14	13	11	10
SW	24	24	18	26	29	35	38	41	34	40	31	28
W	8	6	5	8	11	9	10	10	9	6	5	5
NW	10	9	10	8	9	7	8	7	8	5	10	9
CALM	3	3	3	2	2	2	2	2	1	2	2	3

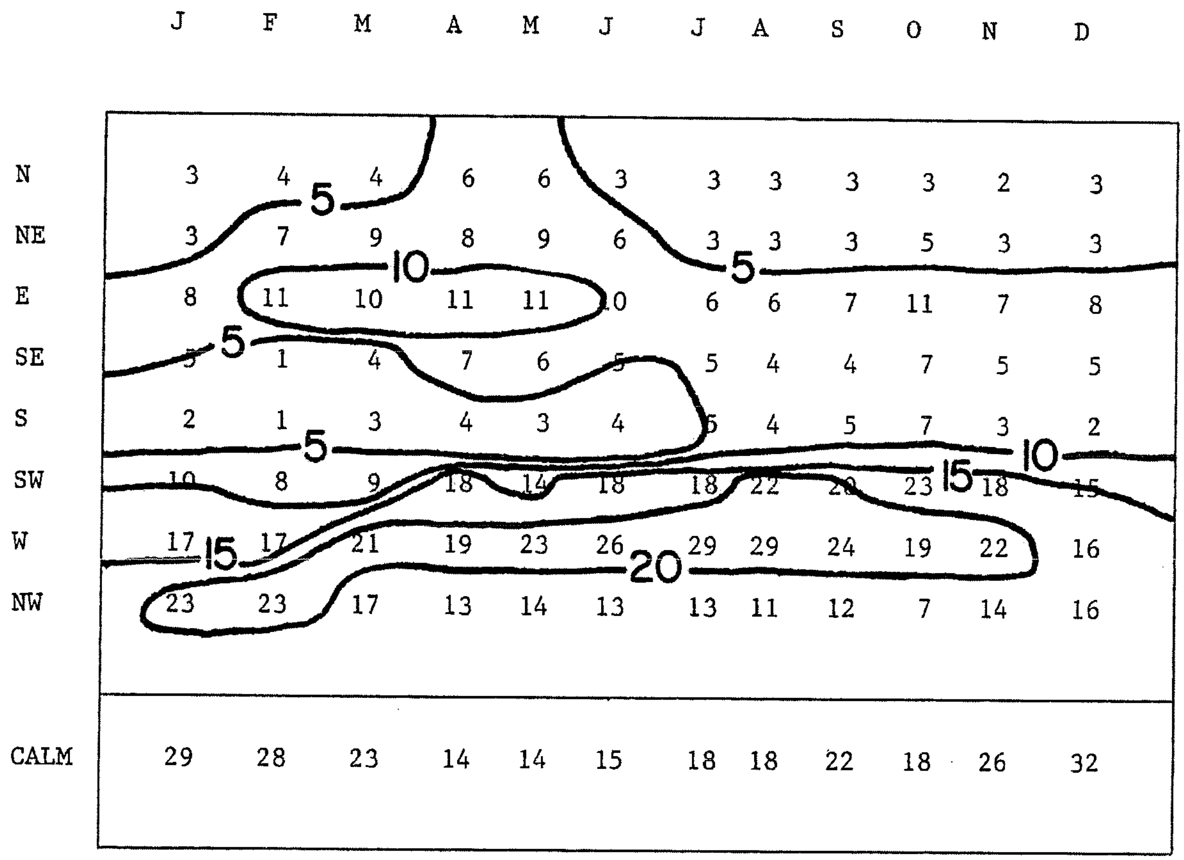
FIGURE 5.2.1.1-2

FORT ST. JOHN, B.C. - PERCENTAGE FREQUENCY WIND DIRECTION (AND CALMS) BY MONTHS

	J	F	M	A	M	J	J	A	S	O	N	D
N	6.8	6.2	6.5	8.3	8.1	8.3	8.0	8.1	7.4	8.0	6.0	5.8
NE	5.9	6.4	7.6	7.8	7.9	8.1	6.6	7.6	7.0	8.8	3.2	4.7
E	5.6	5.5	5.9	7.4	7.9	7.0	5.9	5.8	6.0	6.2	5.5	5.6
SE	5.7	6.4	5.9	8.6	7.3	6.2	6.9	5.5	6.8	7.2	6.6	5.8
S	5.4	5.5	6.6	8.2	8.0	7.8	7.2	8.2	7.85	9.5	7.6	8.4
SW	18.34	15.9	13.1	13.1	13.0	12.6	11.7	12.2	13.3	15.2	15.3	15.4
W	9.8	9.5	10.3	11.3	11.7	11.0	10.5	11.0	10.9	12.9	11.1	10.3
NW	8.0	7.1	7.1	7.5	7.9	7.7	7.2	7.4	7.7	7.5	7.4	6.9

FIGURE 5.2.1.1-3

DAWSON CREEK, B.C. - MEAN WIND SPEED (MPH) BY DIRECTION AND MONTH



	J	F	M	A	M	J	J	A	S	O	N	D
N	3	4	4	6	6	3	3	3	3	3	2	3
NE	3	7	9	8	9	6	3	3	3	5	3	3
E	8	11	10	11	11	10	6	6	7	11	7	8
SE	5	1	4	7	6	5	5	4	4	7	5	5
S	2	1	3	4	3	4	5	4	5	7	3	2
SW	10	8	9	18	14	18	18	22	20	23	18	15
W	17	17	21	19	23	26	29	29	24	19	22	16
NW	23	23	17	13	14	13	13	11	12	7	14	16
CALM	29	28	23	14	14	15	18	18	22	18	26	32

FIGURE 5.2.1.1-4

DAWSON CREEK, B.C. - PERCENTAGE FREQUENCY WIND DIRECTION

(AND CALMS) BY MONTHS

	J	F	M	A	M	J	J	A	S	O	N	D
N	7.5	7.7	9.0	9.3	8.7	7.8	7.1	6.4	7.5	7.5	7.1	7.7
NE	3.0	3.7	5.6	8.1	8.3	6.0	5.6	4.8	4.9	5.5	3.2	3.1
E	2.4	2.3	4.2	5.1	5.4	4.4	3.8	3.6	3.2	3.1	2.8	3.1
SE	5.8	6.4	7.3	7.1	6.4	5.9	5.2	5.4	5.6	8.0	7.1	5.7
S	11.4	10.8	9.8	9.2	7.1	7.1	6.6	6.9	8.1	11.3	11.4	11.1
SW	6.5	7.7	7.8	8.6	7.9	7.4	6.8	6.4	6.1	7.4	7.6	6.2
W	6.5	8.7	9.1	9.3	8.9	8.5	8.2	7.6	7.6	8.6	7.3	6.5
NW	8.0	8.7	8.2	8.0	7.9	7.5	7.0	6.7	6.6	6.4	7.2	7.2

FIGURE 5.2.1.1-5

PRINCE GEORGE, B.C. - MEAN WIND SPEED (MPH) BY DIRECTION AND MONTH

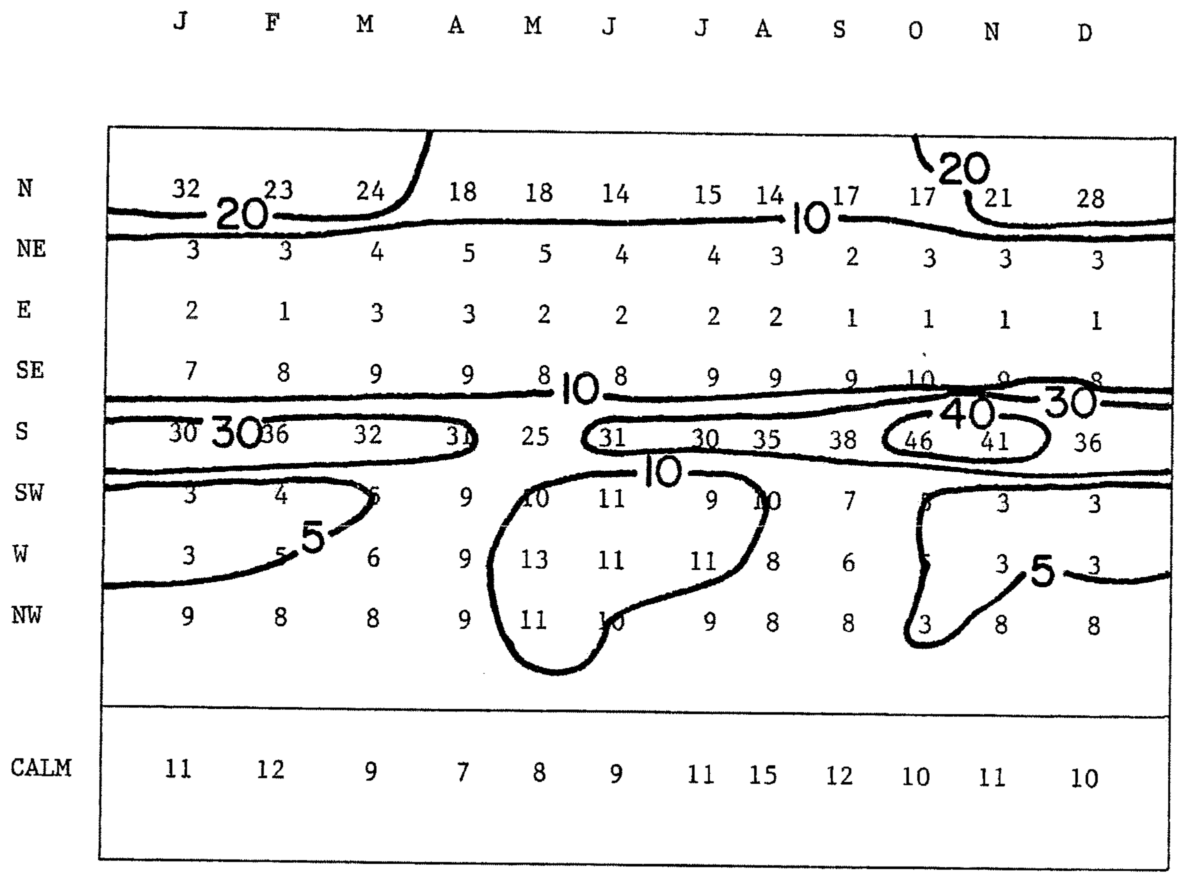
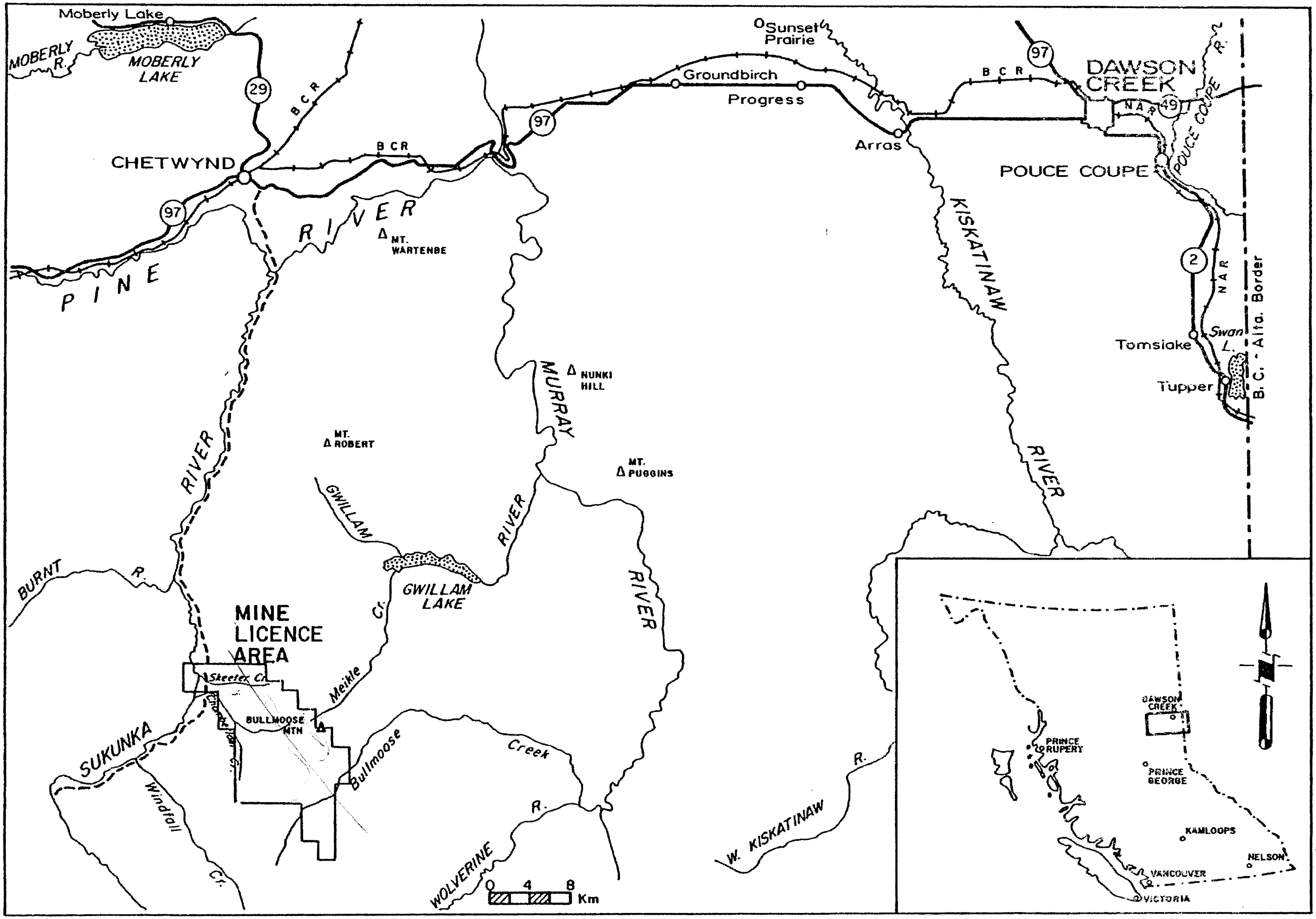
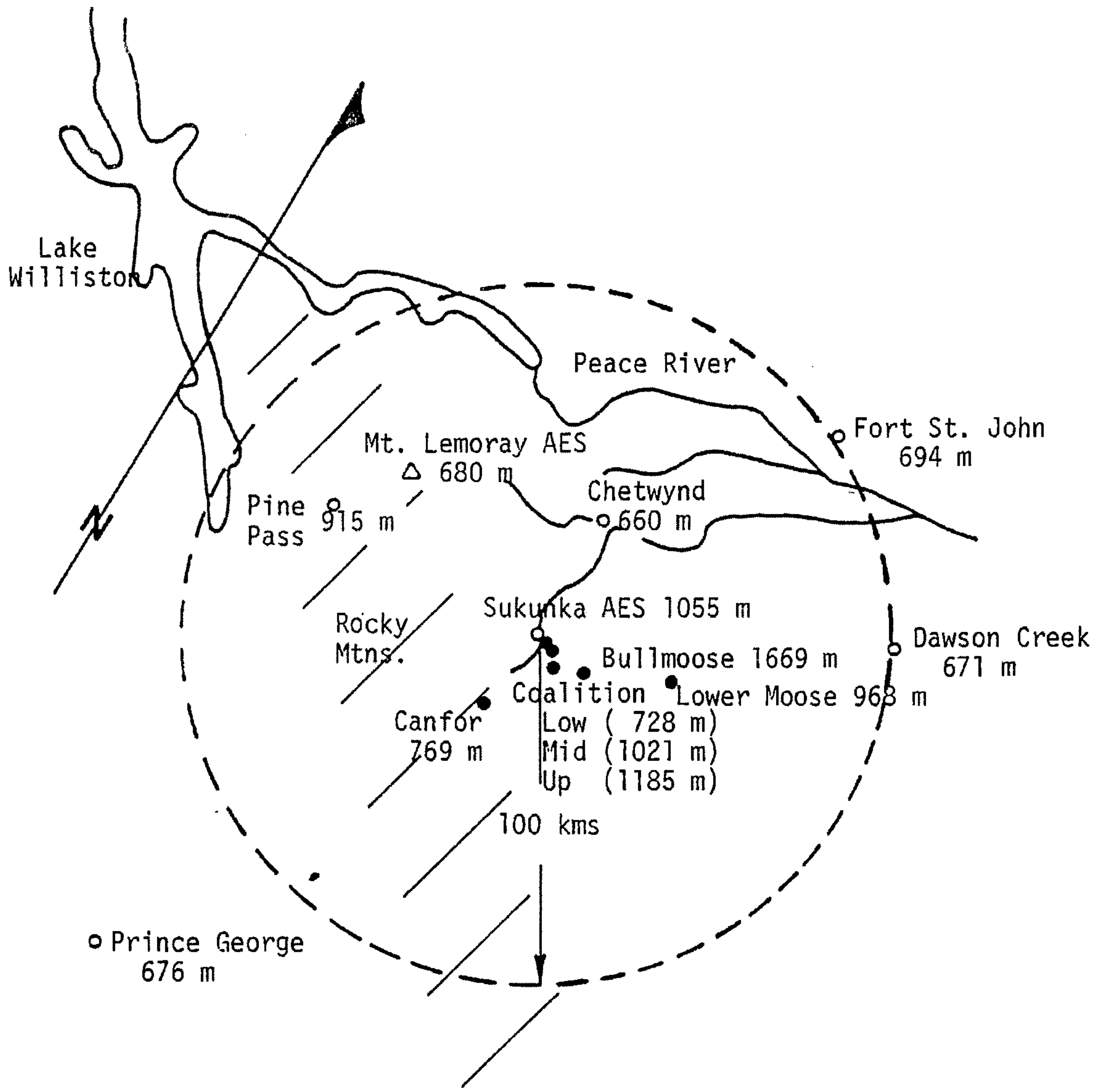


FIGURE 5.2.1.1-6

PRINCE GEORGE, B.C. - PERCENTAGE FREQUENCY WIND DIRECTION (AND CALMS) BY MONTHS



Map 2.4-1
LOCATION OF SUKUNKA-BULLMOOSE COAL LEASE AREA



MAP 3.2.1-1

CLIMATE RECORDING STATIONS WITHIN A 100 KM RADIUS OF THE SUKUNKA-BULLMOOSE PROPERTY

SUKUNKA-BULLMOOSE STAGE I ENVIRONMENTAL STUDY

VOLUME I - TEXT

November, 1977

BP Exploration Canada Ltd.
Coal Division

SUKUNKA / BULLMOOSE

STAGE 1 ENVIRONMENTAL STUDY

VOLUME I

(Text)

BP EXPLORATION CANADA LIMITED

COAL DIVISION

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3.2 ATMOSPHERIC STUDIES

3.2.1 Climate

The climate of the study area was inferred from data summaries from long-term climatological stations at Dawson Creek, Fort St. John and Prince George (Atmospheric Environment Section, Department of the Environment, 1975 Temperature and Precipitation, British Columbia) and from observations from shorter period stations at Chetwynd, Sukunka AES, Pine Pass and Mt. Lemoray. (British Columbia Department of Agriculture, N.D.: Climate of B.C. Report for 1974 and 1975). The locations and altitudes of these stations are shown in Map 3.2.1-1.

In addition, data from Bullmoose, Lower Moose, Canfor and Sukunka (Lower, Middle and Upper) were obtained from the Climatology Section, Resource Analysis Branch.

3.2.2 Air Quality

At present, sufficient data to evaluate air quality is not available. Limited data for regional air quality parameters has been taken for the town of Chetwynd by the Atmospheric Environment Service (Enslie, 1974).

3.3 AQUATIC STUDIES

3.3.1 Hydrology

3.3.1.1 Surface water

In May, 1975 and June, 1976 stream discharges were approximated at selected streams on the property. Stream velocity was measured by timing the passage of a floating object over a measured distance.

from silt to gravel size material whereas those in the Murray River range from sand to gravel size. Along the edges of these rivers fluvioglacial deposits with rolling or level surfaces exist as terraces.

Cryoturbated zones occur in colluvial deposits in high alpine regions of both Mount Speiker and Bullmoose Mountain. These processes are active and involve frost heaving, churning and congiliturbation.

Several colluvial deposits have their surfaces crossed by a series of channels. These channels, cut by glacial meltwater, in some cases develop into deep parallel and sub-parallel gullies. As well, several steep rock slopes have been modified by frequent avalanche activity.

5.2 ATMOSPHERIC RESOURCES

5.2.1 Climate

The climate of the Sukunka Valley, while it resembles that of the Peace River Region to the northeast does have unique qualities. Items that in particular require attention are precipitation patterns - amounts and rates of fall in both summer and winter seasons, winds - with special interest in gustiness, and finally the frequency, intensity and persistence of inversions.

The climate of the area has been classified as Humid Continental, Short Summer after Köppen (in Chapman et al, 5th B.C. Natural Resources Conference, 1952). It is further described as: a cold, snowy, forest climate with the average temperature of the coldest month less than -3^{o}C; showing no distinct dry season (greater than 1.2 in of precipitation in driest summer month) and a summer in which less than four months have an average temperature of greater than 10^{o}C.

The Rocky Mountains, which run in a northwest-southeast direction in this area have a major influence on local climate. When the direction of movement of weather systems is from the west, as very often is the case (Hare and Thomas; Climate Canada (1974; pp. 76, 77)), the mountains provide shelter to the regions to their northeast. When, however, the flow of air is from the north or northeast, as happens when there are low pressure systems over southern B.C. or southern Alberta, the reverse applies and weather effects are maximized on the eastern mountain slopes. During the winter season the mountain barrier often slows and sometimes completely blocks the advance southward of arctic air thus holding the northeast regions deep in cold air for long periods of time. Conversely, when an air flow from the west has been established, milder Pacific air descending the eastern mountain slopes will produce the Chinook winds which are better known in southern Alberta (Hare and Thomas; Climate Canada, 1974, p. 115).

Site-specific climate data are sparse. Data including temperature, precipitation and wind have been collected at several sites for just over one year. These sites include Bullmoose, Lower Moose, Canfor and Sukunka (Lower, Middle and Upper). Due to the short collection period, the data cannot be considered totally representative of conditions but may be used to recognize possible trends in comparison to more longstanding data. Tables 5.2.1-1 to 5.2.1-6 summarize the relevant data received from the Resource Analysis Branch, Climatology Section.

The climatic data at the Chetwynd-Sukunka stations for the period 1972-1974 have been summarized in Table 5.2.1-7. Data have been collected at the station only since December, 1971. This too is a relatively short collection period and therefore data from the Dawson Creek and Fort St. John stations averaged over a thirty year period are presented in Tables 5.2.1-8 and 5.2.1-9. These data were obtained from the "Climate of British Columbia, Extremes of Record, 1941-1970" (B.C. Department of Agriculture).

5.2.1.1 Wind

Wind data from Dawson Creek, Fort St. John (Atmospheric Environment Service, 1975, Department of the Environment; Canadian Normals, Volume 3, Wind) are displayed in Figures 5.2.1-1 to 6. From the statistics it is evident that average wind speeds in the area are significant and that the winds tend to blow most commonly from the south or southwest (maximum in summer) or from the north (maximum in winter). In the Sukunka and Bullmoose Valleys the surface winds will tend to follow the valley contours suggesting the winds commonly will be from the south-southwest or north-northeast. It is noted that the strongest average winds at the three reference stations are southerly in direction and that the strongest winds recorded at Prince George, Dawson Creek and Fort St. John are in excess of 80 mph (129 km/h). Similar strong winds are to be expected in the Sukunka Valley.

5.2.1.2 Temperature

Since the valleys lie to the northeast of the Rockies, temperatures will more nearly resemble those recorded at Dawson Creek or Fort St. John (Tables 5.2.1-8 and 9) than at Prince George though they will probably be somewhat colder because of greater altitude.

The average mean daily temperature at Chetwynd-Sukunka was -0.7^{O}C (30.7^{O}F) over the three year measurement period. This is approximately 2^{O}C lower than the values recorded at Dawson Creek and Fort St. John over a thirty year period. The average daily maximum and minimum were 7.5^{O}C and -5.0^{O}C, respectively. These are within about 1^{O}C of the corresponding data from Dawson Creek and Fort St. John.

An annual mean temperature of 32^{O}F (0^{O}C) is probably a reasonable estimate for the study area. Since on a day to day basis wind and radiative effects can have greater influence on temperature in a locale than altitude difference, it is expected that the January mean daily temperature will be somewhat higher than the -6.8^{O}F (-28^{O}C), established at Fort St. John, possibly by as much as 3 or 4 degrees while the July mean temperatures will be somewhat cooler than the 71.2^{O}F (22^{O}C) mean at Fort St. John. The extreme range of temperature will likely run as elsewhere, from a low of -55^{O}F (-48^{O}C) on a "coldest" winter day to 90^{O}F (32^{O}C) on a "warmest" summer afternoon.

The frost-free period at Sukunka averaged 82 days over the 3-year period. The Climatology Section of the Resource Analysis Branch has estimated that in 1976 frost-free periods at the stations near the mine sites are as follows:

Bullmoose	46 days
Coalition Low	75 days
Coalition Mid	110 days
Coalition Upper	71 days

The low value for Coalition Low and Sukunka, compared to Coalition Mid is indicative of valley bottom cold air pooling. The Bullmoose value is indicative of the substantially higher elevation. Only occasionally will minimum temperatures not drop below freezing during winter nights though when a chinook type wind is blowing temperatures in fifties can be expected in winter months.

5.2.1.3 Precipitation

The total annual precipitation at the Chetwynd-Sukunka station is 27.13 inches, split almost evenly between rain and snow. This is significantly more (approximately 10 in) than occurs at both Dawson Creek and Fort St. John. An average of 26 percent of the annual precipitation occurs during the growing season (May to August).

Maximum daily rainfall and snowfall amounts will be about 3 in (8 cm), depending on specific locations. An average winter snowfall of about 100 in (254 cm) can be expected. Snow accumulation on the ground will vary greatly, not only with year and season, but also with altitude. A snow survey at the beginning of April, 1976 indicated a range of 6 in (15 cm) in the valley bottom to 10 or more inches (25 cm) on the ridges.

5.2.1.4 Thunderstorms

Judging from reference station statistics (Meteorological Branch, Department of Transport (1968), Climatic Normals, Volume 3; Sunshine, Cloud, Pressure and Thunderstorms) thunderstorms can be expected to occur rather frequently in the summer, as many as 6 per month in June, July and August. Few, if any, will occur in the winter months.

5.2.1.5 Inversions

The topography of the East Slopes of the Rockies result in many local effects on the diffusion climatology in the Northeast Coal Study Region. Ground-based inversions are frequent occurrences throughout the year, resulting in a stable atmosphere. This condition is conducive to local buildups of airborne pollutants prior to dissipation of the inversions.

Radiation inversions occur in periods of rapid cooling. Overnight and early morning are the most common times for this type of inversion to develop. Dissipation usually occurs before the morning is out by wind and convective heating effects.

Daytime subsidence inversions occur in high pressure zones and when a fairly deep layer of cold air is overrun by warmer air. These capping inversions do not dissipate as easily as radiation inversions.

Inversions of both kinds are expected in the Sukunka-Bullmoose area. An indication of the expected inversion frequency can be obtained by examining the seasonal percentage frequency of ground-based inversions for the Pine River Valley at Chetwynd estimated by the Atmospheric Environment Service (Emslie, 1974) and summarized below.

Percentage Frequency of Ground-Based Inversions

	Percent (%)			
	Winter	Spring	Summer	Fall
Overnight/Early Morning (a.m.)	70	60	80	75
Daytime (p.m.)	45	10	10	40

Radiation inversions would be frequent the year round.

Daytime subsidence inversions would not be as frequent as radiation inversions and would be more likely to occur in the fall and winter.

5.2.2 Air Quality

As the area is yet largely undeveloped the air quality can be expected to be relatively pristine. Air quality measurements on the property are currently being taken by the Pollution Control Board, Victoria.

5.2.3 Noise

Noise data is not available for the area.

7.0 RECOMMENDATIONS

7.1 RECOMMENDED FURTHER STUDIES FOR PREPARATION OF THE STAGE II ENVIRONMENTAL ASSESSMENT

7.1.1 Physiography

The physiography of the general locations of mine portals, transportation corridors, roads and plant site will be studied and described in conjunction with the general physiography of the area. This data will be utilized in the environmental planning and engineering design of the facilities in order that they should better harmonize with the landscape.

7.1.2 Geology

The geology of the development areas will be studied and described in detail as background for the development plan, surficial geology, soils, and other environmental studies.

7.1.3 Surficial Geology

The Resource Analysis Branch (RAB) Terrain and Inventory Mapping will be field-checked in the development areas and expanded where necessary. Sensitive areas which may affect the development will be identified for either avoidance or special care. Surficial geology data will be incorporated in project engineering design.

7.1.4 Climate

Additional RAB climate data will be available and will be incorporated in the Stage II report. These data will be useful to project hydrologic regimes, building standards (snow loading and installation requirements, etc.) and help give an estimate of the general "habitability" of the development area.

7.1.5 Air Quality

Air quality will be documented over a one-year period at the coal treatment plant site and surrounding area to establish current background dust and suspended particulate levels; current air quality at the camp area and along the roads will also be measured.

Air quality will be determined by:

- High volume air sampling (one week samples taken quarterly over a one-year period);

- A network of air sampling stations using conventional dustfall jars and sulfation plates; sampling will be continuous over a year with jars and plates changed monthly.

7.1.6 Hydrology

7.1.6.1 Surface water hydrology

Golder Associates, suggest the following surface water hydrology program in their report (Appendix 5.3.2-1; p. 11):

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SUKUNKA/BULLMOOSE PROPERTY

STAGE ONE PHASE ONE

ENVIRONMENTAL REPORT

BP EXPLORATION CANADA LIMITED

4.0 IMPACTS AND MITIGATIONS

This section identifies and describes the impacts anticipated within Phase I of the proposed Sukunka-Bullmoose coal development venture. It fulfills the Stage I preliminary assessment as described in the Guideline for Coal Development" (ELUC, 1976).

PHASE ONE

4.1 Impact Assessment and Aspects Relevant to the Physical Environment Impacts and Mitigations at Mine Sites and Surrounding Area.

4.1.1 Introduction - Air

At present air quality data are not available for the site area, air quality measurements on the lease have been taken by the Pollution Control Board, Victoria, but are not available in published form. When such information becomes available it will be submitted as part of the Stage II data base. As the area is yet largely undeveloped, air quality can be expected to be relatively pristine. (See 5.2 - Atmospheric Resources Section 5.2.1 to 5.2.1.5 Vol. 1).

4.1.2 Alteration of Atmospheric Properties

4.1.2.1 Insolation

The atmospheric emissions at the mine site will be limited to those products of gasoline or diesel combustion and mine exhaust. Insolation change is therefore not an aspect of concern because insufficient pollutants are being added to the atmosphere and sufficient ventilation exists within the topographic setting to dispurse the pollutants.

4.1.2.2 Visibility

Similar to insolation, visibility reduction requires the existence of numerous area-wide emission sources. Such area wide emission sources are not present therefore visibility reduction is not an aspect of concern. Potential local visibility problems (dirt and grit) will be reduced by seeding road ditches, cut banks etc. Coal dust from the R.O.M. pile will be reduced by spraying with water when necessary.

4.1.2.4 Inversions

See information presented in section 5.2.1.5 Vol. 1

4.1.2.5 Airflow Patterns

Substantial alterations in topography or the construction of large buildings are not associated with any phase of the mining operation, therefore localized general airflow patterns will not be modified to any significant degree. Site specific conditions may be slightly affected, however, this minor change in flow patterns is not expected to be significant.

Wind abrasion and erosion of soils will be reduced by prompt re-vegetation of disturbed sites.

4.1.2.6 Turbulence Factors

As tall buildings or other tall structures are not present in the mining plan wind turbulence from such structures is not a concern.

4.2 Alteration of Atmospheric Constituents

4.2.1 Particulates and Other Primary Emissions

All coal mining operations cause particulates, however, particulate emission will be minimized by a combination of high efficiency abatement equipment and engineering design.

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Particulates and Other Primary Emissions - Cont'd

Particulate matter from the actual mining operations will be negligible because all mining is underground and water is continually used for dust suppression.

Particulate matter can be expected from materials handling, water will be used to suppress dust derived from the creation of minesite R.O.M. piles if deemed necessary. It is expected that coal will be produced from the mine at approximately 10% moisture content, in the winter it is expected the coal will freeze thereby reducing the amount of particulate matter available for dispursion.

The existence of coal refuse fires which often release particulates, smokes, and fumes will not be in an area of concern because of the low sulphur content of the coal and the fact that the Sukunka coal does not exhibit any tendency towards spontaneous combustion, as indicated by the existing coal stockpiles.

4.2.2 Gases

Approximately 80,000 CFM exhaust air will be ventilated from the underground mine. The exhaust air will contain small amounts of methane. It is not considered an area of concern.

The other forms of gases associated with mine site areas will be NO_2 (nitrogen oxides) and CO (Carbon monoxide) associated with stationary sources (power plants) and non-stationary sources like motor vehicles, however, such emissions are not an area of concern because adequate natural ventilation present at the site will allow pollutants to dispurse.

4.3 Alteration of Other Atmospheric Phenomena

Noise - Noise will occur throughout the actual mining operation, the impact of these noise sources on humans (aside from the workforce) will be very low due to the remote location of the mine development.

4.3.1 Moisture

The amounts of moisture released in the form of water vapour from settling ponds will not be at sufficient quantities to cause a change in relative humidity values.

The amounts of vegetation removed from site will be of a small order and will not affect relative humidity values.

4.3.2 Heat

Heat will not dissipate in sufficient quantity from the mine or the mine infrastructure to be an area of concern.

4.3.3 Water - Introduction

It is common to subdivide the analysis of water related impacts into considerations of water quantity and water quality.

4.3.4 Changes in Surface Water Quantity

Surface flow patterns will be changed to some extent throughout the life of the mine. Change of surface flow pattern will result any time a resource is developed. Much of the existing change, which is minor in nature, has occured from localized topographical modification (exploration roads, haul roads, adits, culverts etc.). Singularily or cumulatively these activities have not had a major effect on overall water quantity in the streams draining the exploration area.

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7.0. IMPACT AND MITIGATION FOR THE TRANSPORTATION CORRIDOR FROM MINE SITE TO CHETWYND

7.1. AIR - Alteration of Atmospheric Properties

7.1.1. Insolation - it is estimated the pollutant emission from trucks and other mine traffic will be minimal and dispursed. Therefore, insolation will not be changed by daily mine traffic.

7.1.2. Visibility - Visibility reduction is not a major area of concern because there will be no area wide emission sources. See Alteration of Atmospheric Constituents.

7.1.3. Inversions - Inversions of both kinds are expected in the Sukunka-Bullmoose area. See section 5.2.1.5. Vol. 1 for further discussion.

7.2. Alteration of Atmospheric Constituents

7.2.1. Particulates

Consideration is being given to preventing dust from being blown off trucks as they transport the coal from the mine to Chetwynd. One solution which will be considered will be a through soaking with water of the top of the coal; this solution has proved highly successful in mining operations in southeast Alberta.

It is the policy of BP that road dust will not be allowed to create a public nuisance. It has been decided that the forestry road between the Mine and the Gwillim Lake junction and between the Provincial highway and the plant site will be treated with calcium chloride at sufficient intervals to try to consolidate the road dust. It is also understood that calcium chloride can accumulate and build up through snow removal and thereby provide a "salt lick" for ungulates and thus attracting them to the road. As a result of this understanding BP is currently examining other alternatives.

7.2.2. Gases

Carbon monoxide, CO is the most abundant air pollutant found in the atmosphere. It is derived primarily from incomplete combustion, however it will not be present in sufficient amount to become a major source of air pollution. NO_X, nitrogen oxides are also associated with fuel combustion but like CO is easily dispursed and not considered a major air pollutant from vehicle traffic.

7.3. Alteration of Other Atmospheric Phenomena

7.3.1. Noise - Noise will be generated from the coal haul trucks and other mine traffic. During operating hours the frequency of the vehicle noise is expected to be somewhat constant. Noise related effects can result in fatigue and stress on wildlife. The presence of trees and shrubs along the road will maximize sound attentuation, but otherwise noise pollution from trucks must be considered as a cost of developing the coal resource.

7.3.2. Moisture and Heat - not considered as an area of impact for the transportation corridor.

8.0. WATER

8.1. Changes in Surface Water Quantity

Surface flow patterns have been changed to some extent through construction of the existing roads. Surface flow patterns will be further changed to some extent during the upgrading and realignment planned for the Martin Creek (Gwillim Lake Rd) junction to the Sukunka Main mine. These changes are expected to range from minor topographic modifications to a localized large change in prevailing drainage network configuration. Such a large change in the prevailing dranage network might be experienced at Horse Point. BP intends to consult with various government agencies

Impacts on furbearers due to the development are expected to be low, although some furbearer habitat will be lost due to facility and road construction. Some increase in hunting pressure may also occur on the larger furbearers.

11.0. IMPACTS AND MITIGATIONS ASSOCIATED WITH THE COAL PREPARATION PLANT NEAR CHETWYND

The amounts of naturally occuring insolation will be changed by the emissions of water vapour in the form of exhaust steam from the thermal dryer. It is expected to be an aspect of minor concern because the exhaust steam will either be thermally dispursed or dispursed by prevailing winds. The amount of pollutants being added to the atmosphere will be substantially lower than the amounts allowable by the Pollution Control Branch (P.C.B.) Standards for New Stationary Sources (level A).

However, the amount of insolation will be most directly affected when natural occuring inversions appear. Climatic conditions in general are not well documented for the Chetwynd region, however both ground-based and radiation inversions are expected. An indication of the expected frequency is presented in section 5.2.1.5. Vol. 1. Radiation inversion would be frequent the year round, it occurs in periods of rapid cooling. Overnight and early morning are the most common time for this type of inversion to develop. This condition is conducive to local buildup of airborne pollutants prior to dissipation of the inversion. Dissipation usually occurs during the morning by wind and convective heating effects. The direct effect of insolation are expected to be minor with this type of inversion.

Daytime subsidence inversions occur in high pressure zones when a fairly deep layer of cold air is overridden by warmer air. These capping inversions do not dissipate as easily as radiation inversions. There is a possibility that the evidence of ice-fog may be increased because of the thermal drying of coal. Therefore local insolation values would change, decreasing the direct amounts of solar radiation, and a percentage decrease of possible sunshine time. Local visibility may also be reduced during natural inversion periods.

11.1. Airflow Pattern

The structural design of the coal preparation plant is not expected to modify the localized general airflow patterns.

Airflow pattern in the Chetwynd area is such that prevailing winds will blow any potential pollutants away from the village the majority of the time.

11.1.2. Turbulence Factors

The structural design of the coal preparation plant is not expected to alter any local turbulence phenomena. Proper architectural-engineering design has been relied upon to ensure that no aerodynamic properties of the building will lead to the re-introduction of pollutants back onto the plant site.

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11.2. Alteration of Atmospheric Constituents

11.2.1. Particulates - resulting in an increase in dustfall, as well as an increase in suspended particulates in the air, will be the main pollutant discharged into the atmosphere by the proposed preparation plant.

However, the amount of pollutants being added to the atmosphere will be substantially lower than the amounts allowable by the Pollution Control Branch Standards for new stationary sources (level A). In response to some anticipated potential problems with fugitive dust the following solutions have been considered and will be implemented.

Potential Impact Created by Fugitive Dust	Mitigative Solution
-by haul trucks as they cross the property and dump coal	-yard maintenance, sweeping up spilled lumps of coal and dust suppression with water.
-ROM Coal stockpile, the formation and presence of the stockpile	-ROM stockpile will be surrounded by higher ground which will be excavated thus providing a "berm effect". The ROM coal will be properly consolidated by bulldozer as put down.
-ROM receiving Hopper serviced by the frond-end loader	-Dust suppression with water if necessary
-Scalping Screen and Crusher as larger lumps of rock and coal are crushed	-Design criteria for the proposed plant encloses this area with a metal shell.
-Transfer points, any conveyor transfer points in ROM	-transfer points and conveyor transfer points will be enclosed by a metal shell

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Potential Impact Created by Fugitive Dust	Mitigative Solution
-Dryer building	-is completely enclosed and as such should not be a source of coal dust
-Loadout, the hopper/chute discharge into rail cars	-the loadout chute is enclosed in a metal shell, the coal pile in the load railcars is structured with a blade thereby reducing the load profile then sprayed with a latex foam in accordance with Environment Canada requirement.
-Clean Coal Stockpile, the handling of clean coal during reclaim	-the plan is that a railcar will be under the loadout hopper during the whole of the hours of operation of the plant and therefore a clean coal stockpile will not be required. However, to cater for emergency periods when railcars are not available, a small clean coal stockpile site has been allowed with reclaim by front end loader. Methods are being looked into for controlling any dust which otherwise might be raised during the formation of this stockpile. The most successful type is the Rainbird Spray which simulates a shower of rain.

Potential Impact Created by Fugitive Dust	Mitigative Solution
-Coal rail cars while loaded and awaiting shipment	-cars awaiting shipment will have a maximum waiting period of two days - all coal loaded into rail cars will be sprayed with a latex foam.

11.3.√Gases

Small amounts of methane gas may be emitted from the ROM coal during the crushing process, such emissions will be small in quantity and do not pose a potential environmental hazard.

Natural gas will be used in the coal drying process and so pollution emissions will not be significant.

The Coal Preparation Plant will not be odoriferous.

12.0. ALTERATION OF OTHER ATMOSPHERIC PHENOMENA

12.1.√Noise - Noise generated from the processing plant will be reduced because most moving parts are surrounded by an insulated shell. Also, a berm is planned near the plant site proper which will also aid in sound attentuation.

12.2. Moisture - As previously mentioned the potential for ice fog formed by moisture condensation exists and may cause a localized visibility problem. This must be considered as a short term impact that will dissipate through atmospheric ventilation. Moisture will also be made available to the atmosphere through evaporation from tailings ponds and catchment basins. The increased moisture content of the air is expected to have only a minor influence on relative humidity values surrounding the plant site.

12.3. Heat

Heat will be released into the atmosphere via exhaust emissions from the thermal plant. The amounts released will not be of sufficient quantity to cause a local or regional heating change. Changes in the microclimate immediately surrounding the thermal dryer is expected. Adjoining areas and perferral areas will not be affected.

13.0. WATER

13.1. Changes in Surface Water Quantity

Surface flow patterns present on the proposed site of the coal preparation plant will be changed completely. Surface water originating from the proposed site will be controlled by means of ditch surrounding the site. The general policy will be to control surface water runoff and direct it to a surface catchment basin where it can be evaluated prior to recycling to the plant or discharged into Centurion Creek. Construction operations will be carried out in such a manner that erosion and water pollution will be minimized.

It is not known if draining and clearing of the proposed site will significantly affect the quantity of water available to Centurion Creek, But it is presumed that the creek will not be significantly impacted.

13.2. Hydrologic Factors

13.2.1. Evaporation

Evaporation from tailings ponds and surface water catchment ponds will add moisture to the atmosphere. It is expected to effect relative humidity values only slightly. As such, it is not considered to be a major area of environmental concern.

13.2.2. Evapotranspiration

Evapotranspiration, namely evaporation of soil moisture and transpiration of water by plants will be effected clearing vegetation and soil from the

Porter

BP CANADA INC. - SUKUNKA COAL PROJECT
STAGE II SUBMISSION

Volume 1
Summary Document

PREPARED FOR

The Environment and Land Use Committee

as prescribed by the

Guidelines for Coal Development

British Columbia

PREPARED BY

BP Exploration Canada Limited

November 1979

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Introduction

1

Chapter 1 Introduction

1.1 Background

BP Canada Inc. is proposing to develop an underground coal mine in the Sukunka Valley. This document outlines the proposed development and summarizes the anticipated effects on the environment, people, and economy of the region. This introductory volume represents a summation of information which has been submitted to the Coal Guidelines Steering Committee (the arm of government responsible for reviewing major coal developments in British Columbia), in compliance with the Stage II review process as prescribed by the Environment and Land Use Committee.

The Sukunka project operates under a Joint Venture Management Committee made up of representatives from BP Coal, based in London, England, and BP Canada. Sukunka Mines Limited, a wholly owned subsidiary of BP Canada Inc., has been appointed operator of the Sukunka coal development and is a registered company in B.C., operating out of Chetwynd.

1.2 Setting

Located approximately sixty km south of the village of Chetwynd in northeastern B.C., the Sukunka coal property occupies an area of about 165 square kilometres (about 64 square miles).

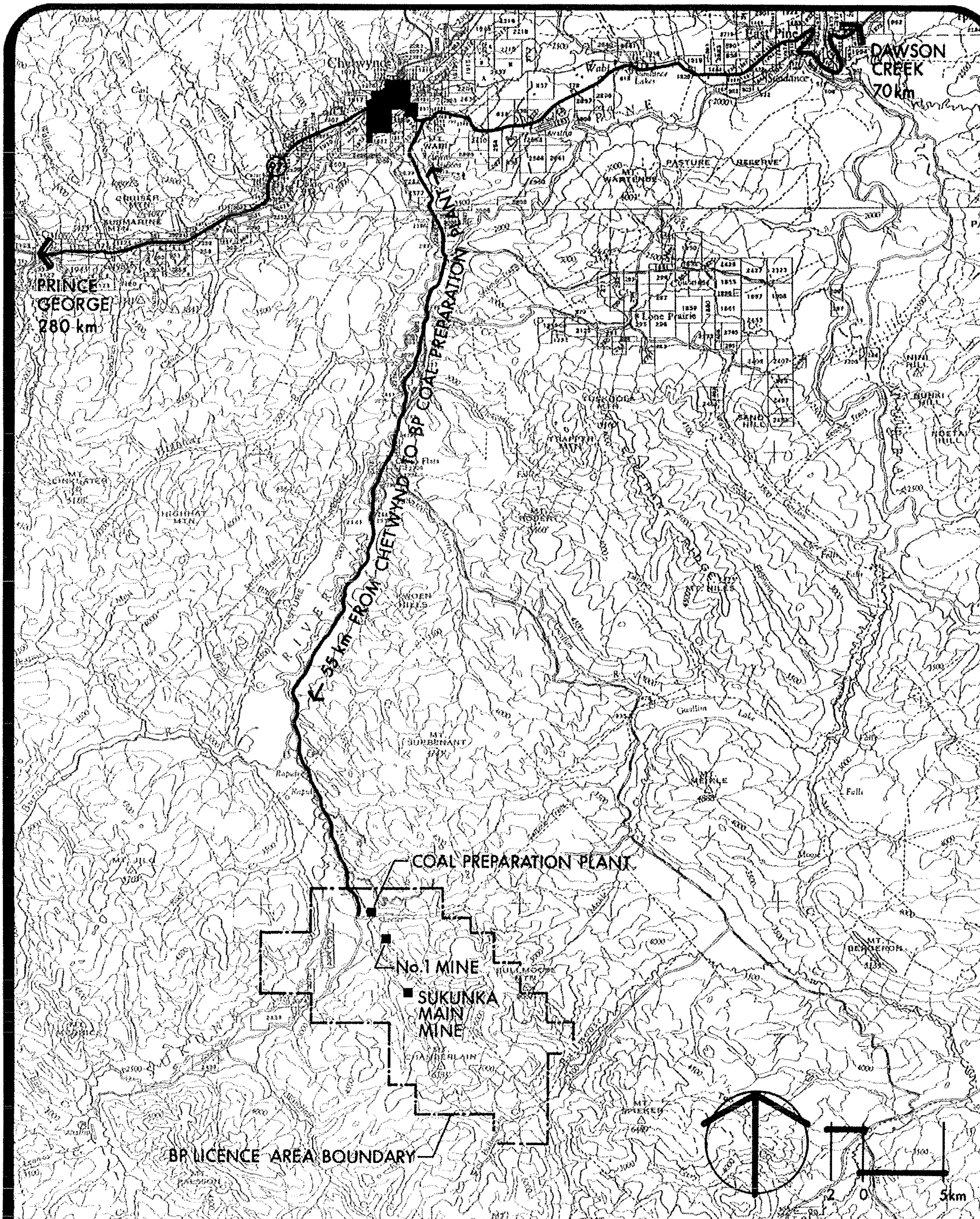
Figure 1-1 shows the location of the Sukunka coal lease. The property is in mountainous terrain with deeply cut valleys.

Access to the property is gained via the Northeast Development Road, which is provincially maintained gravel road (23 km), and the Sukunka Forestry Road (32 km). The mine and coal preparation plant (for cleaning and washing coal) area is drained primarily by two creeks, Skeeter and Chamberlain, which both flow westward into the Sukunka River.

The climate of the area generally resembles that of the Peace River region, and is characterized by long, cold winters and no distinct dry season. Diverse climatic and topographical factors give rise to a number of vegetation patterns: treeless alpine zone on Bullmoose Mountain; subalpine Englemann spruce - alpine fir zones in slightly lower elevations; and subboreal white spruce - alpine fir zones in the valleys. A variety of wildlife can be found on the property, including up to 46 species of mammals and 160 species of birds.

1.3 History of the Property

The Sukunka property has had a number of owners prior to its acquisition by BP in 1976. The area was initially leased by Brameda Resources Limited in 1969.

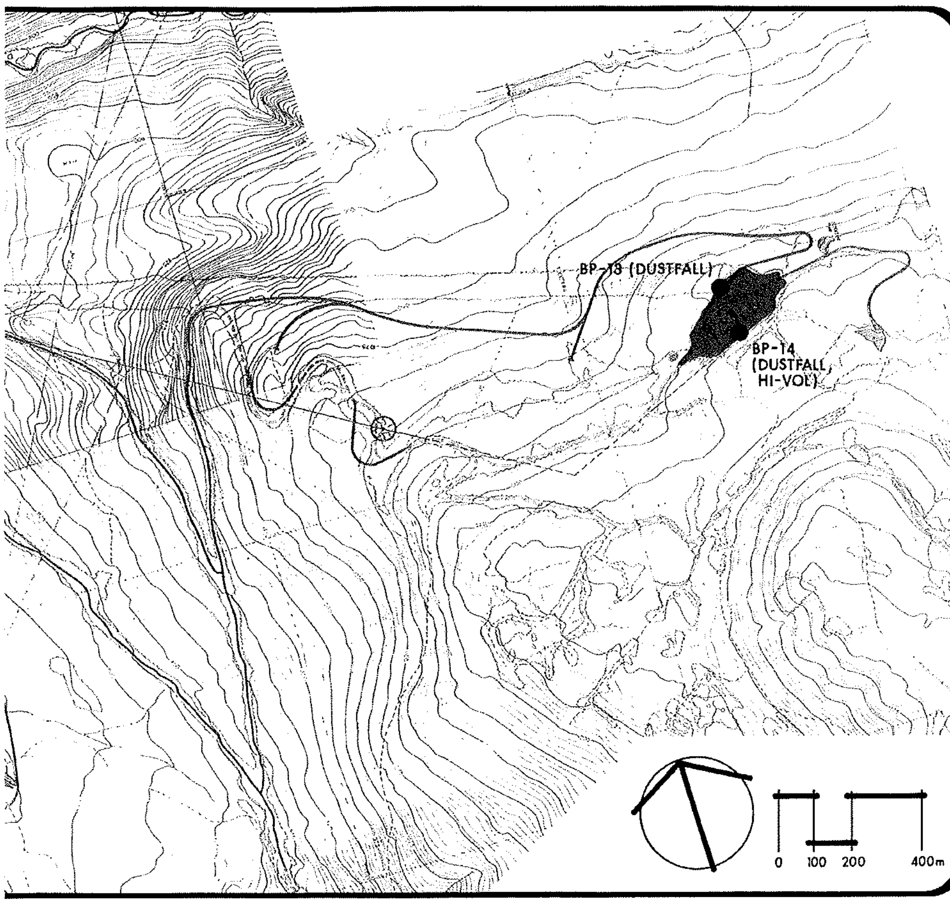


Sukunka Coal Project

BP Exploration Canada Limited
COAL DIVISION

FIGURE TITLE
Location of the Sukunka Coal Project

FIGURE NO.
1-1



LEGEND & NOTES

● LOCATION OF AIR QUALITY MONITORING STATION OPERATED BY BP CANADA

BP Exploration Canada Limited
COAL DIVISION

Sukunka Coal Project

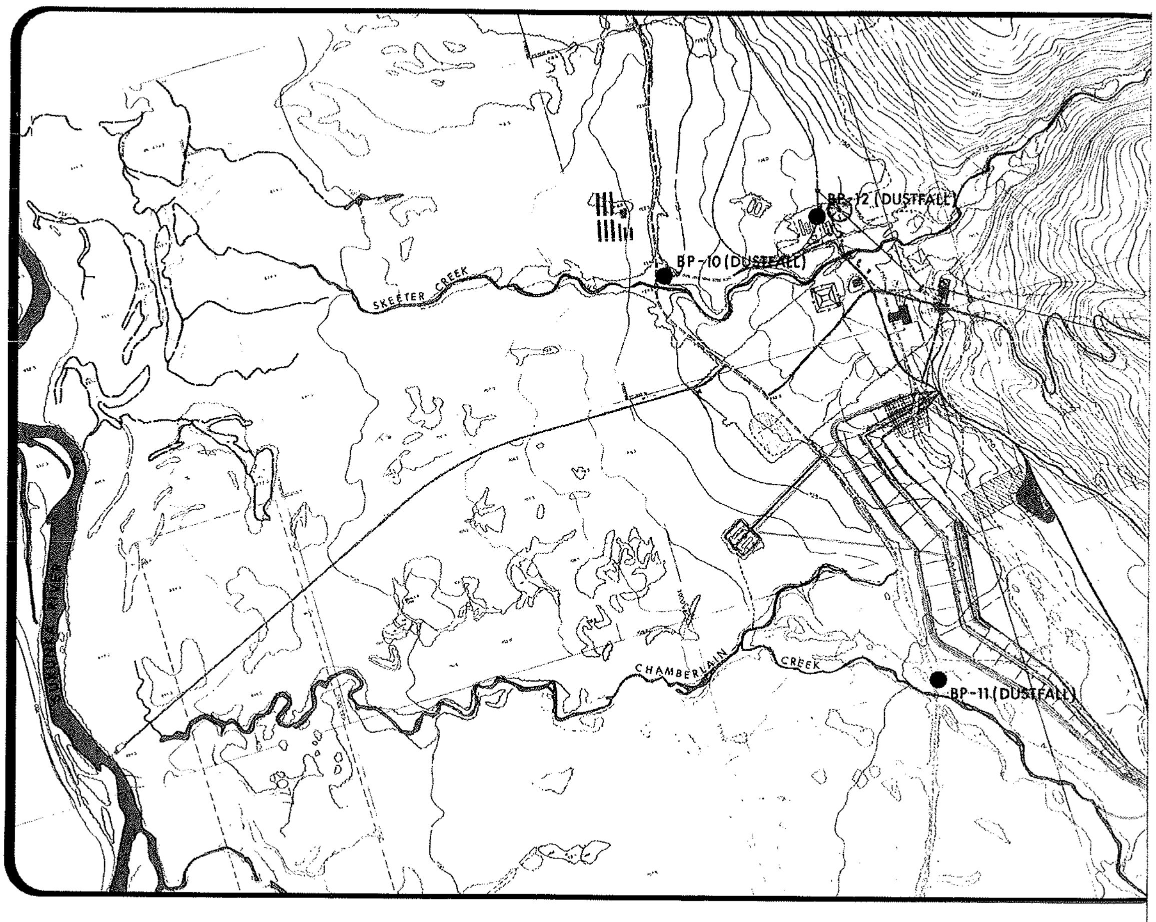
FIGURE TITLE

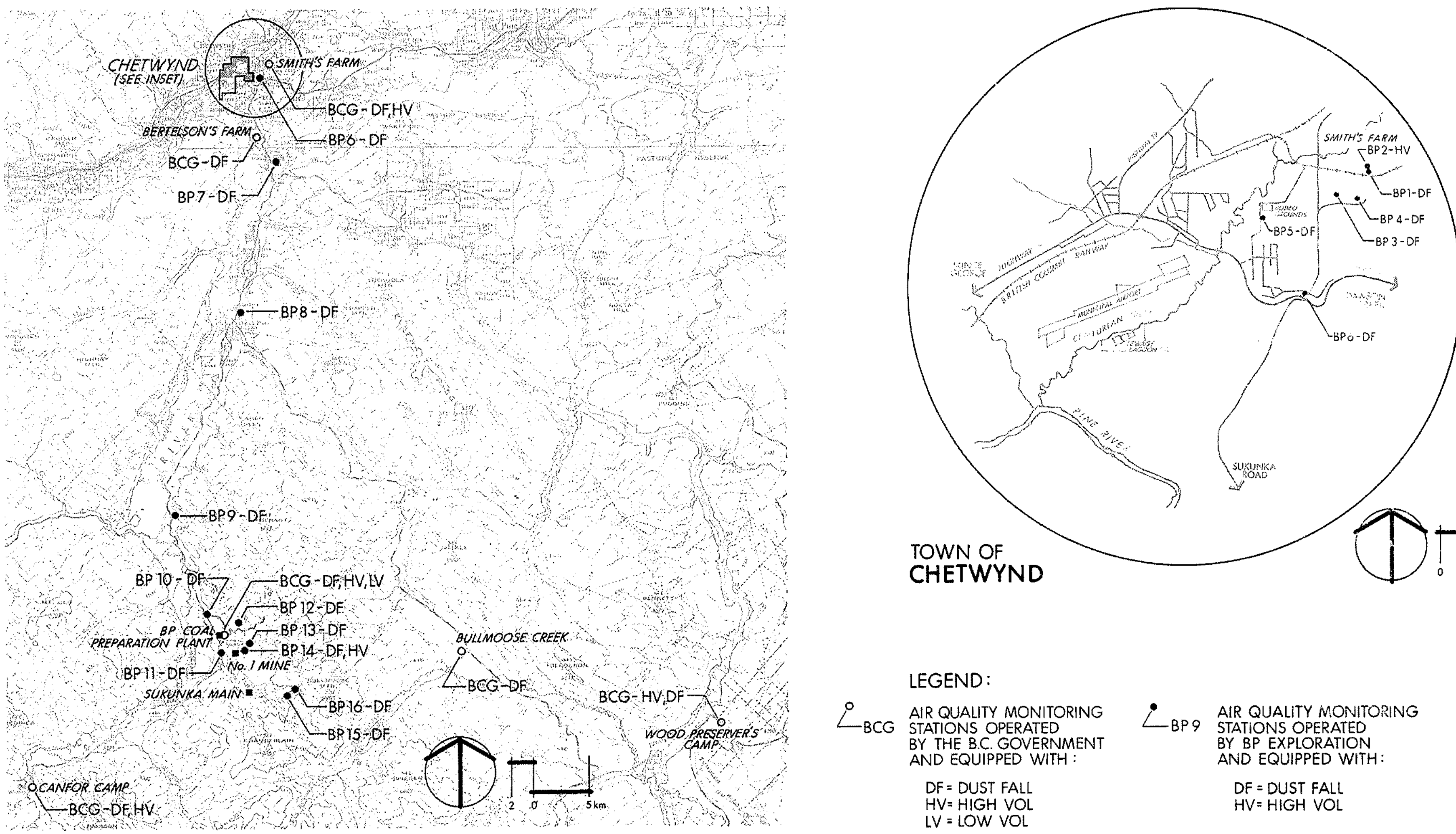
Location of Air Quality Monitoring Stations

FIGURE NO.

4-5

Fig 4-5 continued





LEGEND:

BCG — AIR QUALITY MONITORING STATIONS OPERATED BY THE B.C. GOVERNMENT AND EQUIPPED WITH:

DF = DUST FALL
HV = HIGH VOL
LV = LOW VOL

BP 9 — AIR QUALITY MONITORING STATIONS OPERATED BY BP EXPLORATION AND EQUIPPED WITH:

DF = DUST FALL
HV = HIGH VOL

Sukunka Coal Project

BP Exploration Canada Limited
COAL DIVISION

FIGURE TITLE
Location of Air Quality Sampling Stations

FIGURE NO.
5-3

Essentially, process plant water make-up from the Sukunka River is required to replace water lost through exfiltration or evaporation in the coal processing system. Domestic water supplies will be provided at the plant site and minesite areas from the main water system, after suitable treatment. These uses are conventional: drinking and washing.

4.2 Environmental Effects Associated with Surface Facilities

Similar to the mining operations, environmental effects have been evaluated with respect to atmospheric, aquatic and terrestrial resources. The major impacts on air quality stem from the transportation and preparation of coal. Dust emissions from the thermal dryer, transfer points and unit trains are identifiable sources of air pollution.

Enclosed conveyors, some enclosed transfer points and the use of high-efficiency cyclones and a venturi scrubber on the dryer exhaust will reduce particulate emissions within the Pollution Control Branch (B.C. Government) Level A Air Quality Objective. Prior to shipping from Sukunka, the surface of the coal in unit trains will be sprayed with a latex foam, in compliance with Federal regulations BP presently maintains seven air quality monitoring stations on the property, five of which are shown in Figure 4-5.

From Sukunka, coal unit trains will proceed to the B.C. Railway yards in Chetwynd, then on to the Lower Mainland. This route is shown in Figure 5-2.

The Sukunka Forestry Road presently has a dust control problem which BP has been monitoring, through the use of air quality monitoring stations, since September, 1978. Figure 5-3 shows the location of these stations. It is anticipated that construction traffic, coupled with increased recreational and industrial use will aggravate this problem. To this end BP is considering the use of dust-suppressant chemicals on the upgraded road.

Because of the limited upgrading involved, minor impact is anticipated on terrain, soils and vegetation. However, approximately 40 hectares of vegetation will be cleared for the road right-of-way.

The transportation corridor bisects some high quality, wildlife winter range. Anticipated impacts on wildlife include: increased hunting pressure; limited loss of habitat; and increased collision mortality potential.

Appendix B Description of Dustfall Sites

Site Documentation Form

Site Name: Skeeter Creek		**Site #:** 9	
Project: 123110482 Sukunka EA Project			
Location		**Circle One**	
UTM Easting	585,733	**Measured**	Calculated
UTM Northing	6,122,328		
UTM Zone	10U		
Latitude	55˚ 14' 24" N	Measured	**Calculated**
Longitude	121˚ 39' 5" W		
Elevation	752 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.0 - 2.2 m		
Description			
Terrain	Flat meadow in river valley.		
Tree Canopy	Open; poplars at meadow edge approximately 20 m away.		
Nearby Sources	Chamberlain Rd 90 m west; poplar trees.		
Pictures			
Direction Looking	**Recorded?**	**Picture ID**	
North	Y	Stn9_Skeeter_North	
East	Y	Stn9_Skeeter_East	
South	Y	Stn9_Skeeter_South	
West	Y	Stn9_Skeeter_West	
Access from Hwy	N		
Other Pictures of Interest	N		
Access			
Describe the access to the site and any signs or markers used to identify the site			
From the Sukunka Rd turn left (east) onto Chamberlain Rd at km 32.5. Park off road at 0.4 km Chamberlain Rd. Walk into field toward the east, veering right to find the station, which is visibile from the parking spot.			
Date & Time of Deployment (LST)	1330 MST August 21, 2012		
Field Crew Leader	John Gallagher		

Site Documentation Form

Site Name: Chamberlain Creek **Site #:** 11

Project: 123110482 Sukunka EA Project

Location		Circle One	
UTM Easting	591,096	**Measured**	Calculated
UTM Northing	6,115,555		
UTM Zone	10U		
Latitude	55˚ 10' 41" N	Measured	**Calculated**
Longitude	121˚ 34' 10" W		
Elevation	1658 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.3 m		

Description	
Terrain	Sub-alpine ridge.
Tree Canopy	Station is on a clear area that used to be a road. Scattered spruce in area to about 4 m high.
Nearby Sources	None known.

Pictures

Direction Looking	Recorded?	Picture ID
North	Y	Stn11_Chamberlain_North
East	Y	Stn11_Chamberlain_East
South	Y	Stn11_Chamberlain_South
West	Y	Stn11_Chamberlain_West
Access from Hwy	N	
Other Pictures of Interest	N	

Access

Describe the access to the site and any signs or markers used to identify the site

Helicopter access. Landing zone is approximately 100 m northwest of the station on old road. From landing zone, walk south along the old road. Follow roadbed around the corner to the east; orange flagging tape on trees along the way.

Date & Time of Deployment (LST)	1215 MST August 20, 2012
Field Crew Leader	John Gallagher

Site Documentation Form

Site Name: Bullmoose Creek **Site #:** 12

Project: 123110482 Sukunka EA Project

Location		**Circle One**	
UTM Easting	594,604	**Measured**	Calculated
UTM Northing	6,110,538		
UTM Zone	10U		
Latitude	55˚ 7' 56" N	Measured	**Calculated**
Longitude	121˚ 30' 58" W		
Elevation	1205 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.15 m		

Description

Terrain	Narrow bench on south-facing slope in old clear cut.
Tree Canopy	Planted pines 2-3 m high scattered through old clear cut with willow brush up to 1 m.
Nearby Sources	Unpaved road 65 m northeast and uphill of station.

Pictures

Direction Looking	**Recorded?**	**Picture ID**
North	Y	Stn12_Bullmoose_North
East	Y	Stn12_Bullmoose_East
South	Y	Stn12_Bullmoose_South
West	Y	Stn12_Bullmoose_West
Access from Hwy	N	
Other Pictures of Interest	N	

Access

Describe the access to the site and any signs or markers used to identify the site

From road pullout/helicopter landing site, walk downhill and south into old clear cut. Station is in a relatively clear area among planted pine trees, a bit west of the pullout.

Date & Time of Deployment (LST)	1335 MST August 20, 2012
Field Crew Leader	John Gallagher

Site Documentation Form

Site Name: Sukunka River **Site #:** 13

Project: 123110482 Sukunka EA Project

Location		**Circle One**	
UTM Easting	581,450	**Measured**	Calculated
UTM Northing	6,132,676		
UTM Zone	10U		
Latitude	55˚ 20' 1" N	Measured	**Calculated**
Longitude	121˚ 42' 57" W		
Elevation	705 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.1 m		

Description	
Terrain	Northwest-facing hill near the Sukunka River.
Tree Canopy	Clear cut with planted pines and other scrubby growth to 2 m height.
Nearby Sources	Sukunka Rd is 85 m west; gas well site approximately 80 m south.

Pictures

Direction Looking	**Recorded?**	**Picture ID**
North	Y	Stn13_SukunkaR_North
East	Y	Stn13_SukunkaR_East
South	Y	Stn13_SukunkaR_South
West	Y	Stn13_SukunkaR_West
Access from Hwy	N	
Other Pictures of Interest	N	

Access

Describe the access to the site and any signs or markers used to identify the site

Station is 85 m east of the Sukunka Rd at km 21, opposite Sukunka Falls. Station is visible from the road just below the 21 km marker.

Date & Time of Deployment (LST)	1455 MST August 21, 2012
Field Crew Leader	John Gallagher

Site Documentation Form

Site Name: Windfall Creek **Site #:** 14

Project: 123110482 Sukunka EA Project

Location		**Circle One**	
UTM Easting	576,660	**Measured**	Calculated
UTM Northing	6,114,122		
UTM Zone	10U		
Latitude	55° 10' 3" N	Measured	**Calculated**
Longitude	121° 47' 47" W		
Elevation	730 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.0 m		

Description

Terrain	River flood plain - Sukunka valley near confluence of Windfall Creek.
Tree Canopy	Brushy clearing. Tall (> 20 m) poplars at edge of clearing about 20 m away.
Nearby Sources	Unpaved Sukunka Rd about 100 m southeast (light traffic); poplar trees.

Pictures

Direction Looking	Recorded?	Picture ID
North	Y	Stn14_Windfall_North
East	Y	Stn14_Windfall_East
South	Y	Stn14_Windfall_South
West	Y	Stn14_Windfall_West
Access from Hwy	N	
Other Pictures of Interest	N	

Access

Describe the access to the site and any signs or markers used to identify the site

Park at km 45.5 Sukunka Rd (stay right at West Bullmoose turnoff at km 39). Walk in to clearing approximately 100 m northwest of parking spot.

Date & Time of Deployment (LST)	1525 MST August 20, 2012
Field Crew Leader	John Gallagher

Site Documentation Form

Site Name: District of Chetwynd **Site #:** 16

Project: 123110482 Sukunka EA Project

Location		**Circle One**	
UTM Easting	586,283	**Measured**	Calculated
UTM Northing	6,171,480		
UTM Zone	10U		
Latitude	55° 40' 52" N	Measured	**Calculated**
Longitude	121° 37' 40" W		
Elevation	615 m	**Measured**	Calculated
Measurement Method	**GPS** Survey Other:		
Instrument Inlet Height (agl)	2.0 m		

Description

Terrain	Flat field near the town of Chetwynd
Tree Canopy	Open; Aspen tress at the edge of field are about 20 m away to the south
Nearby Sources	The town of Chetwynd, lumber mill, unpaved roads, vehicle traffic, wood burning stoves

Pictures

Direction Looking	Recorded?	Picture ID
North	Y	16DistofChet_North
East	Y	16DistofChet_East
South	Y	16DistofChet_South
West	Y	16DistofChet_West
Access from Hwy	Y	
Other Pictures of Interest	N	

Access

Describe the access to the site and any signs or markers used to identify the site

Turn west off the John Hart Hwy on to 53 Ave at the Days Inn. Follow 53 Ave until it turns into Girwin Rd and 45a St. Follow Girwin Rd all the way to the end, approximately 2 minutes, until a yellow gate is reached. The site is 500 along the road inside the yellow gate near a small grey brick utility building. The gate is locked overnight and on weekends.

Date & Time of Deployment (LST)	1620 MST October 31, 2012
Field Crew Leader	Wade Gieni

Appendix C Sharp and GRIMM PM Monitor Time Series

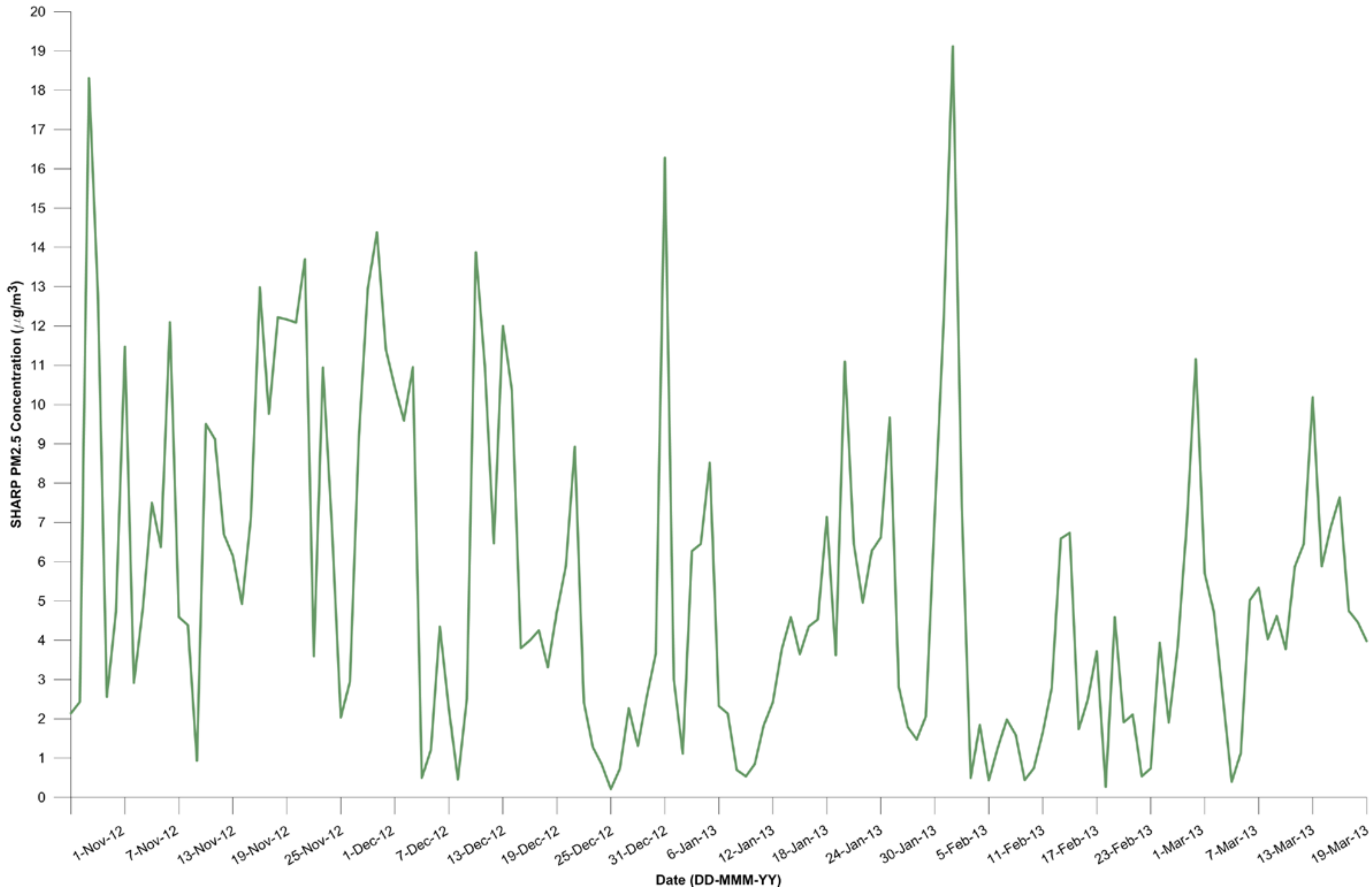


Figure C-1 SHARP PM Monitor 24-Hour Average $PM_{2.5}$ Concentrations from November 2012 to March 2013

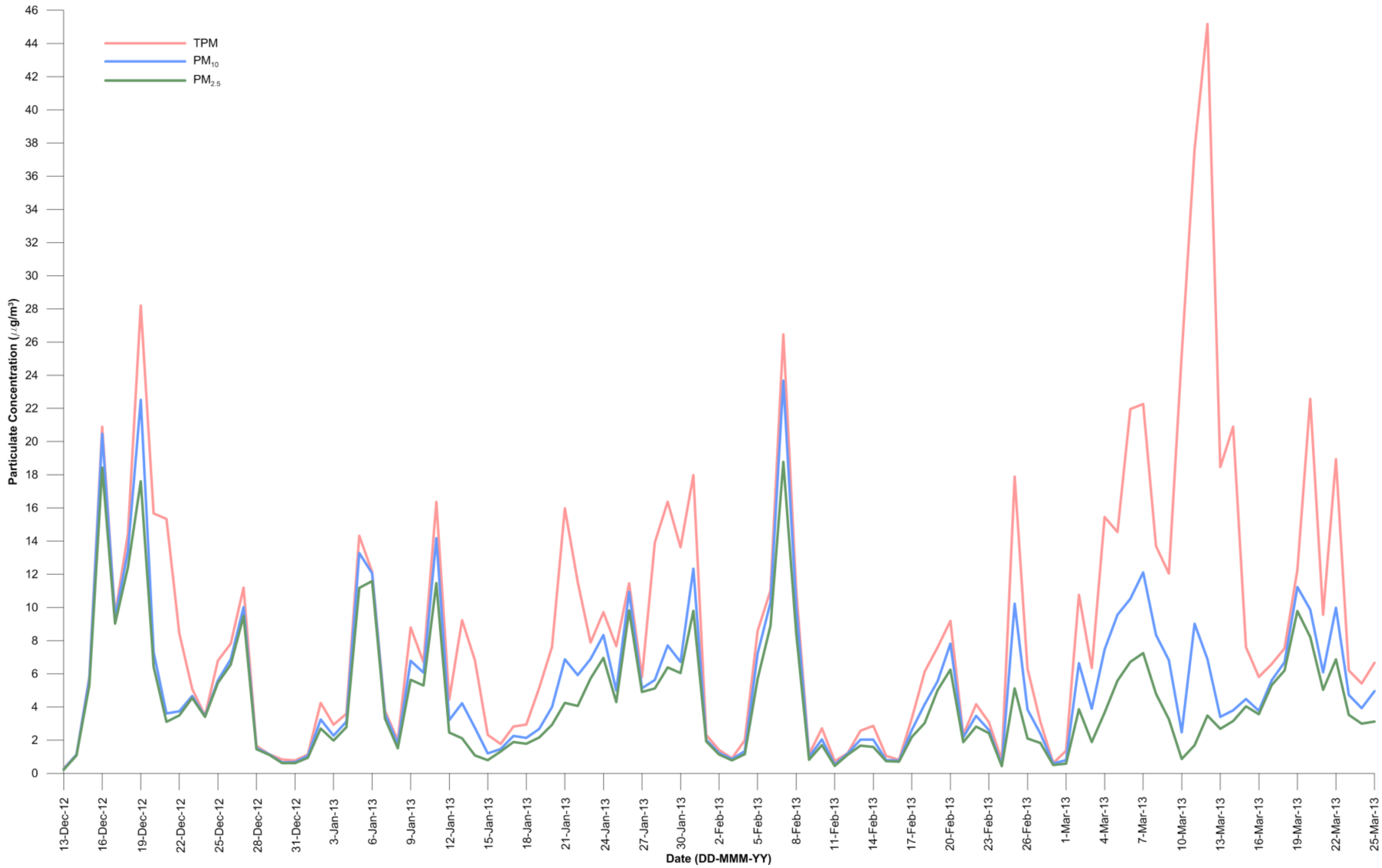


Figure C-2 GRIMM PM Monitor 24-Hour Average TSP, PM_{10}, and $PM_{2.5}$ Concentrations from December 2012 to March 2013

Appendix D Dustfall Lab Reports

STANTEC INC.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 24-SEP-12
Report Date: 03-OCT-12 11:53 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: L1213614

Project P.O. #: NOT SUBMITTED
Job Reference: 1231-10480
C of C Numbers: 10-270438, 10-270439
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1213614-1	L1213614-2	L1213614-3	L1213614-4	L1213614-5
	Description	Dustfall	Dustfall	Dustfall	Dustfall	Dustfall
	Sampled Date	20-SEP-12	20-SEP-12	19-SEP-12	19-SEP-12	20-SEP-12
	Sampled Time	13:40	16:10	16:20	04:45	18:10
	Client ID	01 BEAUDETTE CREEK 1	02 EXPLORATION CAMP	03 WETLAND	04 BRAZION CREEK	06 BEAUDETTE CREEK 2
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.40	1.04	0.45	0.47	1.15
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	0.89	0.12	<0.10	0.77
	Total Soluble Dustfall (mg/dm2.day)	0.31	0.15	0.33	0.43	0.37

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1213614-6	L1213614-7	L1213614-8	L1213614-9	L1213614-10
	Sample ID	L1213614-6	L1213614-7	L1213614-8	L1213614-9	L1213614-10
	Description	Dustfall	Dustfall	Dustfall	Dustfall	Dustfall
	Sampled Date	19-SEP-12	17-SEP-12	17-SEP-12	19-SEP-12	19-SEP-12
	Sampled Time	17:40	09:30	15:05	11:20	11:55
	Client ID	07 HASLER CREEK	08 NORTH BURNT RIVER	09 SKEETER CREEK	11 CHAMBERLAIN CREEK	12 BULLMOOSE CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.64	0.22	0.24	0.37	0.22
	Total Insoluble Dustfall (mg/dm2.day)	0.23	0.14	0.14	<0.10	0.17
	Total Soluble Dustfall (mg/dm2.day)	0.41	<0.10	<0.10	0.31	<0.10

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1213614-11	L1213614-12			
	Description	Dustfall	Dustfall			
	Sampled Date	17-SEP-12	17-SEP-12			
	Sampled Time	10:15	11:00			
	Client ID	13 SUKUNKA RIVER	14 WINDFALL CREEK			
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.88	0.49			
	Total Insoluble Dustfall (mg/dm2.day)	0.43	0.23			
	Total Soluble Dustfall (mg/dm2.day)	0.46	0.25			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate."
Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-270438 10-270439

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-270438

ALS Environmental

Chain of Custody / Analytic
Canada Toll Free: 1 8(
www.alsglobal.(

L1213614-COFC

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	STANTEC	Standard: ✓ Other (specify):		✓ Regular (Standard Turnaround Times - Business Days)
Contact:	DAN JARRATT	Select: PDF ✓ Excel ✓ Digital Fax		Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	805 8TH AVE SOUTHWEST SUITE 300 CALGARY, AB T2P 1H7	Email 1:		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: (403) 441-5064	Fax: (403) 269-5245			Analysis Request
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1231-10480	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	L1213614	ALS Contact: BRENT MACK	Sampler: C. DOUGHTY W. GIENI.	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TOTAL PARTICULATE	SOLUBLE PARTICULATE	INSOLUBLE PARTICULATE										Number of Containers
	01 BEAUDETTE CREEK 1	20-SEP-12	13:40	DUSTFALL	✓	✓	✓										1
	02 EXPLORATION CAMP	20-SEP-12	16:10	"	✓	✓	✓										1
	03 WETLAND	19-SEP-12	16:20	"	✓	✓	✓										1
	04 BRAZION CREEK	19-SEP-12	16:45	"	✓	✓	✓										1
	06 BEAUDETTE CREEK 2	20-SEP-12	18:10	"	✓	✓	✓										1
	07 HASLER CREEK	19-SEP-12	17:40	"	✓	✓	✓										1
	08 NORTH BURNT RIVER	17-SEP-12	09:30	"	✓	✓	✓										1

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: CHRIS DOUGHTY	Date: 21 SEP 12	Time: 09:15	Received by: BP	Date: Sept. 24	Time: 10:50	Temperature: 18.3 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

10-270439

ALS Environmental

Chain of Custody / Analyt
Canada Toll Free: 1
www.alsgloba

L1213614-COFC

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)
Company: STANTEC		Standard: ✓ Other (specify):		✓ Regular (Standard Turnaround Times - Business Days)
Contact: DAN JARRATT		Select: PDF ✓ Excel ✓ Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address: 805 8TH AVENUE SOUTH WEST SUITE 300 CALGARY AB, T2P 1H7		Email 1:		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Phone: (403) 441-5084	Fax: (403) 269-5245	Email 2:		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Invoice To: Same as Report ? (circle) Yes or No (if No, provide details)		Client / Project Information		Analysis Request (Indicate Filtered or Preserved, F/P)
Copy of Invoice with Report? (circle) Yes or No		Job #: 1231 - 10482		
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	L1213614	ALS Contact: BRENT MACK	Sampler: C. DOUGHTY W. GIENI	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TOTAL PARTICULATE	SOLUBLE PARTICULATE	INSOLUBLE PARTICULATE										Number of Containers
	09 SKEETER CREEK	17-SEP-12	15:05	DUSTFALL	✓	✓	✓										1
	11 CHAMBERLAIN CREEK	19-SEP-12	11:20	"	✓	✓	✓										1
	12 BULLMOOSE CREEK	19-SEP-12	11:55	"	✓	✓	✓										1
	13 SUKUNKA RIVER	17-SEP-12	10:15	"	✓	✓	✓										1
	14 WINDFALL CREEK	17-SEP-12	11:00	"	✓	✓	✓										1

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: CHRIS DOUGHTY	Date: 21 SEP 12	Time: 09:15	Received by: BP	Date: Sept. 24	Time: 10:50	Temperature: 18.3 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 26-OCT-12
Report Date: 02-NOV-12 15:13 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: L1229737

Project P.O. #: NOT SUBMITTED
Job Reference: JAC300-FCC200-VA
C of C Numbers: 10-273109
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1229737-1	L1229737-2	L1229737-3	L1229737-4	L1229737-5
	Sample ID	L1229737-1	L1229737-2	L1229737-3	L1229737-4	L1229737-5
	Description	123110482	123110482	123110482	123110482	123110482
	Sampled Date					
	Sampled Time					
	Client ID	9 SKEETER CREEK	11 CHABALIAN CREEK	12 BULLMOOSE CREEK	13 SUSKEENA RIVER	14 WINDFALL CREEK
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.76	0.20	1.36	0.36	0.33
	Total Insoluble Dustfall (mg/dm2.day)	0.56	<0.10	0.83	0.20	0.15
	Total Soluble Dustfall (mg/dm2.day)	0.19	0.18	0.52	0.16	0.18
Metals	Aluminum (Al)-Total (mg/dm2.day)	0.000844	0.00039	0.000513	0.000876	0.000250
	Antimony (Sb)-Total (mg/dm2.day)	<0.0000022	<0.0000039	<0.0000028	<0.0000019	<0.0000029
	Arsenic (As)-Total (mg/dm2.day)	<0.0000022	<0.0000039	<0.0000028	<0.0000019	<0.0000029
	Barium (Ba)-Total (mg/dm2.day)	0.0000586	0.0000243	0.0000194	0.0000431	0.0000148
	Beryllium (Be)-Total (mg/dm2.day)	<0.000011	<0.000020	<0.000014	<0.0000097	<0.000015
	Bismuth (Bi)-Total (mg/dm2.day)	<0.000011	<0.000020	<0.000014	<0.0000097	<0.000015
	Boron (B)-Total (mg/dm2.day)	<0.00022	<0.00039	<0.00028	<0.00019	<0.00029
	Cadmium (Cd)-Total (mg/dm2.day)	0.0000048	<0.0000020	<0.0000014	<0.00000097	<0.0000015
	Calcium (Ca)-Total (mg/dm2.day)	0.00584	DLB <0.0031	DLB <0.0023	0.00916	DLB <0.0029
	Chromium (Cr)-Total (mg/dm2.day)	<0.000011	<0.000020	<0.000014	<0.0000097	<0.000015
	Cobalt (Co)-Total (mg/dm2.day)	<0.0000022	<0.0000039	<0.0000028	<0.0000019	<0.0000029
	Copper (Cu)-Total (mg/dm2.day)	DLB <0.00012	DLB <0.00043	DLB <0.00023	DLB <0.00019	DLB <0.00018
	Lead (Pb)-Total (mg/dm2.day)	0.0000034	0.0000029	0.0000019	0.00000282	0.0000020
	Lithium (Li)-Total (mg/dm2.day)	<0.00011	<0.00020	<0.00014	<0.000097	<0.00015
	Magnesium (Mg)-Total (mg/dm2.day)	0.00212	0.00038	0.00043	0.00157	0.00041
	Manganese (Mn)-Total (mg/dm2.day)	0.0000774	0.0000607	0.0000365	0.0000752	0.0000317
	Molybdenum (Mo)-Total (mg/dm2.day)	<0.0000011	<0.0000020	<0.0000014	<0.00000097	<0.0000015
	Nickel (Ni)-Total (mg/dm2.day)	<0.000011	<0.000020	<0.000014	DLB <0.000029	<0.000015
	Potassium (K)-Total (mg/dm2.day)	0.0074	<0.0020	<0.0014	<0.00097	<0.0015
	Selenium (Se)-Total (mg/dm2.day)	<0.000022	<0.000039	<0.000028	<0.000019	<0.000029
	Silver (Ag)-Total (mg/dm2.day)	<0.00000022	<0.00000039	<0.00000028	<0.00000019	<0.00000029
	Sodium (Na)-Total (mg/dm2.day)	0.0019	<0.0020	<0.0014	<0.00097	<0.0015
	Strontium (Sr)-Total (mg/dm2.day)	DLB <0.000013	DLB <0.0000079	DLB <0.0000071	0.0000182	DLB <0.0000073
	Thallium (Tl)-Total (mg/dm2.day)	<0.0000022	<0.0000039	<0.0000028	<0.0000019	<0.0000029
	Tin (Sn)-Total (mg/dm2.day)	<0.0000022	<0.0000039	<0.0000028	<0.0000019	<0.0000029
	Uranium (U)-Total (mg/dm2.day)	<0.00000022	<0.00000039	<0.00000028	<0.00000019	<0.00000029
	Vanadium (V)-Total (mg/dm2.day)	<0.000022	<0.000039	<0.000028	<0.000019	<0.000029
	Zinc (Zn)-Total (mg/dm2.day)	0.000092	0.00019	<0.000085	0.000089	<0.000088

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLB	Detection limit was raised due to detection of analyte at comparable level in Method Blank.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate."
Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DUST(DM2)-MS-VA	Dustfall	Total Metals in Dustfalls by ICPMS	EPA 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-273109

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-273109

L1229737-COFC

ALS Environmental

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Page 1 of 1

Report To	
Company:	STANTEC CONSULTING Ltd
Contact:	Daniel Jarrette
Address:	805 8 Avenue Suite 300 Calgary AB
Phone:	403 441 5084 Fax: 403 269 5245

Report Format / Distribution

Standard: ✓ Other (specify):

Select: PDF ✓ Excel ✓ Digital Fax

Email 1: dan.jarrette@stantec.com

Email 2: wade.green@stantec.com

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- ✓ Regular (Standard Turnaround Times - Business Days)
- Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or No (if No, provide details)

Copy of Invoice with Report? (circle) Yes or No

Company:
Contact:
Address:
Phone: Fax:

Client / Project Information

Job #: 123110482 Sukunka

PO / AFE:

LSD:

Quote #:

Lab Work Order # (lab use only): L1229737

ALS Contact:

Sampler: Wade Green, Chris Doughty

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Soluble + AS-BULK Dustfall ASTM D1739	Total Metals in Dustfall by ICPMS	Number of Containers
	9 Skeeter Creek	17Sep-21Oct	2505/1510	DUSTFALL	1	1	2
	11 Chamberlain Creek	19Sep-23Oct	1120/930	"	1	1	2
	12 Bullmoose Creek	19Sep-23Oct	1155/1035	"	1	1	2
	13 Suskanka River	17Sep-21Oct	1015/1105	"	1	1	2
	14 Windfall Creek	17Sep-21Oct	1100/1220	"	1	1	2

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Wade Green	Date: 24Oct12	Time: 1030	Received by: TN	Date: Oct 26	Time: 12:45	Temperature: 6 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 27-NOV-12
Report Date: 03-DEC-12 10:49 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: **L1242290**

Project P.O. #: NOT SUBMITTED
Job Reference: 123110482
C of C Numbers: 10-282411
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1242290-1	L1242290-2	L1242290-3	L1242290-4	L1242290-5
	Description	dustfall	dustfall	dustfall	dustfall	dustfall
	Sampled Date					
	Sampled Time					
	Client ID	09 SKEETER CREEK 21-0CT TO 23-NOV	11 CHAMBERLAIN CREEK 23-OCT TO 24-NOV	12 BULLMOOSE CREEK 23-NOV-24-NOV	13 SUKUNKE RIVER 21-OCT-23-NOV	14 WINDFALL CREEK 21-OCT TO 23-NOV
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.36	0.13	0.11	0.12	0.19
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.10	<0.10	<0.10
	Total Soluble Dustfall (mg/dm2.day)	0.27	0.13	0.11	<0.10	0.14
Metals	Aluminum (Al)-Total (mg/dm2.day)					
	Antimony (Sb)-Total (mg/dm2.day)					
	Arsenic (As)-Total (mg/dm2.day)					
	Barium (Ba)-Total (mg/dm2.day)					
	Beryllium (Be)-Total (mg/dm2.day)					
	Bismuth (Bi)-Total (mg/dm2.day)					
	Boron (B)-Total (mg/dm2.day)					
	Cadmium (Cd)-Total (mg/dm2.day)					
	Calcium (Ca)-Total (mg/dm2.day)					
	Chromium (Cr)-Total (mg/dm2.day)					
	Cobalt (Co)-Total (mg/dm2.day)					
	Copper (Cu)-Total (mg/dm2.day)					
	Lead (Pb)-Total (mg/dm2.day)					
	Lithium (Li)-Total (mg/dm2.day)					
	Magnesium (Mg)-Total (mg/dm2.day)					
	Manganese (Mn)-Total (mg/dm2.day)					
	Molybdenum (Mo)-Total (mg/dm2.day)					
	Nickel (Ni)-Total (mg/dm2.day)					
	Potassium (K)-Total (mg/dm2.day)					
	Selenium (Se)-Total (mg/dm2.day)					
	Silver (Ag)-Total (mg/dm2.day)					
	Sodium (Na)-Total (mg/dm2.day)					
	Strontium (Sr)-Total (mg/dm2.day)					
	Thallium (Tl)-Total (mg/dm2.day)					
	Tin (Sn)-Total (mg/dm2.day)					
	Uranium (U)-Total (mg/dm2.day)					
	Vanadium (V)-Total (mg/dm2.day)					
	Zinc (Zn)-Total (mg/dm2.day)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	
	Sample ID	L1242290-6
	Description	dustfall
	Sampled Date	
	Sampled Time	
	Client ID	16 DISTRICT OF CHETWYND FIAR FIALL 31-OCT TO 21-NOV
DUSTFALL		
Particulates	Total Dustfall (mg/dm2.day)	0.17
	Total Insoluble Dustfall (mg/dm2.day)	<0.14
	Total Soluble Dustfall (mg/dm2.day)	<0.14
Metals	Aluminum (Al)-Total (mg/dm2.day)	0.000895
	Antimony (Sb)-Total (mg/dm2.day)	<0.0000028
	Arsenic (As)-Total (mg/dm2.day)	0.0000052
	Barium (Ba)-Total (mg/dm2.day)	0.000302
	Beryllium (Be)-Total (mg/dm2.day)	<0.000014
	Bismuth (Bi)-Total (mg/dm2.day)	<0.000014
	Boron (B)-Total (mg/dm2.day)	<0.00028
	Cadmium (Cd)-Total (mg/dm2.day)	<0.0000014
	Calcium (Ca)-Total (mg/dm2.day)	0.0181
	Chromium (Cr)-Total (mg/dm2.day)	<0.000014
	Cobalt (Co)-Total (mg/dm2.day)	<0.0000028
	Copper (Cu)-Total (mg/dm2.day)	0.000481
	Lead (Pb)-Total (mg/dm2.day)	DLB <0.0000056
	Lithium (Li)-Total (mg/dm2.day)	<0.00014
	Magnesium (Mg)-Total (mg/dm2.day)	0.00221
	Manganese (Mn)-Total (mg/dm2.day)	0.000546
	Molybdenum (Mo)-Total (mg/dm2.day)	<0.0000014
	Nickel (Ni)-Total (mg/dm2.day)	DLB <0.00026
	Potassium (K)-Total (mg/dm2.day)	0.0015
	Selenium (Se)-Total (mg/dm2.day)	<0.000028
	Silver (Ag)-Total (mg/dm2.day)	0.00000035
	Sodium (Na)-Total (mg/dm2.day)	0.0024
	Strontium (Sr)-Total (mg/dm2.day)	0.0000414
	Thallium (Tl)-Total (mg/dm2.day)	<0.0000028
	Tin (Sn)-Total (mg/dm2.day)	<0.0000028
	Uranium (U)-Total (mg/dm2.day)	<0.00000028
	Vanadium (V)-Total (mg/dm2.day)	<0.000028
	Zinc (Zn)-Total (mg/dm2.day)	DLB <0.00033

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLB	Detection limit was raised due to detection of analyte at comparable level in Method Blank.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate."
Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DUST(DM2)-MS-VA	Dustfall	Total Metals in Dustfalls by ICPMS	EPA 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-282411

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L1242290-COFC

10-282411

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ___ of ___

Report To
Company: STANTEC
Contact: DANIEL JARATT
Address: 805 8 AVENUE SW
CALGARY AB
Phone: 403 678 9304 Fax: 403 269 8240

Report Format / Distribution
Standard: X Other (specify):
Select: PDF X Excel Digital Fax
Email 1: dan.jaratt@stantec.com
Email 2:

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
✓ Regular (Standard Turnaround Times - Business Days)
Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or No (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No
Company:
Contact:
Address:
Phone: Fax:

Client / Project Information
Job #: 123110482
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only) L1242290.

ALS Contact:
Sampler:

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TOTAL SOLUBLE + INSOLUBLE DUSTFALL	TOTAL SOLUBLE + INSOL METALS IN DUSTFALL											Number of Containers
1	09 SKEETER CREEK	21 OCT 12 23 NOV 12	1510 1114	DUSTFALL	1												1
2	11 Chamberlain Creek	23 OCT 12 - 21 NOV 12	0930 1200	Dustfall	1												1
3	12 Bullmoose Creek	23 NOV 12 - 24 NOV 12	1035 1130	Dustfall	1												1
4	13 Sukunka River	21 OCT 12 - 23 NOV 12	1555 9:45	DUSTFALL	1												1
5	14 Windfall Creek	21 OCT 12 - 23 NOV 12	1220 1345	Dustfall	1												1
6	District of Chetwynd FAR FALL	31 OCT 12 21 NOV 12	1600 1700	Dustfall	1	1											2

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by: BP	Date: Nov. 27	Time: 8:40	Temperature: 7.8/7.1°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY   GENF 18.01 Front

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 08-JAN-13
Report Date: 11-JAN-13 12:41 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: L1255525

Project P.O. #: task 320.200
Job Reference: 123110480
C of C Numbers: 10-296501, 10-296502
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1255525-1	L1255525-2	L1255525-3	L1255525-4	L1255525-5
	Description	dustfall	dustfall	dustfall	dustfall	dustfall
	Sampled Date	06-JAN-13	04-JAN-13	06-JAN-13	06-JAN-13	06-JAN-13
	Sampled Time	13:30	15:00	15:15	15:35	10:00
	Client ID	01 BEAUDETTE CREEK 1	02 SUSKA EXPLORATION CAMP	03 WETLAND	04 BRAZION CREEK	06 BEAUDETTE CREEK 2
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	<0.10	<0.10	0.12	<0.10	0.42
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.10	<0.10	0.30
	Total Soluble Dustfall (mg/dm2.day)	<0.10	<0.10	0.11	<0.10	0.12

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1255525-6	L1255525-7	L1255525-8	L1255525-9	L1255525-10
	Description	dustfall	dustfall	dustfall	dustfall	dustfall
	Sampled Date	04-JAN-13	03-JAN-13	03-JAN-13	05-JAN-13	05-JAN-13
	Sampled Time	17:30	10:30	12:40	14:25	12:15
	Client ID	07 HASLER CREEK	08 NORTH BRUNT RIVER	09 SKEETER CREEK	11 CHAMBERLAIN CREEK	12 BULLMOOSE CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.23	<0.10	<0.10	<0.10	0.14
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.10	<0.10	<0.10
	Total Soluble Dustfall (mg/dm2.day)	0.19	<0.10	<0.10	<0.10	0.13

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1255525-11	L1255525-12	L1255525-13		
	Description	dustfall	dustfall	dustfall		
	Sampled Date	03-JAN-13	03-JAN-13	03-JAN-13		
	Sampled Time	11:30	14:50	17:30		
	Client ID	13 SUKUNKA RIVER	14 WINDFALL CREEK	CHETWYND FAR FIELD		
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.19	0.17	0.24		
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.10		
	Total Soluble Dustfall (mg/dm2.day)	0.17	0.15	0.14		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate." Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-296501 10-296502

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 296502

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To	**Report Format / Distribution**
Company: Stantec	Standard: ✓ Other (specify):
Contact: Daniel Jarrett	Select: PDF ✓ Excel ✓ Digital Fax
Address: 805 8th Avenue South West Ste 300 Calgary AB T2P 1H7	Email 1: daniel.jarrett@stantec.com
Phone: 403-441-5064 Fax: 403-269-5245	Email 2:
Invoice To Same as Report ? (circle) Yes or No (if No, provide details)	**Client / Project Information**
Copy of Invoice with Report? (circle) Yes or No	Job #: 123110480 / ~~[illegible]~~
Company:	PO / AFE: task 320.200
Contact:	LSD:
Address:	
Phone: Fax:	Quote #:
Lab Work Order # (lab use only) L1255525	ALS Contact: Brent Mack — Sampler:

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
- Regular (Standard Turnaround Times - Business Days)
- Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request
(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TOTAL PARTICULATE	SOLUBLE PARTICULATE	INSOLUBLE PARTICULATE	Number of Containers
	01 BEAUDETTE CREEK 1	06-JAN-13	13:30	DUSTFALL	✓	✓	✓	1
	02 SUSKA EXPLORATION CAMP	04-JAN-13	15:00	"	✓	✓	✓	1
	03 WETLAND	06-JAN-13	15:15	"	✓	✓	✓	1
	04 BRAZION CREEK	06-JAN-13	13:35	"	✓	✓	✓	1
	06 BEAUDETTE CREEK 2	06-JAN-13	10:00	"	✓	✓	✓	1
	07 HASLER CREEK	04-JAN-13	17:30	"	✓	✓	✓	1
	08 NORTH BURNT RIVER	03-JAN-13	10:30	"	✓	✓	✓	1

L1255525-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 7 Jan 13	Time: 1200	Received by: Brittany	Date: Jan. 8	Time: 9:00	Temperature: 6.1 / 5.6°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

10- 296501

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To		**Report Format / Distribution**	
Company: Stantec		Standard: ✓ Other (specify):	
Contact: Daniel Jarratt		Select: PDF ✓ Excel ✓ Digital Fax	
Address: 805 8th Ave. South West Ste 300 Calgary AB T2P 1H7		Email 1: daniel.jarratt@stantec.com	
		Email 2:	
Phone: 403-441-5064	Fax: 403-269-5245		
Invoice To Same as Report ? (circle) Yes or No (if No, provide details)		**Client / Project Information**	
Copy of Invoice with Report? (circle) Yes or No		Job #: 123110482 / 123110483	
Company:		PO / AFE: task 320.200	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Brent Mack	Sampler:

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- Regular (Standard Turnaround Times - Business Days)
- Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request
(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TOTAL PARTICULATE	SOLUBLE PARTICULATE	INSOLUBLE PARTICULATE	Number of Containers
	09 SKEETER CREEK	03-JAN-13	12:40	DUSTFALL	✓	✓	✓	1
	11 CHAMBERLAIN CREEK	05-JAN-13	14:25	"	✓	✓	✓	1
	12 BULLMOOSE CREEK	05-JAN-13	12:15	"	✓	✓	✓	1
	13 SUKUNKA RIVER	03-JAN-13	11:30	"	✓	✓	✓	1
	14 WINDFALL CREEK	05-JAN-13	14:50	"	✓	✓	✓	1
	CHETWYND FAR FIELD	06-JAN-13	17:30	"	✓	✓	✓	1

L1255525-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 7 Jan 13	Time: 1200	Received by: Brittany	Date: Jan. 8	Time: 9:00	Temperature: 6.1/5.6°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY GENF 18.01 Front

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 05-FEB-13
Report Date: 15-FEB-13 15:24 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: L1265141

Project P.O. #:	NOT SUBMITTED
Job Reference:	123110480 TASK 320.200
C of C Numbers:	10-291932, 10-291933, 10-291934, 10-291935
Legal Site Desc:	

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1265141-1	L1265141-2	L1265141-3	L1265141-4	L1265141-5
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL
	Sampled Date	30-JAN-13	29-JAN-13	30-JAN-13	01-FEB-13	30-JAN-13
	Sampled Time	16:50	11:00	16:15	09:55	13:30
	Client ID	01 BEAUDETTE CREEK 1	02 SUSKA EXPLORATION CAMP	03 WETLAND	04 BRAZLON CREEK	06 BEAUDETTE CREEK 2
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	<0.13	0.20	<0.13	0.13	1.68
	Total Insoluble Dustfall (mg/dm2.day)	<0.13	<0.12	<0.13	<0.12	1.18
	Total Soluble Dustfall (mg/dm2.day)	<0.13	<0.12	<0.13	<0.12	0.50
Metals	Aluminum (Al)-Total (mg/dm2.day)					
	Antimony (Sb)-Total (mg/dm2.day)					
	Arsenic (As)-Total (mg/dm2.day)					
	Barium (Ba)-Total (mg/dm2.day)					
	Beryllium (Be)-Total (mg/dm2.day)					
	Bismuth (Bi)-Total (mg/dm2.day)					
	Boron (B)-Total (mg/dm2.day)					
	Cadmium (Cd)-Total (mg/dm2.day)					
	Calcium (Ca)-Total (mg/dm2.day)					
	Chromium (Cr)-Total (mg/dm2.day)					
	Cobalt (Co)-Total (mg/dm2.day)					
	Copper (Cu)-Total (mg/dm2.day)					
	Lead (Pb)-Total (mg/dm2.day)					
	Lithium (Li)-Total (mg/dm2.day)					
	Magnesium (Mg)-Total (mg/dm2.day)					
	Manganese (Mn)-Total (mg/dm2.day)					
	Molybdenum (Mo)-Total (mg/dm2.day)					
	Nickel (Ni)-Total (mg/dm2.day)					
	Potassium (K)-Total (mg/dm2.day)					
	Selenium (Se)-Total (mg/dm2.day)					
	Silver (Ag)-Total (mg/dm2.day)					
	Sodium (Na)-Total (mg/dm2.day)					
	Strontium (Sr)-Total (mg/dm2.day)					
	Thallium (Tl)-Total (mg/dm2.day)					
	Tin (Sn)-Total (mg/dm2.day)					
	Uranium (U)-Total (mg/dm2.day)					
	Vanadium (V)-Total (mg/dm2.day)					
	Zinc (Zn)-Total (mg/dm2.day)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1265141-6	L1265141-7	L1265141-8	L1265141-9	L1265141-10
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL
	Sampled Date	29-JAN-13	29-JAN-13	30-JAN-13	29-JAN-13	30-JAN-13
	Sampled Time	15:30	18:00	16:50	11:00	16:15
	Client ID	07 HASLER CREEK	08 NORTH BURNT RIVER	01-M BEAUDETTE CREEK 1	02-M SUSKA EXPLORATION CAMP	03-M WETLAND
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.20	0.24			
	Total Insoluble Dustfall (mg/dm2.day)	0.14	0.15			
	Total Soluble Dustfall (mg/dm2.day)	<0.12	<0.12			
Metals	Aluminum (Al)-Total (mg/dm2.day)			0.000299	0.000599	0.000154
	Antimony (Sb)-Total (mg/dm2.day)			0.0000050	0.0000019	<0.0000015
	Arsenic (As)-Total (mg/dm2.day)			0.0000863	0.0000057	0.0000017
	Barium (Ba)-Total (mg/dm2.day)			DLB <0.000015	0.0000190	DLB <0.0000074
	Beryllium (Be)-Total (mg/dm2.day)			<0.000015	<0.0000091	<0.0000074
	Bismuth (Bi)-Total (mg/dm2.day)			<0.000015	<0.0000091	<0.0000074
	Boron (B)-Total (mg/dm2.day)			<0.00030	<0.00018	<0.00015
	Cadmium (Cd)-Total (mg/dm2.day)			<0.0000015	<0.00000091	<0.00000074
	Calcium (Ca)-Total (mg/dm2.day)			0.00207	0.00424	0.00081
	Chromium (Cr)-Total (mg/dm2.day)			<0.000015	<0.0000091	<0.0000074
	Cobalt (Co)-Total (mg/dm2.day)			<0.0000030	<0.0000018	<0.0000015
	Copper (Cu)-Total (mg/dm2.day)			0.000369	0.0000340	0.0000481
	Lead (Pb)-Total (mg/dm2.day)			DLB <0.000015	DLB <0.0000073	DLB <0.0000044
	Lithium (Li)-Total (mg/dm2.day)			<0.00015	<0.000091	<0.000074
	Magnesium (Mg)-Total (mg/dm2.day)			0.00031	0.000642	0.000143
	Manganese (Mn)-Total (mg/dm2.day)			0.0000501	0.0000322	0.0000163
	Molybdenum (Mo)-Total (mg/dm2.day)			<0.0000015	<0.00000091	<0.00000074
	Nickel (Ni)-Total (mg/dm2.day)			<0.000015	<0.0000091	<0.0000074
	Potassium (K)-Total (mg/dm2.day)			<0.0015	<0.00091	<0.00074
	Selenium (Se)-Total (mg/dm2.day)			<0.000030	<0.000018	<0.000015
	Silver (Ag)-Total (mg/dm2.day)			<0.00000030	<0.00000018	<0.00000015
	Sodium (Na)-Total (mg/dm2.day)			<0.0015	<0.00091	<0.00074
	Strontium (Sr)-Total (mg/dm2.day)			0.0000047	0.0000078	0.0000023
	Thallium (Tl)-Total (mg/dm2.day)			<0.0000030	<0.0000018	<0.0000015
	Tin (Sn)-Total (mg/dm2.day)			<0.0000030	<0.0000018	<0.0000015
	Uranium (U)-Total (mg/dm2.day)			<0.00000030	<0.00000018	<0.00000015
	Vanadium (V)-Total (mg/dm2.day)			<0.000030	<0.000018	<0.000015
	Zinc (Zn)-Total (mg/dm2.day)			0.000102	<0.000055	<0.000044

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1265141-11	L1265141-12	L1265141-13	L1265141-14	L1265141-15
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL
	Sampled Date	01-FEB-13	30-JAN-13	29-JAN-13	29-JAN-13	31-JAN-13
	Sampled Time	09:55	13:30	15:30	18:00	16:55
	Client ID	04-M BRAZLON CREEK	06-M BEAUDETTE CREEK 2	07-M HASLER CREEK	08-M NORTH BURNT RIVER	09 SKEETER CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)					<0.11
	Total Insoluble Dustfall (mg/dm2.day)					<0.11
	Total Soluble Dustfall (mg/dm2.day)					<0.11
Metals	Aluminum (Al)-Total (mg/dm2.day)	0.000148	0.00769	0.00162	0.00146	
	Antimony (Sb)-Total (mg/dm2.day)	<0.0000013	0.0000044	0.0000023	<0.0000020	
	Arsenic (As)-Total (mg/dm2.day)	<0.0000013	0.0000297	0.0000142	0.0000072	
	Barium (Ba)-Total (mg/dm2.day)	DLB <0.0000067	0.000945	0.000134	0.0000552	
	Beryllium (Be)-Total (mg/dm2.day)	<0.0000067	<0.0000095	<0.000010	<0.0000098	
	Bismuth (Bi)-Total (mg/dm2.day)	<0.0000067	<0.0000095	<0.000010	<0.0000098	
	Boron (B)-Total (mg/dm2.day)	<0.00013	<0.00019	<0.00021	<0.00020	
	Cadmium (Cd)-Total (mg/dm2.day)	<0.00000067	0.00000100	<0.0000010	<0.00000098	
	Calcium (Ca)-Total (mg/dm2.day)	0.00066	0.0588	0.0115	0.00447	
	Chromium (Cr)-Total (mg/dm2.day)	<0.0000067	0.0000194	<0.000010	<0.0000098	
	Cobalt (Co)-Total (mg/dm2.day)	<0.0000013	0.0000084	<0.0000021	<0.0000020	
	Copper (Cu)-Total (mg/dm2.day)	0.0000326	0.000151	0.000037	0.0000637	
	Lead (Pb)-Total (mg/dm2.day)	DLB <0.0000053	DLB <0.000017	DLB <0.0000041	DLB <0.0000039	
	Lithium (Li)-Total (mg/dm2.day)	<0.000067	<0.000095	<0.00010	<0.000098	
	Magnesium (Mg)-Total (mg/dm2.day)	0.000107	0.00855	0.00172	0.00111	
	Manganese (Mn)-Total (mg/dm2.day)	DLB <0.000013	0.00216	0.000452	0.0000785	
	Molybdenum (Mo)-Total (mg/dm2.day)	<0.00000067	0.00000420	<0.0000010	<0.00000098	
	Nickel (Ni)-Total (mg/dm2.day)	<0.0000067	0.0000410	<0.000010	<0.0000098	
	Potassium (K)-Total (mg/dm2.day)	<0.00067	0.0111	0.0023	<0.00098	
	Selenium (Se)-Total (mg/dm2.day)	<0.000013	<0.000019	<0.000021	<0.000020	
	Silver (Ag)-Total (mg/dm2.day)	<0.00000013	0.00000058	<0.00000021	<0.00000020	
	Sodium (Na)-Total (mg/dm2.day)	<0.00067	<0.00095	<0.0010	<0.00098	
	Strontium (Sr)-Total (mg/dm2.day)	0.0000018	0.000126	0.0000209	0.0000100	
	Thallium (Tl)-Total (mg/dm2.day)	<0.0000013	<0.0000019	<0.0000021	<0.0000020	
	Tin (Sn)-Total (mg/dm2.day)	<0.0000013	<0.0000019	<0.0000021	<0.0000020	
	Uranium (U)-Total (mg/dm2.day)	<0.00000013	0.00000100	<0.00000021	<0.00000020	
	Vanadium (V)-Total (mg/dm2.day)	<0.000013	0.000048	<0.000021	<0.000020	
	Zinc (Zn)-Total (mg/dm2.day)	<0.000040	0.000182	0.000076	<0.000059	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1265141-16	L1265141-17	L1265141-18	L1265141-19	L1265141-20
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL
	Sampled Date	01-FEB-13	31-JAN-13	01-FEB-13	30-JAN-13	31-JAN-13
	Sampled Time	14:00	18:15	13:25	09:40	16:55
	Client ID	12 BULLMOOSE CREEK	13 SUKUNKA CREEK	14 WINDFALL CREEK	16 CHETWYND FARFIELD	09-M SKEETER CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	<0.11	0.15	<0.11	0.18	
	Total Insoluble Dustfall (mg/dm2.day)	<0.11	0.15	<0.11	0.16	
	Total Soluble Dustfall (mg/dm2.day)	<0.11	<0.11	<0.11	<0.13	
Metals	Aluminum (Al)-Total (mg/dm2.day)					0.000467
	Antimony (Sb)-Total (mg/dm2.day)					<0.0000016
	Arsenic (As)-Total (mg/dm2.day)					0.0000038
	Barium (Ba)-Total (mg/dm2.day)					0.0000168
	Beryllium (Be)-Total (mg/dm2.day)					<0.0000079
	Bismuth (Bi)-Total (mg/dm2.day)					<0.0000079
	Boron (B)-Total (mg/dm2.day)					<0.00016
	Cadmium (Cd)-Total (mg/dm2.day)					<0.00000079
	Calcium (Ca)-Total (mg/dm2.day)					0.00249
	Chromium (Cr)-Total (mg/dm2.day)					<0.0000079
	Cobalt (Co)-Total (mg/dm2.day)					<0.0000016
	Copper (Cu)-Total (mg/dm2.day)					0.000337
	Lead (Pb)-Total (mg/dm2.day)					DLB <0.0000094
	Lithium (Li)-Total (mg/dm2.day)					<0.000079
	Magnesium (Mg)-Total (mg/dm2.day)					0.000504
	Manganese (Mn)-Total (mg/dm2.day)					0.0000422
	Molybdenum (Mo)-Total (mg/dm2.day)					<0.00000079
	Nickel (Ni)-Total (mg/dm2.day)					<0.0000079
	Potassium (K)-Total (mg/dm2.day)					<0.00079
	Selenium (Se)-Total (mg/dm2.day)					<0.000016
	Silver (Ag)-Total (mg/dm2.day)					<0.00000016
	Sodium (Na)-Total (mg/dm2.day)					<0.00079
	Strontium (Sr)-Total (mg/dm2.day)					0.0000051
	Thallium (Tl)-Total (mg/dm2.day)					<0.0000016
	Tin (Sn)-Total (mg/dm2.day)					<0.0000016
	Uranium (U)-Total (mg/dm2.day)					0.00000030
	Vanadium (V)-Total (mg/dm2.day)					<0.000016
	Zinc (Zn)-Total (mg/dm2.day)					<0.000047

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1265141-21	L1265141-22	L1265141-23	L1265141-24	
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	
	Sampled Date	01-FEB-13	31-JAN-13	01-FEB-13	30-JAN-13	
	Sampled Time	14:00	18:15	13:25	09:40	
	Client ID	12-M BULLMOOSE CREEK	13-M SUKUNKA RIVER	14-M WINDFALL CREEK	16-M CHETWYND FARFIELD	
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)					
	Total Insoluble Dustfall (mg/dm2.day)					
	Total Soluble Dustfall (mg/dm2.day)					
Metals	Aluminum (Al)-Total (mg/dm2.day)	0.000148	0.00230	0.000221	0.00173	
	Antimony (Sb)-Total (mg/dm2.day)	<0.0000020	<0.0000013	<0.0000013	<0.0000018	
	Arsenic (As)-Total (mg/dm2.day)	0.0000030	0.0000024	0.0000017	0.0000074	
	Barium (Ba)-Total (mg/dm2.day)	DLB <0.0000049	0.0000745	0.0000125	0.000186	
	Beryllium (Be)-Total (mg/dm2.day)	<0.0000098	<0.0000065	<0.0000064	<0.0000092	
	Bismuth (Bi)-Total (mg/dm2.day)	<0.0000098	<0.0000065	<0.0000064	<0.0000092	
	Boron (B)-Total (mg/dm2.day)	<0.00020	<0.00013	<0.00013	<0.00018	
	Cadmium (Cd)-Total (mg/dm2.day)	<0.00000098	<0.00000065	<0.00000064	<0.00000092	
	Calcium (Ca)-Total (mg/dm2.day)	0.00104	0.0112	0.00166	0.0180	
	Chromium (Cr)-Total (mg/dm2.day)	<0.0000098	<0.0000065	<0.0000064	<0.0000092	
	Cobalt (Co)-Total (mg/dm2.day)	<0.0000020	<0.0000013	<0.0000013	<0.0000018	
	Copper (Cu)-Total (mg/dm2.day)	0.0000773	0.0000207	0.0000219	0.000341	
	Lead (Pb)-Total (mg/dm2.day)	DLB <0.0000059	DLB <0.0000052	DLB <0.0000038	DLB <0.0000073	
	Lithium (Li)-Total (mg/dm2.day)	<0.000098	<0.000065	<0.000064	<0.000092	
	Magnesium (Mg)-Total (mg/dm2.day)	0.000122	0.00184	0.000270	0.00260	
	Manganese (Mn)-Total (mg/dm2.day)	0.0000199	0.000110	0.0000298	0.000654	
	Molybdenum (Mo)-Total (mg/dm2.day)	<0.00000098	<0.00000065	<0.00000064	0.00000161	
	Nickel (Ni)-Total (mg/dm2.day)	<0.0000098	<0.0000065	<0.0000064	<0.0000092	
	Potassium (K)-Total (mg/dm2.day)	<0.00098	0.00118	<0.00064	0.00193	
	Selenium (Se)-Total (mg/dm2.day)	<0.000020	<0.000013	<0.000013	<0.000018	
	Silver (Ag)-Total (mg/dm2.day)	<0.00000020	<0.00000013	<0.00000013	<0.00000018	
	Sodium (Na)-Total (mg/dm2.day)	<0.00098	0.00068	0.00228	0.00140	
	Strontium (Sr)-Total (mg/dm2.day)	0.0000025	0.0000220	0.0000054	0.0000289	
	Thallium (Tl)-Total (mg/dm2.day)	<0.0000020	<0.0000013	<0.0000013	<0.0000018	
	Tin (Sn)-Total (mg/dm2.day)	<0.0000020	<0.0000013	<0.0000013	<0.0000018	
	Uranium (U)-Total (mg/dm2.day)	<0.00000020	0.00000016	<0.00000013	<0.00000018	
	Vanadium (V)-Total (mg/dm2.day)	<0.000020	<0.000013	<0.000013	<0.000018	
	Zinc (Zn)-Total (mg/dm2.day)	<0.000059	0.000040	0.000044	0.000114	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLB	Detection limit was raised due to detection of analyte at comparable level in Method Blank.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate."
Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DUST(DM2)-MS-VA	Dustfall	Total Metals in Dustfalls by ICPMS	EPA 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-291932	10-291933	10-291934	10-291935

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 291934

ALS Environmental

L1265141-COFC

Page ____ of ____

Report To		Report		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	Stantec	Standard: ✓ Other (specify):		✓ Regular (Standard Turnaround Times - Business Days)
Contact:	Daniel Jarratt	Select: PDF ✓ Excel ✓ Digital Fax		Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	805 8th Avenue South West Ste 300 Calgary AB T2P 1H7	Email 1: daniel.jarratt@stantec.com		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	403-441-5064 Fax: 403-269-5245			

Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) Yes or (No)	Job #:	123110480 task 320.200
Company:	Xstrata Coal Canada Resources Ltd (Air Quality)	PO / AFE:	
Contact:	Kim de Gannes	LSD:	
Address:			
Phone:	604-453-4446 Fax: 604-605-8822	Quote #:	
Lab Work Order # (lab use only)	L1265141	ALS Contact:	Sampler:

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Particulate	Soluble Particulate	Insoluble Particulate	Number of Containers
	01 Beaudette Creek 1	30-Jan-13	16:50	Dustfall	✓	✓	✓	
	02 Suska Exploration Camp	29-Jan-13	11:00	"	✓	✓	✓	
	03 Wetland	30-Jan-13	16:15	"	✓	✓	✓	
	04 Brazion Creek	01-Feb-13	9:55	"	✓	✓	✓	
	06 Beaudette Creek 2	30-Jan-13	13:30	"	✓	✓	✓	
	07 Hasler Creek	29-Jan-13	15:30	"	✓	✓	✓	
	08 North Burnt River	29-Jan-13	18:00	"	✓	✓	✓	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 2-2-13	Time: 1200	Received by: Brittany	Date: Feb. 5	Time: 8:55	Temperature: 10.2/10.9/10.8 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

10- 291935

ALS Environmental

L1265141-COFC

Page ___ of ___

Report To	**Repc**...
Company: Stantec	Standa... Other (specify):
Contact: Daniel Jarrett	Select: PDF ✓ Excel ✓ Digital Fax
Address: 805 8th Avenue Southwest Ste 300 Calgary AB T2P 1H7	Email 1: daniel.jarrett@stantec.com
	Email 2:
Phone: 403-441-5064 Fax: 403-269-5245	
Invoice To Same as Report ? (circle) Yes or No (if No, provide details)	**Client / Project Information**
Copy of Invoice with Report? (circle) Yes or No	Job #: 123110480 task 320.200
Company: Xstrata Coal Canada Resources Ltd	PO / AFE:
Contact: Kim de Gannes (Air Quality)	LSD:
Address:	
Phone: 604-453-4446 Fax: 604-605-8822	Quote #:
Lab Work Order # (lab use only) L1265141	**ALS Contact:** **Sampler:**

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- ✓ Regular (Standard Turnaround Times - Business Days)
- Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals	Number of Containers
	01-M Beaudette Creek 1	30-Jan-13	16:50	Dustfall	✓	
	02-M Suska Exploration Camp	29-Jan-13	11:00	"	✓	
	03-M Wetland	30-Jan-13	16:15	"	✓	
	04-M Brazion Creek	01-Feb-13	9:55	"	✓	
	06-M Beaudette Creek 2	30-Jan-13	13:30	"	✓	
	07-M Hasler Creek	29-Jan-13	15:30	"	✓	
	08-M North Burnt River	29-Jan-13	18:00	"	✓	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

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By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 2-2-13	Time: 1200	Received by: Brittany	Date: Feb. 5	Time: 8:55	Temperature: 10.2/10.9/10.8 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

10-291933

ALS Environmental

L1265141-COFC

Page ____ of ____

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company: Stantec		Standard: ✓ Other (specify):		✓ Regular (Standard Turnaround Times - Business Days)
Contact: Daniel Jarratt		Select: PDF ✓ Excel ✓ Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address: 805 8th Avenue Southwest Ste 300		Email 1: daniel.jarratt@stantec.com		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Calgary AB T2P 1H7		Email 2:		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: 403-441-5064	Fax: 403-269-5245			Analysis Request
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)
	Copy of Invoice with Report? (circle) Yes or No	Job #: 12310482 task 320.200		
Company: Boreas Coal Ltd. (Air Quality)		PO / AFE:		
Contact: Kim de Gannes		LSD:		
Address:				
Phone: 604-453-4446	Fax: 604-605-8822	Quote #:		
Lab Work Order # (lab use only)	L1265141	ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Particulate	Soluble Particulate	Insoluble Particulate										Number of Containers
	09 Skeeter Creek	31-Jan-13	16:55	Dustfall	✓	✓	✓										
	~~11 Chamberlain Creek~~			"	~~✓~~	~~✓~~	~~✓~~										
	12 Bullmoose Creek	01-Feb-13	14:00	"	✓	✓	✓										
	13 Sukunka River	31-Jan-13	18:15	"	✓	✓	✓										
	14 Windfall Creek	01-Feb-13	13:25	"	✓	✓	✓										
	16 Chetwynd Fairfield	30-Jan-13	9:40	"	✓	✓	✓										

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 2-2-13	Time: 1200	Received by: Brittany	Date: Feb. 5	Time: 8:55	Temperature: 10.2/10.9/10.8 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY GENF 18.01 Front

10- 291932

ALS Environmental

L1265141-COFC

...orm

Page ___ of ___

Report To		Report Format / Distribution	
Company: Stantec		Standard: ✓ Other (specify):	
Contact: Daniel Jarratt		Select: PDF ✓ Excel ✓ Digital Fax	
Address: 805 8th Avenue Southwest Ste 300 Calgary AB T2P 1H7		Email 1: daniel.jarratt@stantec.com	
		Email 2:	
Phone: 403-441-5064	Fax: 403-269-5245		
Invoice To: Same as Report ? (circle) Yes or No (if No, provide details)		Client / Project Information	
Copy of Invoice with Report? (circle) Yes or No		Job #: 12311048 2 task 320.200	
Company: Boreas Coal Ltd. (Air Quality)		PO / AFE:	
Contact: Kim de Gennes		LSD:	
Address:			
Phone: 604-453-4446	Fax: 604-605-8822	Quote #:	
Lab Work Order # (lab use only): L1265141		ALS Contact:	Sampler:

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- ✓ Regular (Standard Turnaround Times - Business Days)
- Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals	Number of Containers
	09-M Skeeter Creek	31-Jan-13	16:55	Dustfall	✓	
	~~11-M Chamberlain Creek~~			~~"~~	~~✓~~	
	12-M Bullmoose Creek	01-Feb-13	14:00	"	✓	
	13-M Sukunka River	31-Jan-13	18:15	"	✓	
	14-M Windfall Creek	01-Feb-13	13:25	"	✓	
	16-M Chetwynd Fairfield	30-Jan-13	9:40	"	✓	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

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By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: John Gallagher	Date: 2-2-13	Time: 1200	Received by: Brittany	Date: Feb. 5	Time: 8:55	Temperature: 10.2/10.9/10.8 C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 04-MAR-13
Report Date: 12-MAR-13 12:36 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #:	**L1274709**
Project P.O. #:	NOT SUBMITTED
Job Reference:	123110482 TASK 320.200
C of C Numbers:	10-292536
Legal Site Desc:	

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1274709-1				
	Description	Dustfall				
	Sampled Date	27-FEB-13				
	Sampled Time	12:20				
	Client ID	11-M CHAMBERLAIN CREEK (JAN. 5-FEB. 27)				
Grouping	**Analyte**					
DUSTFALL						
Metals	Aluminum (Al)-Total (mg/dm2.day)	0.000526				
	Antimony (Sb)-Total (mg/dm2.day)	<0.0000020				
	Arsenic (As)-Total (mg/dm2.day)	<0.0000020				
	Barium (Ba)-Total (mg/dm2.day)	0.0000169				
	Beryllium (Be)-Total (mg/dm2.day)	<0.000010				
	Bismuth (Bi)-Total (mg/dm2.day)	<0.000010				
	Boron (B)-Total (mg/dm2.day)	<0.00020				
	Cadmium (Cd)-Total (mg/dm2.day)	<0.0000010				
	Calcium (Ca)-Total (mg/dm2.day)	0.00123				
	Chromium (Cr)-Total (mg/dm2.day)	<0.000010				
	Cobalt (Co)-Total (mg/dm2.day)	<0.0000020				
	Copper (Cu)-Total (mg/dm2.day)	0.000229				
	Lead (Pb)-Total (mg/dm2.day)	0.0000080				
	Lithium (Li)-Total (mg/dm2.day)	<0.00010				
	Magnesium (Mg)-Total (mg/dm2.day)	0.00029				
	Manganese (Mn)-Total (mg/dm2.day)	0.0000262				
	Molybdenum (Mo)-Total (mg/dm2.day)	<0.0000010				
	Nickel (Ni)-Total (mg/dm2.day)	<0.000010				
	Potassium (K)-Total (mg/dm2.day)	<0.0010				
	Selenium (Se)-Total (mg/dm2.day)	<0.000020				
	Silver (Ag)-Total (mg/dm2.day)	<0.00000020				
	Sodium (Na)-Total (mg/dm2.day)	<0.0010				
	Strontium (Sr)-Total (mg/dm2.day)	0.0000042				
	Thallium (Tl)-Total (mg/dm2.day)	<0.0000020				
	Tin (Sn)-Total (mg/dm2.day)	<0.0000020				
	Uranium (U)-Total (mg/dm2.day)	<0.00000020				
	Vanadium (V)-Total (mg/dm2.day)	<0.000020				
	Zinc (Zn)-Total (mg/dm2.day)	<0.000061				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DUST(DM2)-MS-VA	Dustfall	Total Metals in Dustfalls by ICPMS	EPA 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-292536

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 292536

L1274709-COFC

ALS Enviro

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To	**Report Format / Distribution**	**Service Request:** (Rush subject to availability - Contact ALS to confirm TAT)
Company: stantec	Standard: ✓ Other (specify):	Regular (Standard Turnaround Times - Business Days)
Contact: Daniel Jarratt	Select: PDF ✓ Excel ✓ Digital Fax	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address: 805 8th Ave Southwest St 300	Email 1: daniel.jarratt@stantec.com	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Calgary AB T2P 1H7	Email 2:	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: 403-441-5064 Fax: 403-269-5245		**Analysis Request**
Invoice To Same as Report ? (circle) Yes or No (if No, provide details)	**Client / Project Information**	(Indicate Filtered or Preserved, F/P)
Copy of Invoice with Report? (circle) Yes or No	Job #: 123110482 task 320.200	
Company: Boreas Coal Ltd (Air Quality)	PO / AFE:	
Contact: Kim de Gannes	LSD:	
Address:		
Phone: 604-453-4446 Fax: 604-605-8822	Quote #:	
Lab Work Order # (lab use only) L1274709	**ALS Contact:** **Sampler:**	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals												Number of Containers
	1HM Chamberlain Creek	27-Feb-13	12:20	Dustfall	✓												

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Katelyn Wells	Date: 1-3-2013	Time: 9:00	Received by: HD	Date: March 4/13	Time: 8:30	Temperature: 10 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 04-MAR-13
Report Date: 12-MAR-13 12:37 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: **L1274735**

Project P.O. #:	NOT SUBMITTED
Job Reference:	123110482 TASK 320.200
C of C Numbers:	10-292535
Legal Site Desc:	

Comments:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1274735-1	L1274735-2	L1274735-3	L1274735-4	L1274735-5
	Description	Dustfall	Dustfall	Dustfall	Dustfall	Dustfall
	Sampled Date	01-MAR-13	27-FEB-13	27-FEB-13	01-MAR-13	27-FEB-13
	Sampled Time	11:07	12:20	12:47	12:24	09:50
	Client ID	09 SKEETER CREEK	11 CHAMBERLAIN CREEK	12 BULLMOOSE CREEK	13 SUKUNKA RIVER	14 WINDFALL CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.13	0.13	0.14	0.11	0.15
	Total Insoluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.12	<0.10	<0.12
	Total Soluble Dustfall (mg/dm2.day)	<0.10	<0.10	<0.12	<0.10	<0.12

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1274735-6				
	Description	Dustfall				
	Sampled Date	26-FEB-13				
	Sampled Time	15:20				
	Client ID	16 CHETWYN FARFIELD				
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.86				
	Total Insoluble Dustfall (mg/dm2.day)	<0.11				
	Total Soluble Dustfall (mg/dm2.day)	0.77				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate." Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-292535

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 292535

ALS Environmental

L1274735-COFC

Page ___ of ___

Report To	
Company:	Stantec
Contact:	Daniel Jarratt
Address:	805 8th Avenue ~~[illegible]~~ South West St 300 Calgary AB T2P 1H7
Phone:	403-441-5064 Fax: 403-269-5245
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)
	Copy of Invoice with Report? (circle) Yes or No
Company:	Boreas Coal Ltd. (Air Quality)
Contact:	Kim de Gannes
Address:	
Phone:	604-453-4446 Fax: 604-605-8822
Lab Work Order # (lab use only)	L1274735

Report Format / Distribution	
Standard: ✓	Other (specify):
Select: PDF ✓ Excel ✓ Digital	Fax
Email 1:	daniel.jarrett@stantec.com
Email 2:	
Client / Project Information	
Job #:	123110482 task 320.200
PO / AFE:	
LSD:	
Quote #:	
ALS Contact:	**Sampler:**

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- Regular (Standard Turnaround Times - Business Days)
- Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request

(Indicate Filtered or Preserved, **F/P**)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Particulate	Soluble Particulate	Insoluble Particulate										Number of Containers
	09 Skeeter Creek	1-Mar-13	11:07	Dustfall	✓	✓	✓										
	11 Chamberlain Creek	27-~~Feb~~-13	12:20	"	✓	✓	✓										
	12 Bullmoose Creek	27-Feb-13	12:47	"	✓	✓	✓										
	13 Sukunka River	1-Mar-13	12:24	"	✓	✓	✓										
	14 Windfall creek	27-Feb-13	9:50	"	✓	✓	✓										
	16 Chetwyn Farfield	26-Feb-13	15:20	"	✓	✓	✓										

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Katelyn Wells	1-3-2013	9:00	HD	march 4/13	8:30	10 °C				

STANTEC CONSULTING LTD.
ATTN: Dan Jarratt
805 - 8th Avenue SW, Suite 300
Calgary AB T2P 1H7

Date Received: 01-APR-13
Report Date: 08-APR-13 13:11 (MT)
Version: FINAL

Client Phone: 403-441-5064

Certificate of Analysis

Lab Work Order #: **L1284472**

Project P.O. #:	NOT SUBMITTED
Job Reference:	123110482 TASK 320.200
C of C Numbers:	10-292532
Legal Site Desc:	

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1284472-1	L1284472-2	L1284472-3	L1284472-4	L1284472-5
	Description	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL	DUSTFALL
	Sampled Date	26-MAR-13	27-MAR-13	27-MAR-13	21-MAR-13	27-MAR-13
	Sampled Time	08:50	13:55	10:30	11:49	10:55
	Client ID	09 SKEETER CREEK	11 CHAMBERLAN CREEK	12 BULLMOOSE CREEK	13 SUKUNKA RIVER	14 WINDFALL CREEK
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	<0.12	0.38	0.13	0.28	<0.11
	Total Insoluble Dustfall (mg/dm2.day)	<0.12	0.23	<0.11	0.17	<0.11
	Total Soluble Dustfall (mg/dm2.day)	<0.12	0.15	<0.11	<0.12	<0.11

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1284472-6				
	Description	DUSTFALL				
	Sampled Date	26-MAR-13				
	Sampled Time	16:45				
	Client ID	16 CHETWYND DISTRICT OF				
Grouping	**Analyte**					
DUSTFALL						
Particulates	Total Dustfall (mg/dm2.day)	0.38				
	Total Insoluble Dustfall (mg/dm2.day)	0.27				
	Total Soluble Dustfall (mg/dm2.day)	<0.11				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
DUSTFALLS-COM-DM2-VA	Dustfall	Combined Dustfalls-Total, soluble, insol	BCMOE PARTICULATE

This analysis is carried out using procedures modified from British Columbia Environmental Manual "Particulate." Particulates or Dustfall are determined gravimetrically. Total Insoluble Dustfall is determined by filtering a sample through a 0.45 um membrane filter and drying the filter at 104 degrees celsius. Total Soluble Dustfall is determined by evaporating the filtrate to dryness at 104 degrees celsius. The Total Dustfall is the sum of Insoluble Dustfall and the Soluble Dustfall.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-292532

GLOSSARY OF REPORT TERMS

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mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
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UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 292532

ALS Environmental

L1284472-COFC

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...378

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Report To	
Company:	Stantec
Contact:	Daniel Jarratt
Address:	805 8th Ave Southwest Ste 300 Calgary AB T2P 1H7
Phone:	403-441-5064 Fax: 403-269-5245
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)
	Copy of Invoice with Report? (circle) Yes or No
Company:	Boreas Coal Ltd. (Air Quality)
Contact:	Kim de Barnes
Address:	
Phone:	604-453-4446 Fax: 604-505-8822
Lab Work Order # (lab use only)	L1284472

Report Format / ...	
Standard: ✓	Other (specify):
Select: PDF ✓ Excel ✓ Digital Fax	
Email 1:	daniel.jarratt@stantec.com
Email 2:	
Client / Project Information	
Job #:	123110482 task 320.200
PO / AFE:	
LSD:	
Quote #:	
ALS Contact:	**Sampler:**

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- Regular (Standard Turnaround Times - Business Days)
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- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request

(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Particulates	Soluble Particulates	Insoluble Particulates	Number of Containers
	09 Skeeter creek	26-Mar-13	08:50	Dustfall	✓	✓	✓	
	11 Chamberlain creek	27-Mar-13	13:55	"	✓	✓	✓	
	12 Bullmoose creek	27-Mar-13	10:30	"	✓	✓	✓	
	13 Sukunka River	21-Mar-13	11:49	"	✓	✓	✓	
	14 Windfall creek	27-Mar-13	10:55	"	✓	✓	✓	
	16 Chetwynd, District of	26-Mar-13	16:45	"	✓	✓	✓	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
John Gallagher	24-3-13	16:00	Britt	Apr. 1	8:45	14.5 / 14.0 °C				

Appendix E SHARP Leak Check and Flow Audit

Chapter 4
Calibration

The Model 5030*i* is an instrument that can make accurate mass concentration measurements of PM_{10}, $PM_{2.5}$ and $PM_{1.0}$. However, with all electronic instruments, the accuracy of the measurements depends on proper calibration.

In general terms, calibration, also called standardization, is the process that establishes the relationship between sensor output signals and the parameter the operator is attempting to measure. The 5030*i* instrument uses sensors that measure temperature, humidity, pressure, and radiation. This chapter describes the procedures for performing the necessary sensor calibrations. This chapter is also a follow-up to the Acceptance Testing outlined in the "Installation" chapter and a continuation of the menu display descriptions in the "Operation" chapter.

Frequency of Calibration

Each instrument is calibrated and tested for accuracy at the factory. The mass calibration is conducted with a set of NIST-traceable mass calibration foils. The radiation detector is calibrated against certified check sources for beta and alpha emissions. The temperature, relative humidity, pressure and flow rate are all calibrated against NIST traceable standards.

It is recommended that the instrument be calibrated once per year and encounter quality checks on a periodic basis in accordance with the users specific quality assurance project plan. For example, volumetric flow checks on a two-week basis are common in some air monitoring agencies and with full-scale quarterly audits for flow and mass. The *Quality Assurance Handbook for Air Pollution Measurement Systems,* published by the U.S. EPA, Research Triangle Park, NC 27711, can be consulted for detailed quality assurance guidelines.

Equipment Required

Optional mass transfer standards are available from Thermo Fisher Scientific for performing an annual mass calibration. However, additional specialized equipment is needed to calibrate the Model 5030*i* for temperature, relative humidity, barometric pressure, and volumetric flow. The following equipment should be used:

- A thermistor or thermocouple thermometer capable of measuring ambient temperatures in a range of –20 to 50 °C, readable to the nearest 0.1 °C. This thermometer should be referenced to within an accuracy of ±0.5 °C to NIST-traceable precision thermometers. Multiple thermometers may be used to cover the temperature range as long as each thermometer meets the accuracy and readability specifications described above.

- A barometer capable of measuring barometric pressure over a range of 600 to 800 mmHg (80 to 106 kilo Pascals [kPa]) and readable to the nearest 1 mmHg. At least once a year, this barometer should be calibrated to within ±5 mmHg of a NIST-traceable barometer of known accuracy.
- Flow-rate Transfer Standard (FTS) measurement equipment capable of calibrating, or verifying, the volumetric flow rate measurement with an accuracy of ±2 percent. This flow rate standard must be a separate, stand-alone device. It must have its own certification and be traceable to a NIST primary standard for volume or flow rate. Dry-piston meters and bubble flow meters should only be used under controlled laboratory conditions. Ambient field measurements should use a NIST-traceable low pressure drop orifice/venturi flow meter (such as, BGI Delta-Cal) or a Streamline Pro™ Model SX Kit (2-25 L/min).
- A relative humidity (RH) standard capable of measuring in the range of 35-75% RH, readable to the nearest 0.5% RH and accurate to within 2% RH.

Pre-Calibration

Prior to calibration, be sure the Model 5030*i* is operating properly. The Model 5030*i*'s internal diagnostics makes this a quick and simple process. Turn on the instrument and allow it to stabilize for one hour prior to calibrating. If you are receiving this instrument for the first time, the optional acceptance testing in the "Installation" chapter should also be reviewed. If the internal flow temperature sensor requires calibration, the dynamic heating system should be turned OFF, the cover should be removed, and the instrument should sample room temperature air at least one hour prior to calibrating.

Calibration Procedure

The order of calibration described below is preferred for optimal performance of the 5030*i* and comes from many years of experience working with and developing ambient particulate monitoring instrumentation. The Calibration submenus allow the user to view and calibrate the instrument. All calibration submenus are visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in Chapter 3.

RH/Temperature Calibration

All screens that appear in this chapter have been referenced in the previous chapter.

Ambient Temperature

Using a NIST-traceable thermometer as a reference collocated next to the ambient RH/temperature sensor assembly, measure and compare three individual readings between both the reference and the 5030*i* response. Taking an average of both sets of readings, calculate the average difference between the two readings and record that as your offset. This offset (ZERO) should now be entered in the screen below:

```
CALIBRATE AMBIENT TEMP:
 TEMPERATURE:      29.9 °C
        ZERO:       4.2 °C

             ↑↓ INC/DEC
              ↵ SAVE VALUE

 RANGE   AVG   DIAGS  ALARM
```

Be sure to save the entry and compare the values once more. If it appears that the temperature has shifted into the wrong direction, change the sign of your offset value.

Ambient Relative Humidity

Using a NIST-traceable hygrometer as a reference collocated next to the ambient RH/temperature sensor assembly, measure and compare three individual readings between both the reference and the 5030*i* response. Taking an average of both sets of readings, calculate the average difference between the two readings and record that as your offset. This offset (ZERO) should now be entered in the screen below:

```
CALIBRATE AMBIENT RH:
 REL HUMIDITY:      40.0 %
         ZERO:       0.0 %

              ↑↓ INC/DEC
               ↵ SAVE VALUE

 RANGE   AVG   DIAGS  ALARM
```

Be sure to save the entry and compare the values once more. If it appears that the temperature has shifted into the wrong direction, change the sign of your offset value.

Flow Temperature

Assuming the instrument cover has been removed, the heater has been turned off and removed from the instrument and the instrument has been sampling room temperature air for 1-hour, this calibration can now proceed.

Using a NIST-traceable thermometer as a reference collocated next to the small sample tube inlet on top of the instrument, measure and compare three individual readings between both the reference and the 5030*i* response. Taking an average of both sets of readings, calculate the average difference between the two readings and record that as your offset. This offset (ZERO) should now be entered in the screen below:

```
CALIBRATE FLOW TEMP:
 TEMPERATURE:     28.0 °C
        ZERO:      0.8 °C

             ↑↓ INC/DEC
              ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Be sure to save the entry and compare the values once more. If it appears that the temperature has shifted into the wrong direction, change the sign of your offset value.

Pressure/Vacuum Calibration

There are three pressure sensors that can be calibrated, however, the primary sensor to be calibrated is the barometric pressure sensor. Both the vacuum sensor and pressure flow sensors are re-zeroed automatically with every filter tape change.

Barometer Pressure Calibration

Using a NIST-traceable barometer, measure the barometric pressure (and convert as necessary) in units of millimetres of mercury (mmHg). Use the SPAN feature from the barometric calibration submenu.

```
BARO PRES CALIBRATION:
>SPAN               1.0000
 SET DEFAULTS



 RANGE  AVG  DIAGS ALARM
```

```
CAL BARO PRESSURE SPAN:
 PRESSURE:        760 mmHg
   SET TO:        74█ mmHg?

         ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Be sure to save the entry and compare the values once more. Repeat as necessary to within 2 mmHg.

Calibrate Vacuum/Flow Zero

The Calibrate Vacuum/Flow Zero screen calibrates the vacuum/flow sensor at zero value. This is done automatically with every filter tape change. However, if for any reason this needs to be done, proceed to the following screen below to execute a zeroing filter tape change.

```
CAL VACUUM/FLOW ZERO:
 VAC  ZERO:        0.0
 FLOW ZERO:        0.0

 ↵ TO CALIBRATE ZERO BY
      CHANGING FILTER

 RANGE  AVG  DIAGS ALARM
```

Calibrate Vacuum Pressure Span

The Calibrate Vacuum Pressure Span screen allows the user to view and set the vacuum sensor calibration span point.

To calibrate the vacuum sensor, zero a digital manometer (capable of measuring up to 100 mmHg) and attach to the +ΔPA port on the rear panel. Then push the toggle switch on the right inward to open (see Figure 4–1). The manometer reading can now be used to calibrate the vacuum sensor.

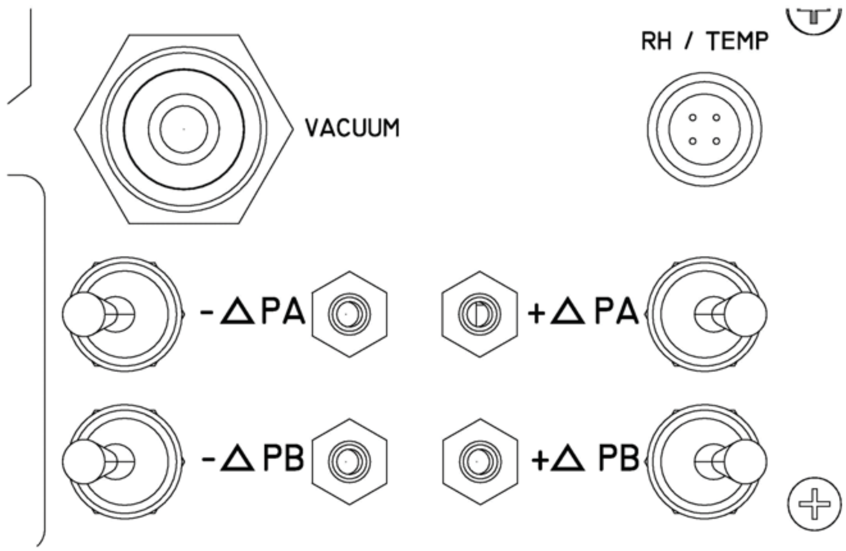

Figure 4–1. Differential Pressure and Vacuum Calibration Ports

- In the Main Menu, choose Service > Pres/Vacuum Calibration > Vac/Flow > **Vac Pres Span**.

```
CAL VAC PRESSURE SPAN:
 VACUUM:          58.7 mmHg
 SET TO:          60.0 mmHg?

            ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE     ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Calibrate Flow Pressure Span

The Flow Pressure Span screen allows the user to view and set the flow sensor calibration span point.

To calibrate the flow pressure sensor span point, the instrument must be pulling an active flow through the filter tape. By use of a manometer, connect the respective +/- ports of your NIST-traceable manometer to the respective rear panel +/- ports. (Please be certain to zero any digital manometers prior to connecting!) Open the ports by pressing the toggle switches inward. Calculate an average reading from the reference manometer in units of mmHg. Enter this span value into the screen below:

- In the Main Menu, choose Service > Pres/Vacuum Calibration > Vac/Flow > **Flow Pres Span**.

```
CAL FLOW PRESSURE SPAN:
 FLOW:           21.0 mmHg
 SET TO:         20.0 mmHg?

         ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Be sure to save the entry and compare the values once more. Repeat as necessary to within 2 mmHg.

Flow Calibration

The preferred method of flow rate calibration is the Auto Flow Calibration.

Auto Flow Calibration

Place a NIST-traceable volumetric flow meter on top of the instrument after complete installation (reassembled heater tube, sample tubes, and inlets). Allow approximately 1-minute for the flow to stabilize. Once stable, measure and average three individual readings from the reference. This average observed flow rate from your reference meter should now be entered in the screen below:

```
FLOW AUTO CALIBRATION:
   FLOW:          16.67 LPM
 SET TO:          17.25 LPM?

         ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Be sure to save the entry and compare the values once more. Repeat as necessary to within +/- 2 %.

Perform the "Leak Test" procedure on page 5-6 to verify no leaks.

Mass Calibration

The Model 5030*i* SHARP is calibrated for mass in the factory using a series of null and span foils. The mass transfer standard foil sets are available from Thermo Fisher Scientific, and should be used as part of a QA Program for performing a QC check on the mass measurements. This mass foil calibration procedure can be used for QC checks, auditing, and calibration.

The Mass Calibration submenu is used to view and set the mass calibration point. The mass calibration screen is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

- In the Main Menu, choose Service > **Mass Calibration>Mass Coefficient**.

```
MASS CALIBRATION:
 THERMAL    COEFFICIENT
 VACUUM     COEFFICIENT
 BARO       COEFFICIENT
>MASS       COEFFICIENT
 ALPHA EFF  COEFFICIENT

 RANGE  AVG  DIAGS ALARM
```

It is recommended to perform an annual Mass Coefficient on the Model 5030*i* Beta Monitor.

- The foil sets must be kept in a clean container. **Do not** touch the foil window with your fingers.
- The foils must **not** be wiped, otherwise a loss or gain of mass can occur thereby biasing the mass calibration.
- Foils sets can be returned to Thermo Fisher Scientific for recalibration as necessary.
- Separate foil sets are recommended for periodic QC checks, auditing, and calibration.
- Should the user suspect the foil window(s) has been damaged, scratched, or coated, these foil sets should be returned to Thermo Fisher Scientific for re-calibration.

The null foil has the same approximate mass as a clean filter spot and the span foil is a calibrated mass increase above the null foil. Therefore, the foils come in a set and must not be mixed with other sets since a bias in mass calibration will occur.

Since the beta attenuation method is linear with mass increase, the Model 5030*i* need not be calibrated in the exact range of beta attenuation per filter spot. What is important, is calibrating the corresponding beta count reduction with an increase of calibrated mass.

Note To achieve the most accurate mass calibration, the flow temperature should be as stable as possible and therefore the instrument should have the heating system turned off, and the instrument should be allowed to equilibrate to shelter or ambient temperature. If the Model 5030*i* Beta is mounted within an ambient shelter, then the most stable time of day to perform a mass calibration would be either early morning or late afternoon. ▲

Mass Coefficient

The preferred method of mass coefficient calibration is the Auto Mode.

- In the Main Menu, choose Service > Mass Calibration > **Mass Coefficient**.

```
MASS COEFFICIENT:
>AUTO
 MANUAL



 RANGE  AVG  DIAGS ALARM
```

Auto Mass Coefficient

The Auto Mass Coefficient screen allows the user to conduct a mass calibration of the measurement head and will walk you through the process.

Use the following procedure to conduct a mass calibration:

1. In the Main Menu, choose Service > Mass Calibration > Mass > **Auto**.

2. Enter the SPAN foil value (e.g., 1,328 µg) using the keypad and press ↵ to save the foil value and to open the bench. The beta attenuation chamber should now open.

```
MASS COEF:       7000.0
FOIL VALUE:      1328 µg

   ↵ TO SAVE FOIL VALUE
   AND OPEN BENCH
 RANGE  AVG  DIAGS ALARM
```

3. Cut/break the filter tape and remove from the bench. Then insert the Foil Holder from the calibration kit and press ↵ while maintaining a slight sideward pressure on the filter holder.

```
MASS COEF:       7000.0
FOIL VALUE:      1328  µg

 REMOVE TAPE, INSERT FOIL
 HOLDER, ↵ TO CLOSE BENCH

 RANGE   AVG   DIAGS ALARM
```

4. Insert the Null/Zero foil with the label side up and press ↵ to proceed with the foil calibration, or press ■ to stop the foil.

```
MASS COEF:       7000.0
FOIL VALUE:      1328  µg

   INSERT NULL FOIL
   ↵ TO START ZERO CAL

 RANGE   AVG   DIAGS ALARM
```

```
MASS COEF:       7000.0
FOIL VALUE:      1328  µg
Beta Avg         12016 1/sec

   PLEASE WAIT      265 sec

 RANGE   AVG   DIAGS ALARM
```

The auto zero procedure of mass will begin and last approximately 270 seconds. When the zero is complete, the beta attenuation measurement will remain closed and an average Beta count rate is displayed.

```
MASS COEF:      7000.0
FOIL VALUE:     1328  µg
Beta Avg       12022 1/sec

   REMOVE NULL FOIL
   ↵ TO CONTINUE

 RANGE   AVG   DIAGS ALARM
```

5. Remove the zero/null foil and insert with the Span foil (e.g., 1328 ug) and press ↵ to begin the span calibration, or press ■ to stop the foil.

```
MASS COEF:       7000.0
FOIL VALUE:      1328  µg
Beta Avg        12022 1/sec

   INSERT SPAN FOIL
   ↵ TO START MASS CAL

 RANGE   AVG   DIAGS ALARM
```

```
MASS COEF:       7000.0
FOIL VALUE:      1328  µg
Beta Avg         9884 1/sec


    PLEASE WAIT     245 sec

 RANGE   AVG   DIAGS ALARM
```

The span foil calibration procedure is now active and after another 270 seconds the calibration procedure should end, whereby a new Mass Coef value is shown and the percent difference is shown from the last foil calibration to the current calibration. This percent difference can also be used to directly audit the mass coefficient value since a percent difference in a mass coefficient is the same percent mass difference overall.

```
MASS COEF:       6878.7
FOIL VALUE:      1328  µg
Beta Avg         9911  1/SEC
difference       -1.7  %
   REMOVE SPAN FOIL
   ↵ TO CONTINUE

 RANGE   AVG   DIAGS ALARM
```

6. After the span calibration, the screen will ask you to press ↵ to accept the new calibration. Otherwise press ■ to keep the old Mass Coef value. Remove the span foil and press ↵. The bench will now open. Remove the filter holder, replace the filter tape and press ↵ to confirm the calibration routine has now been competed.

```
MASS COEF:       6878.7
FOIL VALUE:      1328  µg
Beta Avg         9911  1/sec
difference       -1.7  %
  REMOVE HOLDE, INSERT
 TAPE, ↵ TO CLOSE BENCH

 RANGE   AVG   DIAGS ALARM
```

```
MASS COEF:       6878.7
FOIL VALUE:     1328  µg
Beta Avg        9911 1/sec
difference      -1.7 %
  ↵ TO ACCEPT NEW VALUES
  ← TO DECLINE
 RANGE  AVG  DIAGS ALARM
```

Detector Calibration

The Detector Calibration submenu is used to view and set the detector calibration. The detector calibration screen is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

- In the Main Menu, choose Service > **Detector Calibration**.

```
DETECTOR CALIBRATION:
>AUTO
 MANUAL



 RANGE  AVG  DIAGS ALARM
```

Auto Detector Calibration

The Auto Detector Calibration screen allows the user to optimize the detector performance. This should be done at least once per year and as often as once per quarter.

- In the Main Menu, choose Service > Detector Calibration > **Auto**.

```
DETECTOR AUTO CAL:
 HIGH VOLT:     1500 V
 BETA CNT :    14649 1/sec

PRESS ↵ TO START AUTO CAL
 RANGE  AVG  DIAGS ALARM
```

This procedure will take approximately 30 minutes until completed. Thereafter, a high voltage (HV), beta reference threshold and alpha threshold will be assigned a new valve.

Nephelometer Calibration

The Nephelometer Calibration submenu is used to view and set the nephelometer calibration. The nephelometer calibration screen is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

- In the Main Menu, choose Service > **Nephelometer Calibration**.

```
NEPHELOMETER CALIBRATION:
>NEPH RH           0.0  %
 NEPH TEMP         0.0  °C
 NEPH SRC LEVEL      0  %


 RANGE  AVG  DIAGS ALARM
```

Nephelometer RH

The Nephelometer RH screen allows the user to view and calibrate the nephelometer relative humidity.

Note Calibration of the nephelometer RH must be done with the heater in the “OFF” position. ▲

- In the Main Menu, choose Service > Neph Calibration > **Neph RH**.

```
CALIBRATE NEPH RH:
 NEPH RH:          0.0 %
  OFFSET:          0.0 %

           ↑↓ INC/DEC
            ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Nephelometer Temperature

The Nephelometer Temperature screen allows the user to view and calibrate the nephelometer temperature sensor calibration.

Note Calibration of the nephelometer temperature must be done with the heater in the “OFF” position. ▲

- In the Main Menu, choose Service > Neph Calibration > **Neph Temp**.

```
CALIBRATE NEPH TEMP:
 NEPH TEMP:        0.0 °C
    OFFSET:        0.0 °C

          ↑↓ INC/DEC
           ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Nephelometer Source Level

The Nephelometer Source Level screen allows the user to view and calibrate the source level. This should be within 60-70 mA. If it is outside of this range, please adjust the % SRC Level until the IRED reads 65 mA

- In the Main Menu, choose Service > Neph Calibration > **Neph Src Level**.

```
SOURCE LEVEL SET:
      IRED:        65 mA
 SRC LEVEL:        32 %

          ↑↓ INC/DEC
           ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter. ▲

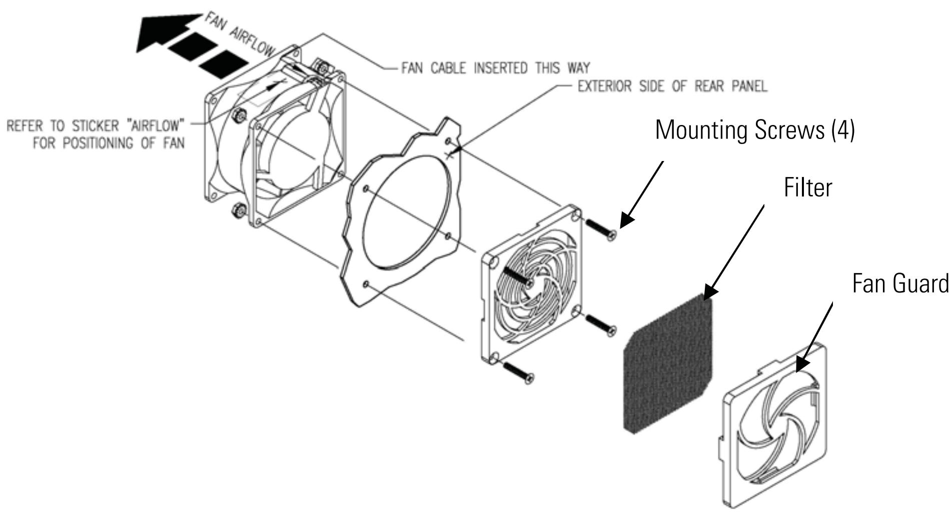

Figure 5–4. Inspecting and Cleaning the Fan

Pump Rebuilding

Rebuild the sample pump once every 12–18 months, or as necessary depending on the environment is is used in. The pump repair kit contains instructions for rebuilding the pump. See the "Servicing" chapter for a list of replacement parts. Perform the "Leak Test" procedure that follows.

Leak Test

This leak test procedure uses a volumetric flow meter and a custom leak check adapter. Use the following procedure to verify no leaks.

1. Place a reference volumetric flow meter (e.g., BGI Delta Cal) onto the inlet adapter and calibrate the 5030*i* SHARP so that the reference flow meter and the 5030*i* SHARP Monitor read the same flow rate.

2. Install the custom leak check adapter onto the inlet adapter and then place the reference flow meter onto the leak check adapter.

3. Record the reference volumetric flow meter reading and the instant flow reading. If the difference between both readings is less than 80 ml/minute, the leak check passes.

Filter Tape Replacement

Use the following procedure to replace the filter tape in case of breaks or if the tape runs out.

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter. ▲

1. Remove left side panel.

2. From the main menu choose Instrument Controls > Filter Tape Control > Manual > **Bench(s)**. Press ↵.

3. Loosen both reel nuts on tape spindler. Remove used filter tape and empty tape spool from tape spindles.

4. Insert new filter tape on left tape spindle and tighten reel nut.

5. Insert new blank pick up spool on right tape spindle.

6. Route tape according to Figure 5–5.

7. Attach end of tape to blank tape spool on right tape spindle with 2-inch of tape.

8. Turn blank tape spool until there is two complete wrappings of tape.

9. Tighten right reel nut. From Filter Tape Control > Manual > choose **Tape** and press ↵ to MOVE tape.

10. From the main menu choose Alarms > **Instrument Alarms** to verify that there are no filter tape alarms.

11. Replace left side cover.

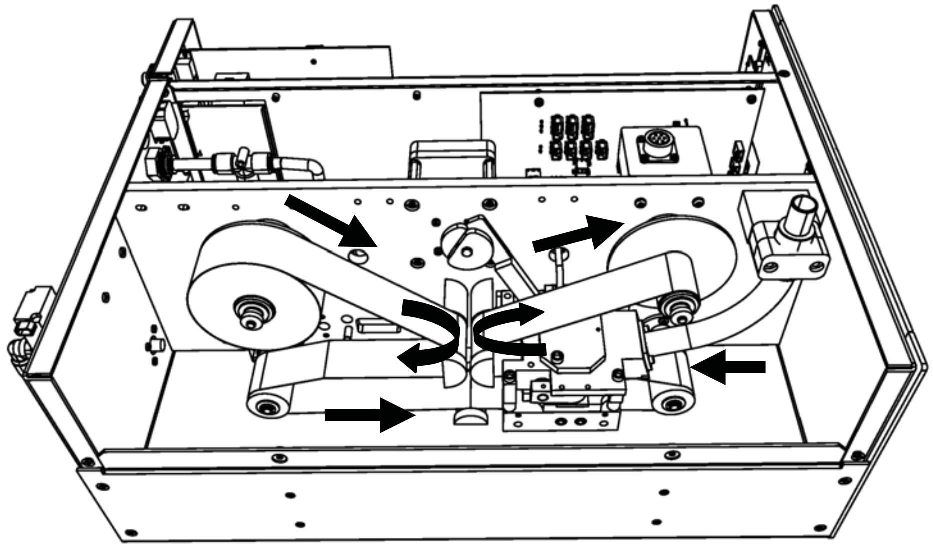

Figure 5–5. Replacing the Filter Tape

Greasing the Cam

Use the following procedure to grease the cam.

Equipment Required:

Dow Corning Molykote G-N

1. Apply metal assembly paste around the parameter of the cam.

External Pump Exhaust Filter

It is recommended to replace the external pump exhaust filter every six months. On an annual basis, remove top plate of optics and vacuum out optic chamber per the following procedure or send it for service and re-calibration.

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter. ▲

Appendix F GRIMM Calibration Certificates

CALIBRATION CERTIFICATE

GRIMM

Date :	09-Aug-12	**Mother Unit Serial No. :**	7G040006
Model :	179	**Number of Channels :**	31
Version :	7.80E	**Calibration Date (Germany) :**	19-Mar-12
Serial No. :	79G08007	**Calibration Expiry Date :**	30-Apr-13
Client :	STANTEC - Xstrata Coal		

Before Service	
DC_v	614
DC_d	883
DC_h	1236
CO_h	0
CO_d	0
DC_Diff	353
La_1	57
La_h	113
Factor K	1.0
Flow (L/min)	1.201
Imot %	29.7
Vacuum (KPa)	n/a
Flow Vacuum (L/min)	n/a

After Service	
DC_v	652
DC_d	922
DC_h	1256
CO_h	0
CO_d	0
DC_Diff	334
La_1	58
La_h	110
Factor K	1.0
Flow (L/min)	1.203
Imot %	30.5
Vacuum (KPa)	n/a
Flow Vacuum (L/min)	n/a

Customer Values	
Alarm N	0
Location	1
Run Time Hours (sample)	10766.1
Run Time Hours (vacuum)	n/a
Output Channels	10 - 2.5 - TSP

Customer Values	
Alarm N	0
Location	1
Run Time Hours (sample)	10771.8
Run Time Hours (vacuum)	n/a
Output Channels	10 - 2.5 - TSP

Comments:

Replaced Sheath Air Filter

GRIMM Aerosol Canada Inc. - Service & Calibration Department

Address: 1890 Marchand Street
Laval, QC, H7G 4V6
Canada

Contact: Gil Cossette

Phone: 1-877-474-6602
1-877-GRIMM 02
450-933-4766

Fax: 514-907-5978

Calibration performed by Gil Cossette	Gil Cossette

CALIBRATION CERTIFICATE

GRIMM

Date :	09-Aug-12	**Mother Unit Serial No. :**	7G040006
Model :	179	**Number of Channels :**	31
Version :	7.80 E (P)	**Calibration Date (Germany) :**	19-Mar-12
Serial No. :	79G08007	**Calibration Expiry Date :**	30-Apr-13
Client :	STANTEC - Xstrata Coal		

ID	Channel	Mother Threshold	Candidate Threshold Before	Candidate Threshold After	Candidate Threshold Variation %	Candidate Calibration Pass/Fail	Particulate Count Variation Variation %
0	> 0.25 µm	37	29	35	21%	Pass	-2.4
1	> 0.28 µm	68	46	54	17%	Pass	-1.6
2	> 0.30 µm	134	77	104	35%	Pass	-2.3
3	> 0.35 µm	288	177	217	23%	Pass	-1.4
4	> 0.40 µm	581	360	414	15%	Pass	0.6
5	> 0.45 µm	869	585	635	9%	Pass	-0.7
6	> 0.50 µm	1077	734	800	9%	Pass	1.4
7	> 0.58 µm	1104	1075	1081	1%	Pass	-0.2
8	> 0.65 µm	1133	1104	1107	0%	Pass	-1.7
9	> 0.70 µm	1154	1122	1126	0%	Pass	-0.5
a	> 0.80 µm	1194	1156	1160	0%	Pass	-1.8
b	> 1.0 µm	1245	1200	1208	1%	Pass	1.3
c	> 1.3 µm	1315	1275	1286	1%	Pass	2.3
d	> 1.6 µm	1364	1335	1335	0%	Pass	1.5
e	> 2.0 µm	1469	1451	1451	0%	Pass	2.0
f	> 2.5 µm	1583	1599	1597	0%	Pass	-1.0
g	> 2.5 µm	144	126	128	2%	Pass	-0.3
h	> 3.0 µm	198	174	177	2%	Pass	2.5
i	> 3.5 µm	260	237	242	2%	Pass	0.0
j	> 4.0 µm	330	313	312	0%	Pass	-0.4
k	> 5.0 µm	560	541	541	0%	Pass	-0.3
l	> 6.5 µm	948	951	934	-2%	Pass	-1.3
m	> 7.5 µm	1082	1088	1080	-1%	Pass	-0.5
n	> 8.5 µm	1098	1102	1095	-1%	Pass	2.4
o	> 10.0 µm	1127	1126	1121	0%	Pass	2.3
p	> 12.5 µm	1185	1183	1178	0%	Pass	Calculated
q	> 15.0 µm	1256	1253	1247	0%	Pass	Calculated
r	> 17.5 µm	1339	1336	1330	0%	Pass	Calculated
s	> 20.0 µm	1436	1432	1426	0%	Pass	Calculated
t	> 25.0 µm	1668	1661	1654	0%	Pass	Calculated
u	> 30.0 µm	1951	1942	1933	0%	Pass	Calculated
v	> 32.0 µm	2046	2046	2037	0%	Pass	Calculated