Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

AIR QUALITY ASSESSMENT

BURNCO WEST COCHRANE GRAVEL PIT
NE-15-026-05 W5M TO NE-14-026-05 W5M

Prepared for:
BURNCO ROCK PRODUCTS LTD.

Prepared by:
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TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 Assessment Objective 1
1.2 Assessment Approach 1
2 AIR QUALITY LIMITS AND MANAGEMENT CRITERIA 2
2.1 Alberta Ambient Air Quality Criteria 2
3 MONITORED AMBIENT AIR QUALITY 2
4 PROJECT BOUNDARY AND STUDY AREA 3
4.1 Receptor Grid 4
5 ASSESSMENT CASES 4
6 MODELLING APPROACH 4
6.1 Transport and Dispersion Model 5
6.2 Meteorology 5
6.3 Terrain and Land Cover 6
6.4 Building Downwash 6
6.5 Model Results Presentation 6
7 EMISSIONS 7
7.1 Existing and Approved Regional Emissions 7
7.2 Project Emissions 10
7.2.1 Electrical Generators 10
7.2.2 Dirt Work 10
7.2.3 Crush Plant Operations 10
7.2.4 Wash Plant Operations 11
7.2.5 Gravel Mining 11
7.2.6 Sales Traffic 11
7.3 Upset Emissions 15
8 RESULTS AND DISCUSSION 15
8.1 Project, Application, and Baseline Cases 15
8.1.1 Nitrogen Dioxide (NO_2) 15
8.1.2 Fine Particulate Matter ($PM_{2.5}$) 16
8.1.3 Total Suspended Particulates (TSP) 16
8.1.4 Carbon Monoxide (CO) 17
9 SUMMARY AND CONCLUSIONS 18
10 REFERENCES 19

IN-TEXT TABLES

TABLE 1 Alberta Ambient Air Quality Objectives 2
TABLE 2 Ambient Model Background Concentrations 3
TABLE 3 Summary of Major Existing and Approved Emissions Sources within the Study Area 9
TABLE 4 Project Point Emission Sources 12
TABLE 5 Project Area Emission Sources 13
TABLE 6 Maximum Predicted NO_2 Ground Level Concentrations –Project, Application, and Baseline Cases 15
TABLE 7 Maximum Predicted $PM_{2.5}$ Ground Level Concentrations – Project, Application, and Baseline Cases 16
TABLE 8 Maximum Predicted TSP Ground Level Concentrations –Project, Application, and Baseline Cases 17
TABLE 9 Maximum Predicted CO Ground Level Concentrations –Project, Application, and Baseline Cases 17

FIGURES

FIGURE 1 Site Location
FIGURE 2 Air Modelling Plot Plan Assessment Area 1
FIGURE 3 Background Emission Sources within the Modelling Domain
FIGURE 4 Wind Rose for 2015 to 2019 Based on WRF Data 10 m Above Grade
FIGURE 5 Maximum Predicted 1-h Average (9th highest) NO_2 (TCM) Concentration Contours - Application Case
FIGURE 6 Maximum Predicted Annual Average NO_2 (TCM) Concentration Contours - Application Case
FIGURE 7 Maximum Predicted 24-h Average $PM_{2.5}$ Concentration Contours - Application Case
FIGURE 8 Maximum Predicted 24-h TSP Concentration Contours - Application Case
FIGURE 9 Maximum Predicted Annual Average TSP Concentration Contours - Application Case
FIGURE 10 Maximum Predicted 1-h Average (9th highest) CO Concentration Contours - Application Case
FIGURE 11 Maximum Predicted 8-h Average CO Concentration Contours - Application Case

APPENDICES

APPENDIX A CALMET and CALPUFF Switches Used
APPENDIX B Existing and Approved Emission Sources Details

1 INTRODUCTION

BURNCO Rock Products Ltd. (BURNCO) is currently operating the West Cochrane gravel pit which is located approximately 5 km west of Cochrane, Alberta. This site, located within NW-13-026-05 W5M, was first opened in 2016 and provides aggregate (sand and gravel) to construction projects in the Cochrane and Calgary areas.

To meet with market needs, BURNCO is proposing to permit the lands in Section 14 and 15 of 026-05-W5M (Figure 1), referred to as the West Cochrane #2 Gravel Pit (the Project). This site will be developed once the existing West Cochrane Gravel Pit is depleted. It is envisioned that this site will continue to supply aggregates in the years ahead and will also become a washing location which will provide high quality aggregates for use in asphalt and ready-mix production.

1.1 Assessment Objective

The objective of this assessment is to assess the potential effects of the proposed Project on the ambient air quality in the region. The Project emissions interact with existing emissions from other sources in the region; therefore, the assessment considers the effect of nitrogen oxides (NO_X), fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$), total suspended particulates (TSP), and carbon monoxide (CO) emissions as a result of the Project, in combination with other regional sources.

1.2 Assessment Approach

The air quality assessment approach and methods are consistent with the *Air Quality Model Guideline* (AQMG; AEP 2021) and includes the completion of the following tasks:

- review air quality objectives and management criteria (Section 2)
- review monitored ambient air quality (Section 3)
- define the Study Area and the Project boundary (Section 4)
- define the assessment cases (Section 5)
- model setup including selecting an approved dispersion modelling system, selecting receptors, accounting for building downwash, and defining criteria for interpreting model results (Section 6)
- estimate and summarize the Project emissions and emissions from regional sources (Section 7)
- dispersion modelling and presentation of modelling results (Section 8)
- summarize results and conclude assessment (Section 9)

2 AIR QUALITY LIMITS AND MANAGEMENT CRITERIA

2.1 Alberta Ambient Air Quality Criteria

The Alberta Ambient Air Quality Objectives (AAAQOs) were developed under the *Environmental Protection and Enhancement Act* (EPEA, R.S.A. 2000) to protect Alberta's air quality (AEP 2019a). The objectives refer specifically to ambient concentrations expressed in units of micrograms per cubic metre ($\mu g/m^3$) and parts per billion (ppb). The objectives also represent a range of averaging periods that address potential short-term exposure responses (i.e., 1-hour or 24-hour) and/or long-term chronic exposures (i.e., 30-day or annual). The assessment considers both short- and long-term averaging objectives. The air quality objectives relevant to the Project are provided in Table 1. As seen in Table 1, nitrogen dioxide (NO_2) concentrations are regulated, as such NO_X concentrations will be converted to NO_2 as described in Section 6.5.

TABLE 1 Alberta Ambient Air Quality Objectives

Substances	Averaging Period	AAAQO [a] ($\mu g/m^3$)
Nitrogen Dioxide (NO_2)	1-hour	300
	Annual	45
Fine Particulate Matter ($PM_{2.5}$)	24-hour	29
Total Suspended Particulates	24-hour	100
	Annual	60 [b]
Carbon Monoxide (CO)	1-hour	15,000
	8-hour	6,000

Notes:
a. Alberta Ambient Air Quality Objectives, AAAQO (AEP 2019a)
b. Calculated using the arithmetic mean concentration as a conservative approach.

3 MONITORED AMBIENT AIR QUALITY

Background concentrations represent contributions from sources not included in the modelling (such as naturally occurring sources, nearby non-industrial sources, and unidentified distant sources). The background concentrations were estimated using the methodology outlined in the AQMG, using data from two air quality monitoring stations based on the availability of continuous data.

The air quality in the Project region is monitored by continuous air quality monitoring stations operated by the Calgary Region Airshed Zone (CRAZ) and the Parkland Airshed Management Zone (PAMZ). The Caroline Station, operated by PAMZ, located 81 km north of the Project, was considered the most representative station for the Project and was used for ambient NO_2 and $PM_{2.5}$ concentrations. The Caroline Station is representative of the Project since it is surrounded by rural land, such as undisturbed land and agricultural land, and has limited anthropogenic emission sources in close proximity. CO is not monitored at the Caroline Station; therefore, the monitoring station used to represent CO was Calgary Varsity Station, located in the City of Calgary (36 km southeast of the Project) and operated by CRAZ.

Recent data were not available in the CRAZ or PAMZ monitoring networks for TSP, so $PM_{2.5}$ data were assumed to be representative of this particulate size fraction.

The background concentrations were added to the calculated model background concentrations for each averaging period. A summary of the ambient air quality monitored values for NO_2, $PM_{2.5}$, and CO for 2019 to 2021 is provided in Table 2.

TABLE 2 Ambient Model Background Concentrations

Averaging Period	NO_2 [(a)] ($\mu g/m^3$)	$PM_{2.5}$ [(a)] ($\mu g/m^3$)	TSP [(b)] ($\mu g/m^3$)	CO [(c)] ($\mu g/m^3$)
1-hour	8.7	-	-	343.6
8-hour	-	-	-	343.6
24-hour	-	10.8	10.8	-
Annual	3.6	-	3.1	-

Notes:

(a) Data are from Caroline Station (AEP 2019b).
(b) Data are from Caroline Station (AEP 2019b). $PM_{2.5}$ data are assumed to be representative of TSP.
(c) Data are from Calgary Varsity Station (AEP 2019b).

TSP - total suspended particulates

4 PROJECT BOUNDARY AND STUDY AREA

An Air Assessment Boundary is determined by the facility fenceline and/or the perimeter of disturbed area that defines where public access is restricted. The AAAQOs are applied on and beyond the Air Assessment Boundary. The Project shown in Figure 1 would not be developed all at once. The Project has been subdivided into phases, with phasing being developed in accordance with the mine plan. For this assessment, the stage of development where crushing and mining operations are located at the western extent of the Project was selected to model as it will have long stretches of internal road, which could be significant sources of dust, and includes a wash plant among its emission sources. The Air Assessment Boundary for the air assessment for is shown on Figure 2.

The Study Area (Figure 3) defines the area over which air dispersion calculations are performed. The Study Area for this assessment:

- was set to a 23 km × 23 km area centred on the midpoint of the Project; this domain is large enough to encompass the cumulative effects related to air emissions from developments in the area surrounding the Project
- includes emissions from existing and approved regional sources
- contains the maximum predicted ground level concentrations from the Project at or above 10% of the AAAQO or Baseline concentration, whichever is higher (AEP 2021)

4.1 Receptor Grid

A series of Cartesian gridded receptors was selected for the Study Area. The grid spacing of the receptors are as follows:

- 20 m spacing at the Air Assessment Boundary
- 50 m spacing for a 3.5 km × 2.0 km area centred on the sources of interest at the Project
- 250 m spacing for a 7.0 km × 5.5 km area centred on the sources of interest at the Project
- 500 m spacing for a 14 km × 13 km area centred on the sources of interest at the Project
- 1,000 m or less spacing for all other areas in the Study Area

The density of the receptor spacing is in accordance with the AQMG.

5 ASSESSMENT CASES

The air quality assessment was completed for the following cases:

- The **Baseline Case** considers the effect of the existing and approved sources in the Study Area, as well as background concentrations.
- The **Project Case** considers the effect of only the Project emissions on ambient air quality.
- The **Application Case** considers the effect of the Project emissions in combination with the existing and approved sources in the Study Area, as well as background concentrations.

6 MODELLING APPROACH

This section presents details of the air dispersion modelling approach, relating to model selection, meteorology, topography, and building downwash effects. Key aspects of the dispersion modelling include:

- the selection of dispersion model
- the selection of input parameters (including modelling switches) recommended for use in Alberta and consistent with the AQMG
- consideration of local meteorological fields and terrain
- the use of representative emission and dispersion parameters (i.e., stack height, diameter, areas)

6.1 Transport and Dispersion Model

Air dispersion models provide a scientific means of relating air emissions to ground level pollutant concentrations at receptors by using complex mathematical equations that simulate transportation, dispersion, chemical transformation, and deposition processes.

The California Puff Dispersion Model (CALPUFF) is a non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. The CALPUFF model is approved by the AQMG for refined assessments with potential long range (>200 km) impacts. For this assessment the CALPUFF model (version 7.2.1) was used in accordance with the AQMG to determine air quality changes for the Baseline Case, Project Case, and Application Case. Key switches used in CALPUFF modelling are outlined in Appendix A. A period of 5 years (from 2015 to 2019) was modelled, as outlined in the AQMG.

6.2 Meteorology

Meteorological parameters such as atmospheric stability, mixing height, wind direction, and wind speed determine plume transportation and dispersion. The California Meteorological Model (CALMET; version 6.5.0) provides representative three-dimensional temporally and spatially varying wind, temperature, and turbulence fields for the CALPUFF model. The CALMET model contains technical options for meteorological modelling, which are used for this assessment in accordance with the AQMG. Key switches used in CALMET modelling are outlined in Appendix A.

For this assessment, the CALMET model predictions for the Study Area are based on the following:

- the 5-year (2015 to 2019) Weather Research and Forecasting Model (WRF) dataset obtained from Alberta Environment and Parks (now Alberta Environment and Protected Areas; AEP)
- regional terrain elevations and spatially varying land use information
- seasonal variations in surface cover based on surface characteristics outlined in the AQMG

The wind fields created by the CALMET model were used in the CALPUFF modelling. A wind rose for the Project based on CALMET predictions is presented on Figure 4. The following comments can be made based on the predicted wind rose:

- the dominant winds are from the west and southeast
- the least frequent winds originate from the northeast

6.3 Terrain and Land Cover

Terrain and land use features (such as surface roughness, land cover, and vegetation) affect atmospheric turbulence and local meteorological circulation. Atmospheric turbulence creates eddies that influence plume dispersion. Local meteorological circulation determines the local transportation pathway of the plume. Both effects influence the maximum ground level concentrations at receptors.

The Project is located at an elevation between 1,140 and 1,190 m above sea level (asl; Figure 4). The domain contains the Bow River valley running west to east and the foothills in the northwest and southwest. The selected grid spacing (1 km) is sufficient to represent wind flow patterns from changing terrain in the Study Area. The minimum elevation in the Study Area is in a river valley east of the domain centre with an elevation of 1,099 m asl. The peak elevation in the Study Area is in the northwest of the domain at an elevation of 1,628 m asl.

6.4 Building Downwash

Buildings and other structures located near short stacks can have a substantial effect on plume transport and dispersion, and on the subsequent ground level concentrations. If emissions occur close to buildings, the downwind dispersion can be affected by the flow deformation and enhanced turbulence created as air moves over and around the building.

Building Profile Input Program for PRIME (BPIPPRM) can be used to prepare downwash related input for the Plume Rise Model Enhancement (PRIME) building downwash algorithm. BPIPPRM can determine whether a stack is subjected to wake effects from structure(s) and calculate building heights and projected building widths for cases when the plume is affected by building wakes. Building information (i.e., BPIPPRM output) was provided to CALPUFF from the Project electrical generator (per the requirements of the AQMG) and was used by the CALPUFF PRIME algorithm to account for building downwash.

Figure 2 present the locations of the buildings and the emission sources at Assessment Area 1.

6.5 Model Results Presentation

The maximum ground level concentrations due to the Baseline, Project, and Application Cases are presented in a tabular format (Section 8.0).

The maximum NO_2, $PM_{2.5}$, TSP, and CO concentrations are presented for the applicable averaging periods for comparison with the AAAQOs to determine compliance. The maximum concentrations for each averaging period are quantified as per the methodology outlined in the AQMG. For 1-hour averaging periods, the predicted eight highest 1-hour average concentrations for a year were considered to be outliers (caused by extreme, rare, and transient meteorological conditions), and disregarded when

calculating the maximum 1-hour average concentrations. For all other averaging periods, the eight highest 1-hour values were included when estimating the highest predicted concentrations.

For this assessment, the ninth highest 1-hour predictions are hereafter referred to as the maximum 1-hour values.

Dispersion models estimate ground level NO_X concentrations, while the AAAQO is expressed in terms of NO_2 ground level concentrations. To assess compliance with the AAAQO, NO_X must be converted to NO_2. NO_X primarily consists of nitric oxides (NO) and NO_2 and is naturally oxidized to NO_2 in the atmosphere. A tiered approach of NO_X to NO_2 conversion is recommended by the AQMG (AEP 2021). The Total Conversion Method (TCM) is the first screening approach to estimate NO_X conversion. This approach conservatively assumes 100% of NO_X emissions are converted to NO_2. For this assessment, the NO_2 concentrations resulting from the TCM method are presented.

The Application Case predictions are shown as a series of contours for the AAAQO averaging periods overlaid on base maps to provide an indication of spatial variability. The maximum concentrations are stated on each figure to assist in identifying the location of maximums.

7 EMISSIONS

7.1 Existing and Approved Regional Emissions

The assessment considers the contribution of existing and approved industrial sources within the Study Area (23 km × 23 km). These sources include major facilities in the Study Area, as well as smaller facilities and sand/gravel pits. Figure 4 shows the location of major emission sources in the Study Area. A list of existing and approved emission sources within the Study Area and their total NO_X, $PM_{2.5}$, TSP, and CO emissions by operator is presented in Table 3.

Emission information for existing and approved sources was obtained from an internal database of known emission sources including AEP and Alberta Energy Regulator licence information, approvals, and permits, and recent air quality assessments undertaken in the region. This database is routinely updated as new applications and licenses become available. Existing and approved sources included in the Study Area were identified by searching this database for facilities within the Study Area. In addition to the Matrix database, the IHS Markit database was also reviewed for additional facilities that are likely to have an impact on cumulative air quality in the Study Area (gas plants and processing facilities, sand/gravel pits, etc.).

Although facilities can be located and identified through these databases, specific stack parameters or facility emission rates are often unavailable for some facilities. A readily available detail for most sources is the facility code (i.e., C321: oil battery – multiwell <1 t/d sulphur inlet, B020: gas battery – multiwell >0.01 mol/kmol H_2S in inlet). Matrix has developed generic parameters for each category code through a

review of over 1,000 known oil and gas sources to ensure that emission rates and dispersion parameters are representative of the nature of the source. The average emission rates were calculated from the grouped and reviewed licences to represent generic NO_X emission rates. Generic emission rates for $PM_{2.5}$, TSP, and CO were developed using a ratio of AP 42 (U.S. EPA 2018a) internal combustion emission factors and the average NO_X emission rate. Generic stack parameters are representative of the licence reviews based on each category code.

For approved sand and gravel pits, the AP42 Chapter on Industrial Wind Erosion was used to estimate particulate emissions from these areas (Chapter 13.2.5; U.S. EPA 2018b)

The total NO_X, $PM_{2.5}$, TSP, and CO emissions from existing and approved sources are 8.0, 0.2, 0.7, and 2.0 t/d, respectively. A detailed description of the existing and approved emission sources in the Study Area is presented in Appendix B.

TABLE 3 Summary of Major Existing and Approved Emissions Sources within the Study Area

Operator	Facility/Pit	Emission Totals for All Facilities			
		NO_X (t/d)	$PM_{2.5}$ (t/d)	TSP (t/d)	CO (t/d)
Canlin Energy Corporation	Compressor Station	0.137500	0.000003	0.000003	0.010700
	Compressor Station	0.137500	0.000003	0.000003	0.010700
	Gas Battery	0.013700	0.000000	0.000000	0.001100
Canlin Resources Partnership	Gas Battery	0.040800	0.000001	0.000001	0.003200
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	1.496700	0.032200	0.032200	0.414100
Donna and Ian Airth	Big Springs Gravel Pit	0.046135	0.011050	0.147338	0.403679
Interpipeline Fund	Cochrane Extraction Plant	4.559809	0.061743	0.061743	0.972307
John and Irene Robinson	Robinson Pit	0.108680	0.026031	0.347084	0.950943
Manitok Energy Inc.	Compressor Station	0.137500	0.000003	0.000003	0.010700
	Compressor Station	0.137500	0.000003	0.000003	0.010700
	Gas Battery	0.040800	0.000001	0.000001	0.003200
Nal Resources Limited	Oil Satellite	0.005200	0.000000	0.000000	0.000400
Orlen Upstream Canada Ltd.	Oil Battery	0.012500	0.000000	0.000000	0.001000
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
Ridgeback Resources Inc.	Oil Satellite	0.005200	0.000000	0.000000	0.000400
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
	Oil Satellite	0.005200	0.000000	0.000000	0.000400
Rocky View County	Cochrane Pit	0.015686	0.003757	0.050097	0.137256
	Griffin Pit	0.019294	0.004621	0.061620	0.168827
Shell Canada Limited	Gas Battery	0.003400	0.000000	0.000000	0.000300
	Gas Battery	0.003400	0.000000	0.000000	0.000300
	Gas Battery	0.003400	0.000000	0.000000	0.000300
	Gas Battery	0.003400	0.000000	0.000000	0.000300
	Gas Battery	0.003400	0.000000	0.000000	0.000300
	Gas Processing Plant	0.266900	0.000005	0.000005	0.020700
	Jumping Pound Sour Gas Processing Plant	0.972400	0.049500	0.049500	0.524100
Spray Lake Sawmills (1980) Ltd.	Cochrane Sawmill/Wood Treatment Plant	0.013700	0.006600	0.006600	0.015900
	Total	**8.026**	**0.191**	**0.690**	**2.003**

7.2 Project Emissions

The operation of the Project will result in emissions of NO_X, $PM_{2.5}$, TSP, and CO from electrical generators, dirt work, crush plant operations, wash plant operations, gravel mining, and sales activity. Stack parameters, area source parameters, and emission rates associated with the Project's emission sources are shown in Tables 4 and 5. A plot plan showing the emission sources and their relative locations, and the Project boundary, is presented on Figure 2.

7.2.1 Electrical Generators

The electrical generators will be fired on diesel fuel and will power the crush plant and wash plant. The electrical generator at the crush plant is expected to operate for a maximum of 24 hours a day for the months of February to December. The electrical generator at the wash plant is expected to operate for a maximum of 24 hours a day for the months of April to October. The electrical generators will be sources of sulphur dioxide, NO_X, $PM_{2.5}$, TSP, and CO emissions (Table 4). The sulphur dioxide emissions were determined to be relatively small and were not further assessed. The electrical generator has been assumed to operate 24 hours a day to allow for operational flexibility, which will be an overestimate of actual operating times and emissions.

7.2.2 Dirt Work

Dirt work includes the removal of topsoil and overburden from the gravel layer at the Project. Heavy machinery such as buggies, bulldozers, and graders will operate for 10 hours a day for the warmer months of April to November. To reduce dust produced during dirt work, a water truck will be employed and a 70% reduction in particulate emissions has been assumed as a result of moderate wetting of the dirt work area (Figures 2; no reduction was applied to particulate emissions from heavy machinery exhaust). Dirt work activities will be sources of NO_X, $PM_{2.5}$, TSP, and CO emissions (Table 5). Dirt work has been assumed to occur all at once over a 13.1 ha area, which is a conservative estimate of emissions as a much smaller area would be developed at any one time - resulting in lower emissions.

7.2.3 Crush Plant Operations

The crush plant crushes and sorts mined material to prepare it for sale. The crush plant has a feeder, conveyors, a jaw, screening decks, and a loader that operate for a maximum of 24 hours a day for the months of February to December. To reduce dust produced at the crush plant, blanket enclosures, water spray, and spray truck will be employed and a 92.5% reduction in particulate emissions has been assumed as a result of maximum wetting of the crush plant areas as well as a 90% reduction from blanket enclosures. To reduce dust produced at the associated roads (including a road between the crush plant and wash plant), a truck spraying magnesium chloride will be employed and a 98% reduction in particulate emissions has been assumed as a result (Figure 2; no reduction was applied to particulate emissions from heavy machinery exhaust). Crush plant activities will be sources of NO_X, $PM_{2.5}$, TSP, and CO emissions

(Tables 4 and 5). Crush plant activities have been assumed to occur 24 hours a day to allow for operational flexibility, which is a conservative estimate of actual operating times and emissions.

7.2.4 Wash Plant Operations

The wash plant washes and sorts mined material to prepare it for sale. The wash plant has a feeder, conveyors, screening decks, a sand screw, a log washer, stackers, and a loader that operate for a maximum of 24 hours a day for the months of April to October. Most stages of the wash plant will have zero emissions due to the sand and gravel products being saturated with water. To reduce dust produced at the associated roads, a truck spraying magnesium chloride will be employed and a 98% reduction in particulate emissions has been assumed as a result of maximum dust treatment of the roads (Figure 2; no reduction was applied to particulate emissions from heavy machinery exhaust). Wash plant activities will be sources of NO_X, $PM_{2.5}$, TSP, and CO emissions (Tables 4 and 5). Wash plant activities have been assumed to occur 24 hours a day to allow for operational flexibility, which is a conservative estimate of actual operating times and emissions.

7.2.5 Gravel Mining

Development of the mining area includes the removal of sand and gravel, and stockpiling material before and after it goes through the crush plant. Loaders will operate for a maximum of 24 hours a day for the months of February to December. No mitigation is proposed for the mining area (Figure 2). Mining activities will be sources of NO_X, $PM_{2.5}$, TSP, and CO emissions (Table 5). Mining and stockpiling have been assumed to occur over 3.7 ha area which is a conservative estimate of emissions since a much smaller area would be developed at any one time.

7.2.6 Sales Traffic

Sales traffic includes the movement of 20 dump trucks and a loader. This heavy machinery will operate for a maximum of 10 hours a day, year-round. To reduce dust produced on roads, a truck spraying magnesium chloride will be employed and a 98% reduction in particulate emissions has been assumed as a result of maximum dust treatment of roads (Figure 2). In addition, the scale facility will be paved to avoid particulate emissions from vehicles driving on it. Sales traffic activities will be sources of NO_X, $PM_{2.5}$, TSP, and CO emissions (Table 5).

TABLE 4 Project Point Emission Sources

Point Source	UTM Easting	UTM Northing	Elevation	Stack Height	Stack Diameter	Exit Velocity	Exit Temperature	NO_X	$PM_{2.5}$	TSP	CO
	(m)	(m)	(m asl)	(m)	(m)	(m/s)	(K)	(t/d)	(t/d)	(t/d)	(t/d)
Electrical Generator – Crush Plant	666,855	5,677,211	1,190	6.7	0.254	55.8	784	0.336	0.024	0.024	0.072
Electrical Generator – Wash Plant	668,482	5,677,386	1,185	6.7	0.254	55.8	784	0.336	0.024	0.024	0.072

UTM - Universal Transverse Mercator
TSP - total suspended particulates
CO - carbon monoxide

TABLE 5 Project Area Emission Sources

Area Source	Dirt Work	Dirt Work Mobile Heavy Machinery	Crush Plant	Crush Plant Mobile Heavy Machinery	Crush Plant Road Dust	Mining Area	Crushed Product Stockpile Area	Wash Plant	Wash Plant Heavy Machinery	Wash Plant Road Dust	Sales Mobile Heavy Machinery	Sales Road Dust
Operation Schedule	10 hours/day, April to November	10 hours/day, April to November	24 hours/day, February to December	24 hours/day, February to December	24 hours/day, February to December	24 hours/day, February to December	24 hours/day, January to December	24 hours/day, April to October	24 hours/day, April to October	24 hours/day, April to October	10 hours/day, January to December	10 hours/day, January to December
Location	Dirt Work Area	Dirt Work Area	Crush Plant	Road 2, Road 3	Road 2, Road 3	Mining Area	Mining Area	Wash Plant	Road 4	Road 4	Road 1, Road 2	Road 1, Road 2
Mitigation Applied	Water truck	NA	Water spray and blanket enclosures	NA	Truck spraying MgCl	NA	NA	NA	NA	Truck spraying MgCl	NA	Truck spraying MgCl
Number of Areas Modelled	6	6	1	2	2	7	7	1	1	1	4	4
Elevation (m asl)	1,192, 1,189, 1,188, 1,195, 1,192, 1,177	1,192, 1,189, 1,188, 1,195, 1,192, 1,177	1,183	1,185, 1,182	1,185, 1,182	1,185, 1,184, 1,184, 1,182, 1,180, 1,178, 1,175	1,185, 1,184, 1,184, 1,182, 1,180, 1,178, 1,175	1,184	1,184	1,184	1,188, 1,188, 1,188, 1,185	1,188, 1,188, 1,188, 1,185
Effective Height (m)	2.0	3.1	1.0	3.3	2.0	2.0	4.0	1.0	3.3	2.0	3.3	2.0
Initial Sigma z (m)	1.9	2.9	0.9	3.1	1.9	1.9	3.7	0.9	3.1	1.9	3.1	1.9
NW Corner UTM Easting (m)	666609, 666643, 666659, 666609, 666900, 666908	666609, 666643, 666659, 666609, 666900, 666908	666804	666845, 666721	666845, 666721	666721, 666748, 666870, 666748, 666729, 666748, 666910	666721, 666748, 666870, 666748, 666729, 666748, 666910	668437	668481	668481	668360, 668486, 668607, 666906	668360, 668486, 668607, 666906
NW Corner UTM Northing (m)	5677501, 5677419, 5677342, 5677501, 5677527, 5677266	5677501, 5677419, 5677342, 5677501, 5677527, 5677266	5677263	5677222, 5677160	5677222, 5677160	5677265, 5677161, 5677161, 5677111, 5677062, 5677013, 5677111	5677265, 5677161, 5677161, 5677111, 5677062, 5677013, 5677111	5677432	5677327	5677327	5677439, 5677441, 5677515, 5677222	5677439, 5677441, 5677515, 5677222
NE Corner UTM Easting (m)	666900, 666900, 666900, 666900, 666900, 666918	666900, 666900, 666900, 666900, 666900, 666918	666906	668359, 666865	668359, 666865	666803, 666850, 666910, 666910, 666910, 666910, 666916	666803, 666850, 666910, 666910, 666910, 666910, 666916	668538	668501	668501	668486, 668607, 668681, 668359	668486, 668607, 668681, 668359
NE Corner UTM Northing (m)	5677501, 5677419, 5677342, 5677527, 5677265, 2676971	5677501, 5677419, 5677342, 5677527, 5677265, 2676971	5677262	5677438, 5677160	5677438, 5677160	5677264, 5677161, 5677161, 5677111, 5677062, 5677013, 5676975	5677264, 5677161, 5677161, 5677111, 5677062, 5677013, 5676975	5677432	5677327	5677327	5677441, 5677515, 5677590, 5677438	5677441, 5677515, 5677590, 5677438
SE Corner UTM Easting (m)	666900, 666900, 666900, 666900, 666908, 666167	666900, 666900, 666900, 666900, 666908, 666167	666906	668359, 666865	668359, 666865	666803, 666850, 666910, 666910 666910, 666910, 666910	666803, 666850, 666910, 666910 666910, 666910, 666910	668538	668501	668501	668487, 668612, 668688, 668359	668487, 668612, 668688, 668359

Area Source	Dirt Work	Dirt Work Mobile Heavy Machinery	Crush Plant	Crush Plant Mobile Heavy Machinery	Crush Plant Road Dust	Mining Area	Crushed Product Stockpile Area	Wash Plant	Wash Plant Heavy Machinery	Wash Plant Road Dust	Sales Mobile Heavy Machinery	Sales Road Dust
SE Corner UTM Northing (m)	5677419, 5677342, 5677265, 5677501, 5677265, 5676978	5677419, 5677342, 5677265, 5677501, 5677265, 5676978	5677160	5677418, 5677110	5677418, 5677110	5677161, 5677111, 5677111, 5677062, 5677013, 5676975, 5676975	5677161, 5677111, 5677111, 5677062, 5677013, 5676975, 5676975	5677330	5677277	5677277	5677421, 5677495, 5677573, 5677418	5677421, 5677495, 5677573, 5677418
SW Corner UTM Easting (m)	666643, 666720, 666720, 667158	666643, 666720, 666720, 667158	666803	666906, 666845	666906, 666845	666748, 666748, 666870, 666729, 666748, 666755	666748, 666748, 666870, 666729, 666748, 666755	668436	668481	668481	668361, 668487, 668612, 666906	668361, 668487, 668612, 666906
SW Corner UTM Northing (m)	5677419, 5677342, 5677265, 5677266	5677419, 5677342, 5677265, 5677266	5677160	5677202, 5677110	5677202, 5677110	5677161, 5677111, 5677111, 5677062, 5677013, 5676975	5677161, 5677111, 5677111, 5677062, 5677013, 5676975	5677330	5677277	5677277	5677419, 5677421, 5677495, 5677202	5677419, 5677421, 5677495, 5677202
Area (m^2)	131,258	131,258	10,506	29,060, 980	29,060, 980	37,394	37,394	10,404	1,000	1,000	6,420, 29,060	6,420, 29,060
NO_X (t/d)	0	0.037283	0	0.003563, 0.001620	0, 0	0	0	0	0.001653	0	0.0111742, 0.0544218	0, 0
$PM_{2.5}$ (t/d)	0.0007137	0.001864	0.002749	0.000178, 0.000081	0.001412, 0.000083	0.0001132	0.0000601	0.002895	0.000083	0.0000568	0.0005587, 0.0027211	0.0002205, 0.0003418
TSP (t/d)	0.006797	0.001864	0.051869	0.000178, 0.000081	0.05539, 0.00324	0.0010785	0.0003007	0.054626	0.000083	0.002230	0.0005587, 0.0027211	0.008653, 0.01341
CO (t/d)	0	0.326228	0	0.031173, 0.014171	0, 0	0	0	0	0.014460	0	0.0977741, 0.4761903,	0, 0

7.3 Upset Emissions

The Project emissions described in Section 7.2 were modelled simultaneously and represent a maximum emission scenario. During an upset, such as an electrical generator malfunction, the emissions from the Project would be lower than those assessed during normal operation. As a result, no upset emissions were assessed.

8 RESULTS AND DISCUSSION

8.1 Project, Application, and Baseline Cases

The maximum predicted ground level NO_2, $PM_{2.5}$, TSP, and CO concentrations for the Project, Application, and Baseline Cases are presented in Tables 6 to 9, respectively. Application Case contours are also presented on Figures 5 to 11.

8.1.1 Nitrogen Dioxide (NO_2)

The Project Case maximum predicted 1-hour and annual averaged ground level concentrations for NO_2 (TCM) comply with the applicable AAAQOs (Table 6). The 1-hour averaged Application and Baseline Case concentrations exceed the applicable AAAQOs using the conservative modelling approach. The exceedances are likely a direct result of existing operations and current emission sources west of the Air Assessment Boundary (Figure 3). For the Application and Baseline Cases, the maximum predicted 1-hour averages occur 1.7 km from the Project and are mostly driven by existing emission sources (Figure 5).

TABLE 6 Maximum Predicted NO_2 Ground Level Concentrations –Project, Application, and Baseline Cases

Parameter	NO_2 – TCM	
	1-hour [(a)]	Annual
Project Case		
Maximum NO_2 concentration (µg/m^3)	233	32
Application Case		
Maximum NO_2 concentration (µg/m^3)	**337**	37
Baseline Case		
Maximum NO_2 concentration (µg/m^3)	**334**	26
AAAQO	300	45

Notes:
AAAQO - Alberta's Ambient Air Quality Objectives
a. The maximum 1-hour NO_2 concentration excludes the eight highest predictions as per the AQMG. The eight highest 1-hour predictions were included when estimating the maximum annual predictions (AEP 2021).
b. **Bold** denotes an exceedance of the AAAQO.
N = North; S = South; E = East; W = West

8.1.2 Fine Particulate Matter ($PM_{2.5}$)

The Project Case maximum 24-hour averaged $PM_{2.5}$ concentration comply with the AAAQO (Table 7). For the Application and Baseline Cases, the maximum predicted 24-hour averaged $PM_{2.5}$ concentration is above the AAAQO (Table 7). The Application Case maximum 24-hour averaged $PM_{2.5,}$ occurs on the Air Assessment Boundary; however, the Baseline Case maximum 24-hour averaged $PM_{2.5,}$ occurs 11.7 km northeast of the Project (Figure 7). The Application Case maximum concentration is likely a result of high ambient concentrations being added to the compliant Project Case maximum concentration. High ambient concentrations are commonly driven by forest fire smoke in the years 2019 - 2021.

TABLE 7 Maximum Predicted $PM_{2.5}$ Ground Level Concentrations – Project, Application, and Baseline Cases

Parameter	$PM_{2.5}$
	24-hour
Project Case	
Maximum $PM_{2.5}$ concentration (µg/m^3)	22
Application Case	
Maximum $PM_{2.5}$ concentration (µg/m^3)	**33**
Baseline Case	
Maximum $PM_{2.5}$ concentration (µg/m^3)	**32**
AAAQO	29

Notes:
AAAQO - Alberta's Ambient Air Quality Objectives
N = North; S = South; E = East; W = West
Bold values indicate an exceedance of the AAAQO.

8.1.3 Total Suspended Particulates (TSP)

The Project, Application, and Baseline Case maximum predicted annual averaged TSP concentrations comply with the AAAQO (Table 8). The Project, Application, and Baseline Case maximum predicted 24-hour averaged TSP concentrations are above the AAAQO (Table 8) and are predicted to occur along the southern fence line of the Air Assessment Boundary (Figure 8). The impact of the prediction is a result of very conservative modelling assumptions, including over-estimated operational times and simultaneous excavation on the entire site (which is not possible). It is expected that with the planned mitigation of road dust with water trucks and magnesium chloride dust suppressant, as needed, that actual TSP concentrations during operation will remain below the AAAQO. BURNCO has similar operations within municipalities, such as Calgary, where effective dust control is applied.

TABLE 8 Maximum Predicted TSP Ground Level Concentrations –Project, Application, and Baseline Cases

Parameter	TSP	
	24-hour	Annual
Project Case		
Maximum TSP concentration (µg/m^3)	**244**	52
Application Case		
Maximum TSP concentration (µg/m^3)	**255**	55
Baseline Case		
Maximum TSP concentration (µg/m^3)	**173**	46
AAAQO	100	60

Notes:
TSP - total suspended particulate
AAAQO - Alberta's Ambient Air Quality Objectives
N = North; S = South; E = East; W = West
Bold values indicate an exceedance of the AAAQO.

8.1.4 Carbon Monoxide (CO)

The Project, Application, and Baseline Case maximum predicted 1-hour and 8-hour averaged CO concentrations all comply with their respective AAAQOs (Table 9). For the Application Case, maximum concentrations are predicted to occur at the south side of the Air Assessment Boundary (Figures 10 and 11).

TABLE 9 Maximum Predicted CO Ground Level Concentrations –Project, Application, and Baseline Cases

Parameter	CO	
	1-hour [(a)]	8-hour
Project Case		
Maximum CO concentration (µg/m^3)	2,214	1,728
Application Case		
Maximum CO concentration (µg/m^3)	2,558	2,071
Baseline Case		
Maximum CO concentration (µg/m^3)	458	407
AAAQO	15,000	6,000

Notes:
a. The maximum 1-hour CO concentration excludes the eight highest predictions as per the AQMG. The eight highest 1-hour predictions were included when estimating the maximum annual predictions (AEP 2021).
N = North; S = South; E = East; W = West
AAAQO - Alberta's Ambient Air Quality Objectives

9 SUMMARY AND CONCLUSIONS

An air quality assessment was conducted to identify the potential effects and changes to ambient air quality due to the proposed BURNCO expansion Project near Cochrane, Alberta. The assessment considered the Project emissions in combination with regional existing and approved emission sources of NO_2, $PM_{2.5}$, TSP, and CO. The air quality assessment considered worst-case emissions from the Project Area, following methodology consistent with the AQMG and using the CALPUFF dispersion model. Data from background air monitoring stations from PAMZ (Caroline) and CRAZ (Calgary Varsity) were used to represent ambient conditions.

The air assessment identified that emissions of NO_2, $PM_{2.5}$, TSP, and CO will be emitted from the Project site. Predicted results of the dispersion modelling show that maximum ground level NO_2, $PM_{2.5}$, annual TSP, and CO concentrations due to the Project Case will be below the applicable AAAQOs at the Air Assessment Boundary and beyond. In addition, the results from the Application and Baseline Cases also show that the maximum ground level concentrations of annual NO_2, annual TSP, and CO will be below the applicable AAAQOs. While the results predict exceedances of 1-hour NO_2 and $PM_{2.5}$ in the Application and Baseline Cases, the maximum values are attributed to existing emission sources and not the Project.

Predicted maximum ground level concentrations of 1-hour TSP from the Project, Baseline, and Application Cases are above the applicable objectives. The actual impacts are expected to be below these predictions given the highly conservative assumptions used in the modelling, such as using 24 hours per day operations, and assuming the entire area of each Assessment Area will be excavated at one time. These conservative assumptions are primarily affecting emissions of particulate matter which have impacts to air quality that are local, short-term (will cease when operations are not occurring), and reversible when operations end. Impacts due to operations are considered very intermittent and conservative estimates were applied to operations and emissions which ultimately over-predicted worst-case potential of particulate impacts.

There is higher confidence in emissions estimated from combustion sources, such as the generators and vehicle emissions, as the combustion product emissions associated with fuel are well understood. There are higher uncertainties for emissions associated with dust generation such as earth movement, transport of materials, processing, and stock piling. As such, the probability of predictions at the boundary is higher for short-term durations, not as high for annual averages, and not for the entire duration of operations, whereas during most of the operations, mitigated measures will be monitored and used to reduce the surface dust generated.

Given the results of the modelling, and the conservative assumptions used, the operations for the BURNCO west operations are not expected to compromise the far field air quality in the area.

10 REFERENCES

Alberta Environment and Parks (AEP). 2021. *Air Quality Model Guideline*. Air Policy. Effective date: November 15, 2021 Copyright Her Majesty the Queen in right of the Province of Alberta, 2021. Edmonton, Alberta. September 2021. https://open.alberta.ca/dataset/cefcad38-6d49-4cce-98f7-23b1741f85b7/resource/b4ed8dc9-3850-4e5f-a618-42b29c4ba2d4/download/aep-aqmg-air-quality-model-guideline-2021-09.pdf

Alberta Environment and Parks (AEP). 2019a. *Alberta Ambient Air Quality Objectives and Guidelines Summary*. Air Policy, 2016, No. 2. Air Policy Branch. Government of Alberta. January 2019. https://open.alberta.ca/publications/9781460134856

Alberta Environment and Parks (AEP). 2019b. *Airdata, Data Reports*. Accessed February 2019. http://airdata.alberta.ca/aepContent/Reports/DataReports.aspx

United States Environmental Protection Agency (U.S. EPA). 2018a. *Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors*. Last updated on August 1, 2018. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

U.S. Environmental Protection Agency (U.S. EPA). 2018b. *Emission Factor Documentation for AP-42, Section 13.5.2 - Industrial Wind Erosion*. For U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factor and Inventory Group. 2018. https://www3.epa.gov/ttnchie1/ap42/ch13/final/c13s0205.pdf

Easting (m)

665000 666000 667000 668000 669000 670000

Northing (m)

5678000 5677000 5676000

21 26-5-W5
22 26-5-W5
23 26-5-W5
24 26-5-W5
19 26-4-W5
18 26-4-W5
13 26-5-W5
14 26-5-W5
15 26-5-W5
16 26-5-W5
09 26-5-W5
10 26-5-W5
11 26-5-W5
12 26-5-W5
07 26-4-W5

1A

West Cochrane Gravel Pit

Gilchrist Valley Creek

Bumpy Creek

Bow River

Stoney 142, 143, 144

Rg. 5 W5M

Rg. 4

Twp. 26

N

- Project Area
- Air Assessment Boundary
- Disturbance Area
- Indian Reserve
- Water Body
- Watercourse (Field-Verified)
- Railway
- Highway
- Road

1:15,000 metres

150 0 150 300

NAD 1983 UTM Zone 11N

Map Area

Stoney 142, 143, 144

Cochrane

Rocky View County

Calgary

766 772 566 1A 22 201 1 563

Reference: Data obtained from AltaLIS © Government of Alberta and GeoBase® used under license. GDM transportation infrastructure data provided by IHS © 2019 used under license. Imagery (2013) obtained from Valtus © (2019) used under license.

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Site Location

Date:	Project:	Submitter:	Reviewer:
November 2022	26388	K. Burt	S. Dawson

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Figure 1

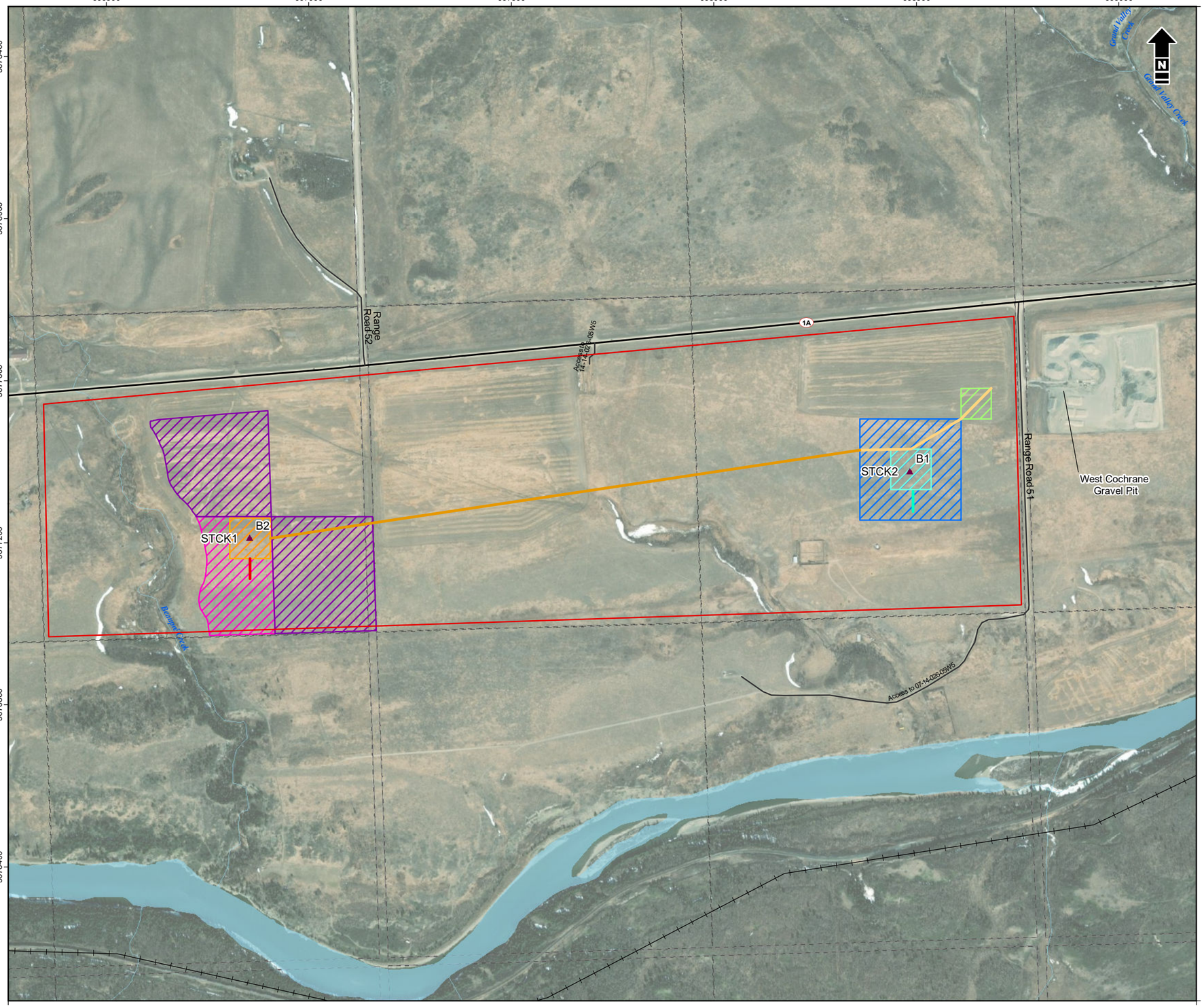
I:\Burnco\26388\FiguresAndTables\REG\2021\Report\Municipal\AQM\Figure-1-Site_Location.mxd - Tabloid_L - 04-Nov-22, 03:22 PM - RhiScott - TD004

Easting (m)

666500 667000 667500 668000 668500 669000

Northing (m)

5678400 5678000 5677600 5677200 5676800 5676400



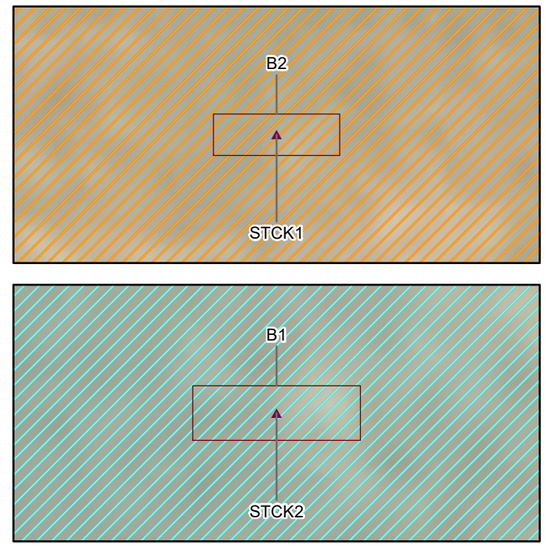
Twp. 26

Rg. 5
W5M

- Air Assessment Boundary
- Crush Plant Area
- Dirt Work Area
- Mining Area/Crushed Stockpile Area
- Scale Facility
- Wash Plant Area
- Washed Stockpile Area
- Water Body
- Watercourse
- Highway
- Road
- Railway
- Road 1
- Road 2
- Road 3
- Road 4

Point Sources		
ID	**Description**	**Height (m)**
STCK1	Electrical Generator - Crush Plant	6.7
STCK2	Electrical Generator - Wash Plant	6.7

Buildings		
RWID	**Description**	**Height (m)**
B1	Electrical Generator Enclosure - Wash Plant	2.8
B2	Electrical Generator Enclosure - Crush Plant	2.8



1:10,000 metres

50 0 50 100 150 200 250

NAD 1983 UTM Zone 11N

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Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Air Modelling Plot Plan
Assessment Area

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 2

I:\Burnco\26388\FiguresAndTables\REG\2021\Report\Municipal\AQM\Figure-2-Air_Modelling_Plot_Plan_Assessment_Area_1.mxd - Tabloid_L - 28-Oct-22, 11:54 AM - RhScott - TID005

Easting (m)

651000 654500 658000 661500 665000 668500 672000 675500 679000 682500 686000

Northing (m)

5691000 5687500 5684000 5680500 5677000 5673500 5670000 5666500 5663000

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

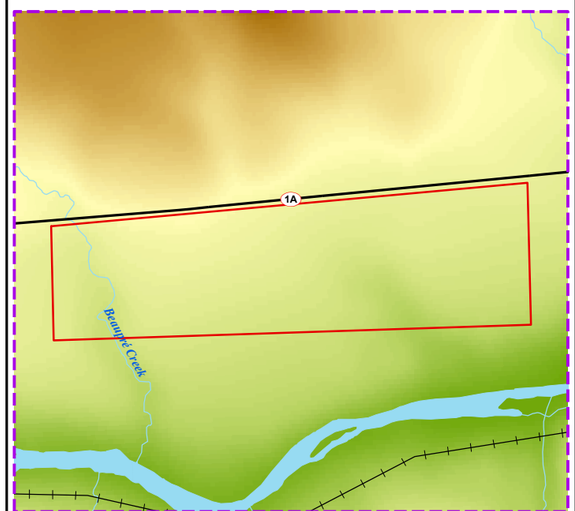
Twp. 27 Twp. 26 Twp. 25 Twp. 24

N

Rabbit Creek
Dogpound Creek
Beaverdam Creek
Lochend Lake
Rabbit Lake
1628 masl
Grand Valley Creek
Rhodes Creek
Bighill Creek
Kerfoot Creek
Robinson Creek
Bbhunhouse Creek
Ranche Creek
Spencer Creek
Beaupré Creek
Waiparous
22
567
766
40
Baymar Creek
Horse Creek
Cochrane Lake
Bigspring Creek
Beaupré Lake
1A
Jamieson Creek
Ghost Lake
Jacob Creek
McLennan Creek
Potts Lake
Cochrane
Chinuki Creek
Bow River
1099 masl
Calgary
Scott Lake
Livingstone Creek
Parks Creek
Cove Creek
Jumpingpound Creek
Towers Creek
Glenbow Lake
Willowyn Creek
Pile of Bones Creek
Westover Lake
68
1
Springbank Creek
Little Jumpingpound Creek
Frederick Lake
Darnell Lake

Study Area
Air Assessment Boundary
Background Emission Area Source
Community
Water Body
Watercourse
Highway
Railway
Background Emission Point Source
Maximum / Minimum Elevation (mASL)

Value
High : 1688
Low : 1093



1:130,000
metres
1,500 0 1,500 3,000
NAD 1983 UTM Zone 11N

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Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Background Emission Sources within the Modelling Domain

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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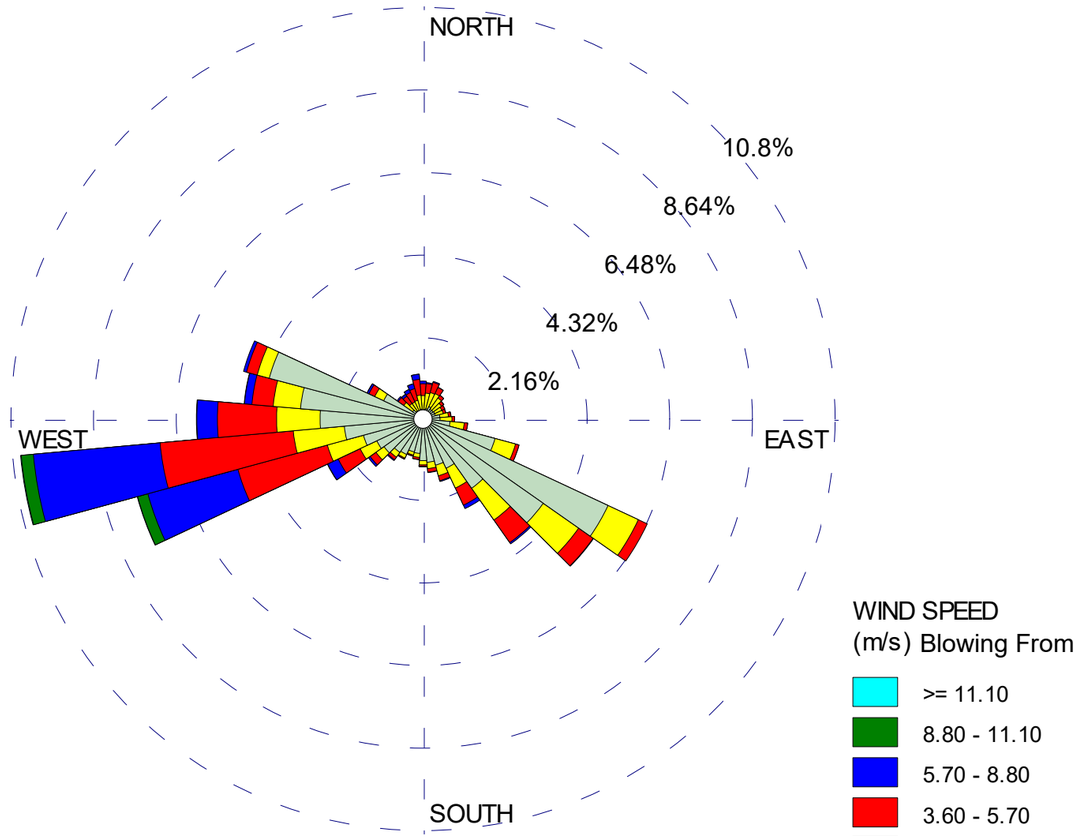
Figure 3

I:\Burnco\26388\Figures\And Tables\REG\2021\Report\Municipal\AQM\Figure-3-Background_Emission_Sources_within_the_Modelling_Domain.mxd - Tabloid_L - 28-Oct-22, 03:26 PM - RhScott - TID005



Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Wind Rose for 2015 to 2019
Based on WRF Data 10 m Above Grade

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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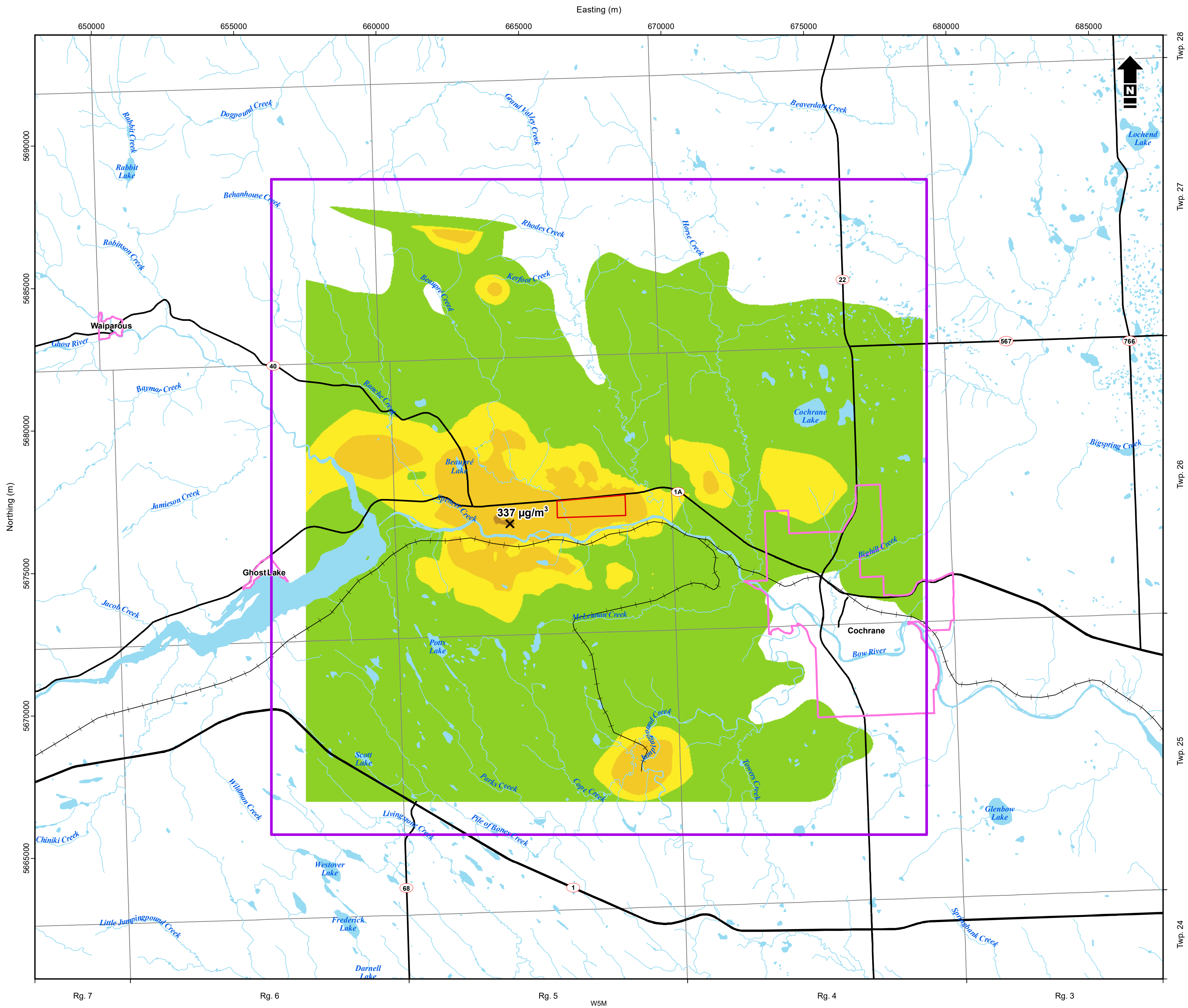
Figure 4

I:\Burnco\26388\Figures And Tables\REG\2021\Report\Municipal\AQM\Figure-4-Wind_Rose_for_2015_to_2019_Based_on_WRF_Data_10m_Above_Grade.mxd - Tabloid_L - 14-Oct-22, 11:32 AM - RhScott - TID005

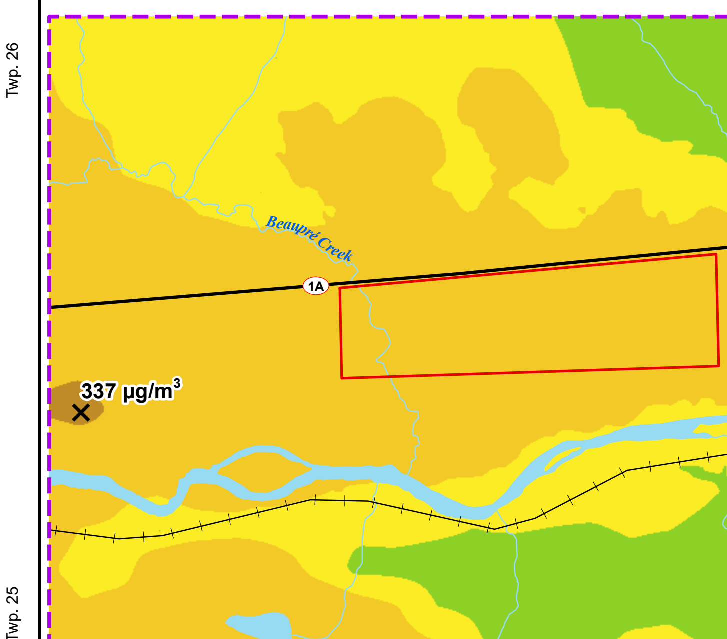


Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum NO_2 1h - 337 µg/m³

NO_2 Concentration µg/m³

- < 30
- 30 - 75
- 75 - 100
- 100 - 300
- > 300

2019 Alberta Ambient Air Quality Standard
300 µg/m³



1:135,000
Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted 1-h Average (9th highest)
NO_2 (TCM) Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure
5

I:\Burnco\26388\FiguresAndTables\REG\2021\Report\Municipal\AQM\Figure-X.mxd - Tabloid_L - 28-Oct-22, 03:28 PM - RhScott - TID005

Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Behanhouse Creek
Robinson Creek
Rhodes Creek
Horse Creek
Bungay Creek
Kerfoot Creek
Waiparous
Ghost River
Baymar Creek
Rundle Creek
Cochrane Lake
Bigspring Creek
Beaupre Lake
Jamieson Creek
Bighill Creek
Ghost Lake
Jacob Creek
Markham Creek
Patts Lake
Cochrane
Bow River
Scott Lake
Wildmint Creek
Parks Creek
Coppe Creek
Livingstone Creek
Pile of Bones Creek
Tenmile Creek
Glenbow Lake
Chiniki Creek
Westover Lake
Frederick Lake
Little Jumpingpound Creek
Darnell Lake
Springbank Creek

22 40 567 766 1A 1 68

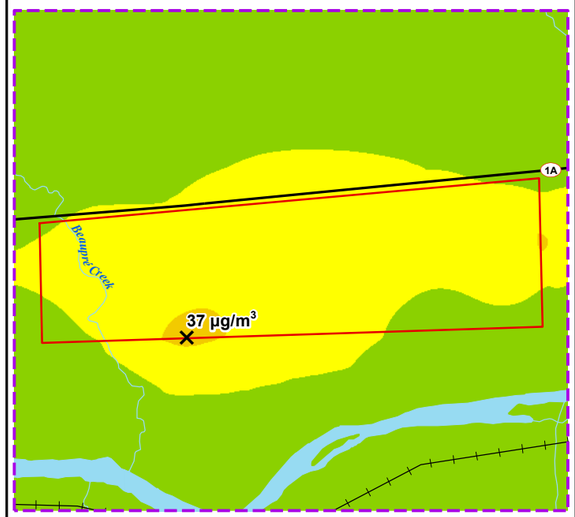
37 µg/m³

Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum NO_2 annual - 37 µg/m³

NO_2 Concentration µg/m³

- < 4.5
- 4.5 - 18
- 18 - 31.5
- 31.5 - 45
- > 45

2019 Alberta Ambient Air Quality Standard
45 µg/m³



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted Annual Average NO_2 (TCM) Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 6

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Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Behanhouse Creek
Robinson Creek
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Rhodes Creek
Horse Creek
Beaupre Creek
Kerfoot Creek
Waiparous
Ghost River
Baymar Creek
Rawlke Creek
Cochrane Lake
Bigspring Creek
Beaupre Lake
Jamieson Creek
Ripple Creek
33 µg/m3
Bighill Creek
Ghost Lake
Jacob Creek
McLennan Creek
Patts Lake
Cochrane
Bow River
Scott Lake
Wildmint Creek
Parks Creek
Cope Creek
Livingstone Creek
Pile of Bones Creek
Chiniki Creek
Westover Lake
Glenbow Lake
Little Jumpingpound Creek
Frederick Lake
Darnell Lake
Springbank Creek

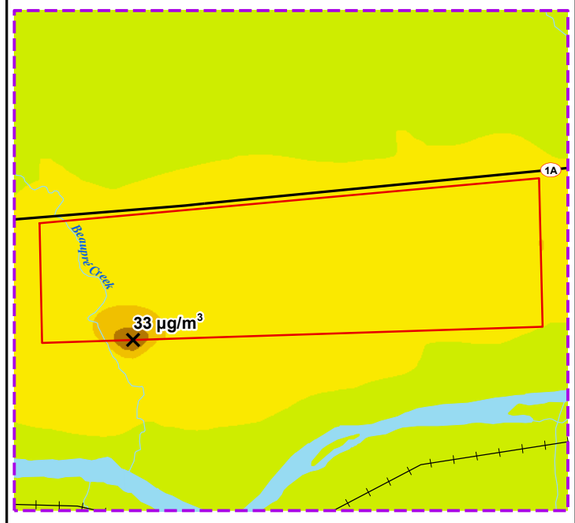
1A 22 40 567 766 68 1

Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum $PM_{2.5}$ 24h - 33 µg/m^3

$PM_{2.5}$ Concentration µg/m^3

- < 3
- 3 - 10
- 10 - 15
- 15 - 25
- 25 - 29
- > 29

2019 Alberta Ambient Air Quality Standard
29 µg/m^3



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Matrix Solutions Inc.
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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted 24-h Average $PM_{2.5}$ Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 7

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Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Behanhouse Creek
Robinson Creek
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Rhodes Creek
Hoos Creek
Bearpaw Creek
Kerfoot Creek
Waiparous
Ghost River
Baymar Creek
Rundle Creek
Cochrane Lake
Bigspring Creek
Beluga Lake
Jamieson Creek
Ghost Lake
Jacob Creek
Big Hill Creek
Mackenzie Creek
Potts Lake
Cochrane
Bow River
Scott Lake
Parks Creek
Cope Creek
Threepoint Creek
Wildmon Creek
Livingstone Creek
Pile of Bones Creek
Glenbow Lake
Chiniki Creek
Westover Lake
Little Jumpingpound Creek
Frederick Lake
Darnell Lake
Springbank Creek

22 40 567 766 1A 68 1

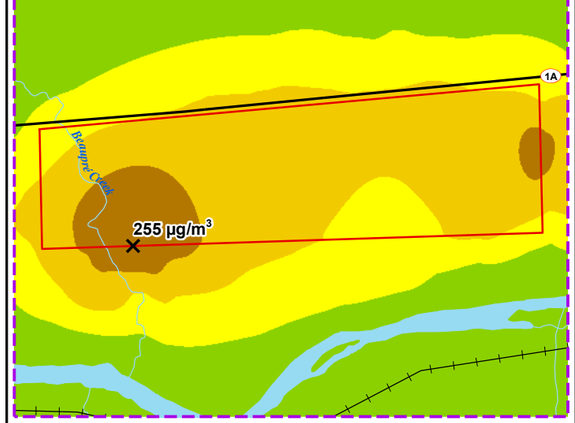
255 µg/m³

Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum TSP 24h - 255 µg/m³

TSP Concentration µg/m³

- < 10
- 10 - 25
- 25 - 50
- 50 - 100
- > 100

2019 Alberta Ambient Air Quality Standard
100 µg/m³



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted 24-h
TSP Concentration Contours -Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 8

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Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Behanhouse Creek
Rhodes Creek
Horse Creek
Robinson Creek
Beaupre Creek
Kerfoot Creek
Waiparous
Ghost River
Baymar Creek
Rancho Creek
Cochrane Lake
Bigspring Creek
Beaupré Lake
Jamieson Creek
Ripples Creek
55 µg/m3
Ghost Lake
Bighill Creek
Jacob Creek
McLennan Creek
Potts Lake
Cochrane
Bow River
Kananaskis Creek
Scott Lake
Wildmint Creek
Parks Creek
Cope Creek
Towers Creek
Livingstone Creek
Pile of Bones Creek
Glenbow Lake
Chiniki Creek
Westover Lake
Little Jumpingpound Creek
Frederick Lake
Darnell Lake
Sheppard Creek

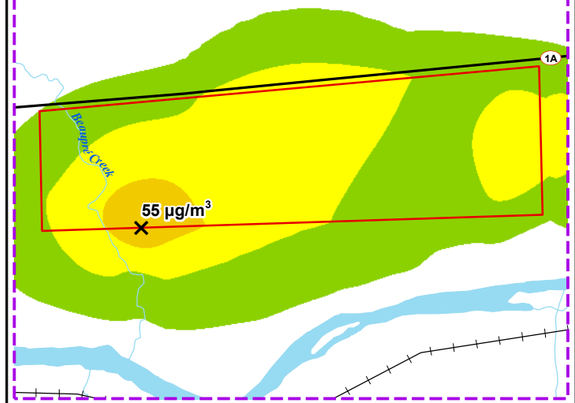
22 40 567 766 1A 68 1

Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum TSP annual - 55 µg/m3

TSP Concentration µg/m3

- < 6
- 6 - 15
- 15 - 30
- 30 - 60
- > 60

2019 Alberta Ambient Air Quality Standard
60 µg/m3



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted Annual Average TSP Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 9

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Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Behanhouse Creek
Rhodes Creek
Horse Creek
Robinson Creek
Beaupre Creek
Kerfoot Creek
Waiparous
Ghost River
Baymag Creek
Rancho Creek
Cochrane Lake
Bigspring Creek
Beaupré Lake
Jamieson Creek
Ispheuse Creek
2558 µg/m3
Bighill Creek
Ghost Lake
Jacob Creek
McLennan Creek
Potts Lake
Cochrane
Bow River
Jumpingpound Creek
Scott Lake
Wildmint Creek
Parks Creek
Cope Creek
Towers Creek
Livingstone Creek
Pile of Bones Creek
Glenbow Lake
Chiniki Creek
Westover Lake
Little Jumpingpound Creek
Frederick Lake
Darnell Lake
Springbank Creek

22 40 1A 567 766 68 1

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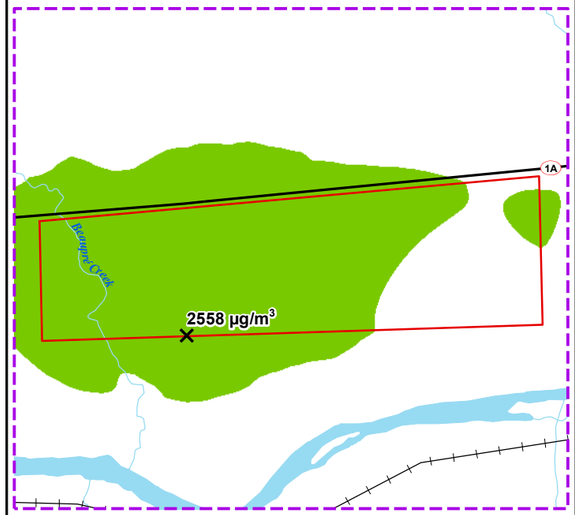
Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum CO 1h - 2558 µg/m3

CO Concentration µg/m3

- < 1,500
- 1,500 - 3,000
- 3,000 - 6,000
- 6,000 - 10,000
- 10,000 - 15,000
- > 15,000

2019 Alberta Ambient Air Quality Standard
15000 µg/m3



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted 1-h Average (9th highest) CO Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 10

Easting (m)

650000 655000 660000 665000 670000 675000 680000 685000

Northing (m)

5690000 5685000 5680000 5675000 5670000 5665000

Twp. 28 Twp. 27 Twp. 26 Twp. 25 Twp. 24

Rg. 7 Rg. 6 Rg. 5 Rg. 4 Rg. 3

W5M

N

Dogpound Creek
Rabbit Creek
Rabbit Lake
Behanhouse Creek
Robinson Creek
Grand Valley Creek
Beaverdam Creek
Lochend Lake
Rhodes Creek
Horse Creek
Beaupre Creek
Kerfoot Creek
Waiparous
Ghost River
Baymar Creek
Rancho Creek
Cochrane Lake
Bigspring Creek
Beaupré Lake
Jamieson Creek
Bighill Creek
Ghost Lake
Jacob Creek
McLennan Creek
Potts Lake
Cochrane
Bow River
Scott Lake
Willdmon Creek
Parks Creek
Cope Creek
Livingstone Creek
Pile of Bones Creek
Twopoint Creek
Tovees Creek
Glenbow Lake
Chiniki Creek
Westover Lake
Little Jumpingpound Creek
Frederick Lake
Darnell Lake
Stoneyhunk Creek

22 567 766 40 1A 68 1

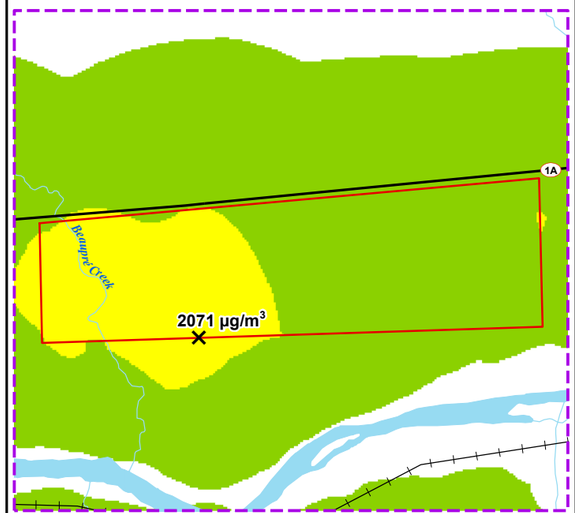
2071 µg/m³

Air Assessment Boundary
Study Area
Community
Water Body
Watercourse
Highway
Railway
Maximum CO 8h - 2071 µg/m³

CO Concentration µg/m³

- < 600
- 600- 1,500
- 1,500- 3,000
- 3,000 - 6,000
- > 6,000

2019 Alberta Ambient Air Quality Standard
6000 µg/m³



1:135,000 Kilometres
1.5 0 1.5 3
NAD 1983 UTM Zone 11N

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Matrix Solutions Inc.
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Burnco Rock Products Ltd.
Burnco West Cochrane #2 Gravel Pit

Maximum Predicted 8-h Average CO Concentration Contours - Application Case

Date:	Project:	Submitter:	Reviewer:
October 2022	26388	K. Burt	S. Dawson

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Figure 11

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APPENDIX A
CALMET and CALPUFF Switches Used

ATTACHMENT A

CALMET AND CALPUFF MODELLING INPUTS

The CALMET and CALPUFF model input options and switches used in dispersion modelling for the Project are presented below:

Table A1: Input Groups in the CALMET Control File

Input Group	Description	Applicable to Project?
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Map projection and grid control parameters	Yes
3	Output options	Yes
4	Meteorological data options	Yes
5	Wind field options and parameters	Yes
6	Mixing height, temperature, and precipitation parameters	Yes
7	Surface meteorological station parameters	use mm5 only
8	Upper air meteorological station parameters	n/a, from mm5/3D
9	Precipitation parameters	n/a, from mm5/3D

Table A2: CALMET Model Options Input Group 1

Parameter	Default	Project	Comments
IBYR	-	2015	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	0	Starting hour
IBSEC	-	0	Starting second
IEYR	-	2019	Ending year
IEMO	-	12	Ending month
IEDY	-	31	Ending day
IEHR	-	23	Ending hour
IESEC	-	0	Ending second
ABTZ	-	UTC-0700	Base time zone
NSECDT	3,600	3600	Length of modelling time step, seconds
IRTYPE	1	1	Compute wind fields and micrometeorological variables
LCALGRD	T	T	Computer special data fields
ITEST	2	2	Flag to stop run after SETUP phase
MREG	-	0	Test options to check if regulatory value conforms

Table A3: CALMET Model Options Input Group 2

Parameter	Default	Project	Comments
PMAP	UTM	UTM	Map projection
FEAST	-	-	Not used for UTM projection
FNORTH	-	-	Not used for UTM projection
IUTMZN	-	11	UTM zone
UTMHEM	N	N	Hemisphere for UTM projection
RLAT0	-	-	Not used for UTM projection
RLON0	-	-	Not used for UTM projection
XLAT1	-	-	Not used for UTM projection
XLAT2	-	-	Not used for UTM projection
DATUM	WGS-84	WGS-84	Datum-region for output coordinates (NAD83)
NX	-	50	No. X grid cells
NY	-	50	No. Y grid cells
DGRIDKM	-	1	Grid spacing (km)
XORIGKM	-	645.000	Reference coordinate of southwest corner of grid cell (1,1) -X coordinate (km)
YORIGKM	-	5650.000	Reference coordinate of southwest corner of grid cell (1,1) -Y coordinate (km)
NZ	-	12	Vertical grid definition: number of vertical layers
ZFACE	-	0.,20.,40.,80., 120.,280.,520., 880.,1320., 1820.,2380., 3000.,4000.	Vertical grid definition: cell face heights in arbitrary vertical grid (m)

Table A4: CALMET Model Options Input Group 3

Parameter	Default	Project	Comments
Disk Output:			
LSAVE	T	T	Save met. fields in the unformatted output files
IFORMO	1	1	CALPUFF/CALGRID type file
Line Printer Output:			
LPRINT	F	F	Not print meteorological fields
IPRINF	1	1	Print intervals (hours)
IUVOUT (NZ)	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Specify which layers of u,v wind component to print
IWOUT (NZ)	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Specify which level of the w wind component to print
ITOUT (NZ)	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Specify which levels of the 3-D temperature field to print

Meteorological fields to print to line printer:

Variable	Print ? 0 = no print 1 = print	Comments
STABILITY	0	PGT stability
USTAR	0	Friction velocity
MONIN	0	Monin-Obukhov length
MIXHT	0	Mixing height
WSTAR	0	Convective velocity scale
PRECIP	0	Precipitation rate
SENSHEAT	0	Sensible heat flux
CONVZI	0	Convective mixing height

Testing and debug print options for micrometeorological module:			
LDB	F	F	Not print input meteorological data and internal variables
NN1	1	1	First time step for which debug data are printed
NN2	1	1	Last time step for which debug data are printed
LDBCST	F	F	Print distance to land internal variables
Testing and debug print options for wind field module:			
IOUTD	0	0	Control variable for writing the test/debug wind fields to disk files
NZPRN2	1	1	Number of levels, starting at surface, to print
IPR0	0	0	Print the interpolated wind components
IPR1	0	0	Print the terrain adjusted surface wind components
IPR2	0	0	Print the smoothed wind components and the initial divergence fields
IPR3	0	0	Print the final wind speed and direction
IPR4	0	0	Print the final divergence fields
IPR5	0	0	Print the winds after kinematic effects are added
IPR6	0	0	Print the winds after the Froude number adjustment is made
IPR7	0	0	Print the winds after slope flows are added
IPR8	0	0	Print the final wind field components

Table A5: CALMET Model Option Input Group 4

Parameter	Default	Project	Comments
Number of Surface and Precipitation Meteorological Stations:			
NOOBS	0, 1 or 2 (AQMG)	2	No surface, overwater, or upper air observations (use MM5)
NSSTA	-	0	Number of surface stations
NPSTA	-	-1	Flag for use of MM5/3D.DAT precipitation
Cloud Data Options:			
ICLOUD	4 (preferred in AQMG)	4	Gridded cloud cover from Prognostic Rel. Humidity at all levels, no complete set of surface observations was available
File Formats:			
IFORMS	2	2	Surface meteorological data file format
IFORMP	2	2	Precipitation data file format
IFORMC	2	2	Cloud data file format

Table A6: CALMET Model Option Input Group 5

Parameter	Default	Project	Comments
Wind Field Model Options:			
IWFCOD	1 (AQMG)	1	Diagnostic wind module
IFRADJ	1	1	Compute Froude Number adjustment
IKINE	0	0	Not compute kinematic effects
IOBR	0	0	Not use O'Brien procedure for adjustment of the vertical velocity
ISLOPE	1	1	Compute slope flow effects
IEXTRP	+/-1 (AQMG)	1	No extrapolation is done, layer 1 data at upper air stations is ignored
ICALM	0	0	No extrapolate surface winds when calm
BIAS	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Zero bias leaves surface and upper air weights unchanged ($1/R^2$ interpolation)
RMIN2	4	4	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed (-1 = all surface stations be extrapolated)
IPROG	14 (AQMG)	14	Use gridded prognostic wind field model output fields as input to the diagnostic wind field model (14=use winds from MM5.DAT file as initial guess field)
ISTEPPGS	3,600	3,600	Timestep (second) of the prognostic model input data
IGFMET	0	0	Do not use coarse CALMET fields as initial guess fields
Radius of Influence Parameters:			
LVARY	F	F	Do not use varying radius of influence
RMAX1	2 × 12 km (AQMG)	24	Maximum radius of influence over land in the surface layer (km)
RMAX2	2 × 12 km (AQMG)	24	Maximum radius of influence over land aloft (km)
RMAX3	2 × 12 km (AQMG)	24	Maximum radius of influence over water (km)
Other Wind Field Input Parameters:			
RMIN	0.1	0.1	Minimum radius of influence used in the wind field interpolation (km)
TERRAD	-	11.	Radius of influence of terrain features (km), terrain is relatively flat with some elevation gain in the northwest and southwest corners
R1	½ × 12 km (suggested in AQMG)	6.	Relative weighting of the first guess field and observations in the surface layer (km)

Parameter	Default	Project	Comments
R2	½ × 12 km (suggested in AQMG)	6.	Relative weighting of the first guess field and observations in the layers aloft (km)
RPROG	-	0	Relative weighting parameter of the prognostic wind field data (km), not used when IPROG = 14
DIVLIM	5.0E-6	5.0E-6	Maximum acceptable divergence in the divergence minimization procedure
NITER	50	50	Maximum number of iterations in the divergence minimization procedure
NSMTH (NZ)	2, (mxnz-1)*4	2,4,4,4,4,4, 4,4,4,4,4,4	Number of passes in the smoothing procedure
NINTR2	99	99	Maximum number of stations used in each layer for the interpolation of data to a grid point
CRITFN	1.0	1.0	Critical Froude number
ALPHA	0.1	0.1	Empirical factor controlling the influence of kinematic effects Not used
FEXTR2(NZ)	NZ*0.0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Multiplicative scaling factor for extrapolation of surface observations to upper layers Not used
Barrier Information:			
NBAR	0	0	Number of barriers to interpolation of the wind fields, no barriers were used in CALMET modelling
KBAR	NZ	NZ	Level (1 to NZ) up to which barriers apply
Diagnostic Module Data Input Options:			
IDIOPT1	0	0	Surface temperature (0 = compute internally from hourly surface observation or prognostic fields)
ISURFT	-1	-1	Use a domain-average prognostic surface temperatures
IDIOPT2	0	0	Domain-averaged temperature lapse (0 = compute internally from prognostic fields)
IUPT	-1	-1	Use 2-d spatially varying lapse rate
ZUPT	200	200	Depth through which the domain-scale lapse rate is computed (m)
IDIOPT3	0	0	Initial guess field winds (0 = computer internally from prognostic wind fields)
IUPWND	-1	-1	-1 indicates 3-D initial guess wind fields
ZUPWND	1.0, 1000	1.0, 1000	Bottom and top of layer through which domain-scale winds are computed (m)
IDIOPT4	0	0	Observed surface wind components for wind field module (0 = read WS and WD from surf.dat)
IDIOPT5	0	0	Observed upper air wind components for wind field module Not used
Lake Breeze Information:			
LLBREZE	F	F	Not use lake breeze module
NBOX	-	0	Number of lake breeze regions Not used
XG1	-	0	X Grid line 1 defining the region of interest Not used
XG2	-	0	X Grid line 2 defining the region of interest Not used
YG1	-	0	Y Grid line 1 defining the region of interest Not used
YG2	-	0	Y Grid line 2 defining the region of interest Not used
XBCST	-	0	X Point defining the coastline in kilometres (Straight line) Not used
YBCST	-	0	Y Point defining the coastline in kilometres (Straight line) Not used

Parameter	Default	Project	Comments
XECST	-	0	X Point defining the coastline in kilometres (Straight line) Not used
YECST	-	0	Y Point defining the coastline in kilometres (Straight line) Not used
NLB	-	0	Number of stations in the region Not used
METBXID	-	0	Station IDs in the region Not used
LLBREZE	F	F	Not use lake breeze module
NBOX	-	0	Number of lake breeze regions Not used

Table A7: CALMET Model Option Input Group 6

Parameter	Default	Project	Comments
Empirical Mixing Height Constants:			
CONSTB	1.41	1.41	Neutral, mechanical equation
CONSTE	0.15	0.15	Convective mixing height equation
CONSTN	2,400	2,400	Stable mixing height equation
CONSTW	0.16	0.16	Over water mixing height equation
FCORIO	1.0E-4	1.0E-04	Absolute value of Coriolis (1/s)
Spatial Averaging of Mixing Heights:			
IAVEZI	1	1	Conduct spatial averaging
MNMDAV	10 (AQMG)	10	Maximum search radius in averaging (grid cells)
HAFANG	30	30	Half-angle of upwind looking cone for averaging (degree)
ILEVZI	1	1	Layer of winds used in upwind averaging
Convective Mixing Height Options:			
IMIXH	-1 (EPA default)	-1	Use Maul-Carson for land and OCD mixing height overwater
THRESHL	0.0	0.0	Threshold buoyancy flux required to sustain convective mixing height growth overland
THRESHW	0.05	0.05	Threshold buoyancy flux required to sustain convective mixing height growth overwater (w/m^3)
ITWPROG	0	2	No SEA.DAT files available, no overwater stations in domain Prognostic lapse rates and delta T values used instead.
ILUOC3D	16	16	Land use category ocean in 3D.DAT datasets (16 for mm5/3D data)
IMIXH	-1 (EPA default)	-1	Use Maul-Carson for land and OCD mixing height overwater
Other Mixing Heights Variables:			
DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in the stable layer above the current convective mixing height (K/m)
DZZI	200	200	Depth of layer above current convective mixing height through which lapse rate is computed (m)
ZIMIN	50	50	Minimum overland mixing height (m)
ZIMAX	3,000	3,000	Maximum overland mixing height (m)
ZIMINW	50	50	Minimum over-water mixing height (m)
ZIMAXW	3,000	3,000	Maximum over-water mixing height (m)
Overwater Surface Fluxes Method and Parameters			
ICOARE	10	10	COARE with no wave parameterization
DSHELF	0	0	Coastal/shallow water length scale
IWARM	0	0	COARE warm layer computation switch. 0 = Off
ICOOL	0	0	COARE col skin layer computation switch. 0 = Off
Relative Humidity Parameters:			
IRHPROG	1 (AQMG)	1	Use Prognostic RH

Parameter	Default	Project	Comments
Temperature Parameters:			
ITPROG	0, 1, or 2 (AQMG)	2	No surface or upper air observations, use MM5/3D.DAT for data
IRAD	1	1	Interpolation type, 1/R
TRADKM	2 × 12 km (AQMG)	24	Radius of influence for temperature interpolation (km)
NUMTS	5	5	Maximum number of stations to include in temperature interpolation
IAVET	1	1	Conduct spatial averaging of temperatures (1 = yes)
TGDEFB	-.0098	-.0098	Default temperature gradient below the mixing height over water (K/m)
TGDEFA	-.0045	-.0045	Default temperature gradient above the mixing height over water (K/m)
JWAT1	-	51	Beginning land use categories for temperature interpolation over water
JWAT2	-	55	Ending land use categories for temperature interpolation over water
Precipitation Interpolation Parameters:			
NFLAGP	2	2	Method of interpolation, $1/R^2$ Not used
SIGMAP	100	100	Radius of influence (km) Not Used
CUTP	0.01	0.01	Minimum precipitation rate cut-off (mm/h) Not used

Table A8: CALMET Model Option Input Group 7

No surface stations were used. (NSSTA = 0)

Station Name	Abbreviation	ID (a)	UTM X (km)	UTM Y (km)	Time Zone	Anemometer Height
-	-	-	-	-	-	-

Table A9: Input Groups in the CALPUFF Control File

Input Group	Description	Applicable to Project?
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Technical options	Yes
3a, 3b	Species list	Yes
4	Map projection and grid control parameters	Yes
5	Output options	Yes
6a, 6b, 6c	Subgrid scale complex terrain inputs	Not used
7	Chemical parameters for dry deposition of gases	Yes
8	Size parameters for dry deposition of particles	Yes
9	Miscellaneous dry deposition parameters	Yes
10	Wet deposition parameters	Yes
11	Chemistry parameters	Yes
12	Miscellaneous dispersion and computational parameters	Yes
13a, 13b, 13c, 13d	Point source parameters	Yes
14a, 14b, 14c, 14d	Area source parameters	Yes
15a, 15b, 15c	Line source parameters	Not used
16a, 16b, 16c	Volume source parameters	Not used
17	Flare source control Parameter	Not used
18a, 18b, 18c	Road Emissions parameters	Not used
19a, 19b	Emission rate scale-factor tables	Yes
20a, 20b, 20c	Non-gridded (discrete) receptor information	Yes

Table A10: CALPUFF Model Options Input Group 1 – General Control Parameters

Parameter	Default	Project	Comments
METRUN	0	0	
IBYR	0	2015	Starting year
IBMO	0	1	Starting month
IBDY	0	1	Starting day
IBHR	0	0	Starting hour
IBMIN	0	0	Starting minute
IBSEC	0	0	Starting second
IEYR	0	2019	Ending year
IEMO	0	12	Ending month
IEDY	0	31	Ending day
IEHR	0	23	Ending hour
IEMIN	0	0	Ending minute
IESEC	0	3,600	Ending second
XBTZ	-	7.0	Base time zone
NSECDT	3,600	3,600	Length of modelling time step
NSPEC	5	13	Number of chemical species
NSE	3	10	Number of chemical species to be emitted
ITEST	2	2	Flag to stop run after SETUP phase
MRESTART	0	2	Control flag
NRESPD	0	0	Restart file updated every 24 hours
METFM	1	1	Meteorological data format
MPRFFM	1	1	Meteorological profile data format
AVET	60.0	60.0	Average time (minutes)
PGTIME	60.0	60.0	PG Averaging time (minutes)
IOUTU	1	1	Output units for binary concentration flux files (mass)
IOVERS	2	2	Output dataset format for binary concentration and flux files (Dataset Version 2.2)

Table A11: CALPUFF Model Options Input Group 2 – Technical Options

Parameter	Default	Project	Comments
MGAUSS	1 (EPA default)	1	Vertical distribution used in the near field – Gaussian distribution
MCTADJ	3 (EPA default)	3	Partial plume path adjustment
MCTSG	0	0	Subgrid-scale complex terrain flag not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated slugs
MTRANS	1 (EPA default)	1	Transitional plume rise modelled
MTIP	1 (EPA default)	1	Stack tip downwash modelled (except for flares, as per ERCB flaring spreadsheet)
MRISE	1	1	Method used to compute plume rise for point sources not subject to building downwash? (MRISE)
MTIP_FL	0	0	Apply stack-tip downwash to FLARE sources?
MBDW	2 (AQMG)	2	PRIME method utilized to simulate building downwash
MSHEAR	0	0	Vertical wind shear above stack top not modelled
MSPLIT	0	0	No puff splitting
MCHEM	0 (AQMG)	0	Chemical mechanism flag. Transformation rates computed internally using (RIVAD/ARM3) scheme. Recommended by AB Model Guideline.
MAQCHEM	0	0	Aqueous phase transformation flag
MLWC	1	1	Liquid Water Content flag (MLWC)
MWET	1 (EPA default)	1	Wet removal modelled
MDRY	1 (EPA default)	1	Dry deposition modelled
MTILT	0	0	Gravitational settling (plume tilt) not modelled

Parameter	Default	Project	Comments
MDISP	2 (AQMG)	2	Dispersion coefficients are computed from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.). This option was used to take advantage of the local meteorology as used in the MM5 data. Allows for spatially varying dispersion coefficients, depending on the CALMET micrometeorology module and the land use classification which is more representative than the P-G stability class method.
MTURBVW	3	3	Use both sigma-v/sigma-theta and sigma-w to computer sigma-Y and sigma-Z
MDISP2	3	3	Dispersion coefficients are computed from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) when measured turbulence data is missing.
MTAULY	0	0	Draxler default was used for Lagrangian timescale for sigma-y
MTAUADV	0	0	No turbulence advection
MCTURB	1	1	Standard CALPUFF subroutine used to compute turbulence sigma-v & sigma-w using micrometeorological variables
MROUGH	0 (EPA default)	0	No PG sigma-y,z adj. for roughness
MPARTL	1 (EPA default)	1	Partial plume penetration of elevated inversion modelled for point sources
MPARTLBA	1 (AQMG)	1	Partial plume penetration of elevated inversion modelled for buoyant area sources
MTINV	0	0	Strength of temperature inversion computed from measured/default gradients
MPDF	1 (AQMG)	1	PDF used for dispersion under convective conditions. Simulates AERMOD-type dispersion by averaging the balance between upward- and down-drafts in the vertical column, which better represents turbulence based dispersion due to vertical air movement.
MSGTIBL	0	0	Sub-Grid TIBL module used for shore line Not used
MBCON	0	0	Boundary conditions (concentration) not modelled
MSOURCE	0	0	Individual source contributions, not applicable for prime method.
MFOG	0	0	Fog not modelled
MREG	0 (AQMG)	0	No checks are made

Table A12: CALPUFF Model Options Input Group 3 – Species List

CSPEC	Modelled (0=no, 1=yes)	Emitted (0=no, 1=yes)	Dry Deposition (0=none, 1=computed-gas, 2=computed-particle, 3=user-specified)	Output Group Number
SO_2	1	1	1	0
SO_4	1	0	2	0
NO	1	1	1	0
NO_2	1	1	1	0
HNO_3	1	0	1	0
NO_3	1	0	2	0
PM	1	1	2	0
CO	1	1	0	0
VOC	1	1	0	0
NOX	1	1	1	0
TRS	1	1	0	0
PM_{10}	1	1	2	0
TPM	1	1	2	0

Table A13: CALPUFF Model Options Input Group 4 – Map Projection and Grid Control Parameters

Parameter	Default	Project	Comments
PMAP	UTM	UTM	Map projection
FEAST	-	-	Not used for UTM projection
FNORTH	-	-	Not used for UTM projection
IUTMZN	as per CALMET	11	UTM zone
UTMHEM	N	N	Hemisphere for UTM projection
RLAT0	-	-	Not used for UTM projection
RLON0	-	-	Not used for UTM projection
XLAT1	-	-	Not used for UTM projection
XLAT2	-	-	Not used for UTM projection
DATUM	WGS-84	WGS-84	Datum-region for output coordinates (NAD83)
NX	as per CALMET	50	No. X grid cells
NY	as per CALMET	50	No. Y grid cells
NZ	as per CALMET	12	No. vertical layers
DGRIDKM	as per CALMET	1.0	Grid spacing (km)
XORIGKM	as per CALMET	645.000	Reference coordinates of SW corner of grid cell
YORIGKM	as per CALMET	5650.000	Reference coordinates of SW corner of grid cell
IBCOMP	-	1	X index of LL corner
JBCOMP	-	1	Y index of LL corner
IECOMP	-	50	X index of UR corner
JECOMP	-	50	Y index of UR corner
LSAMP	T	F	Sampling grid is not used. Receptors modelled as discrete receptors
IBSAMP	-	-	X index of LL corner
JBSAMP	-	-	Y index of LL corner
IESAMP	-	-	X index of UR corner
JESAMP	-	-	Y index of UR corner
MESHDN	-	-	Nesting factor of the sampling grid

Table A14: CALPUFF Model Options Input Group 5 – Output Options

Parameter	Default	Project	Comments
ICON	1	1	Write concentration results
IDRY	1	1	Write dry fluxes
IWET	1	1	Write wet fluxes
IT2D	0	0	Do not write 2D temperature
IRHO	0	0	Do not write 2D density
IVIS	1	0	Do not write relative humidity
LCOMPRS	T	T	Use data compression option in output file
IQAPLOT	1	1	Create a standard series of output files suitable for plotting
IMFLX	0	0	Mass flux across specified boundaries for selected species to report
IMBAL	0	0	Mass balance for each species to report
ICPRT	0	0	Print concentrations
IDPRT	0	0	Print dry fluxes
IWPRT	0	0	Print wet fluxes
ICFRQ	1	1	Concentration print interval
IDFRQ	1	1	Dry flux print interval
IWFRQ	1	1	Wet flux print interval
IPRTU	1	3	Units for line printer output are in $\mu g/m^3$ for concentration and $\mu g/m^2/s$ for deposition
IMESG	2	2	Messages tracking progress of run written to the screen

Species/ Group	Concentrations		Dry Fluxes		Wet Fluxes		Mass Flux
	Printed?	Saved on disk?	Printed?	Saved on disk?	Printed?	Saved on disk?	Saved on disk?
SO_2	0	1	0	1	0	1	0
SO_4	0	1	0	1	0	1	0
NO	0	1	0	1	0	1	0
NO_2	0	1	0	1	0	1	0
HNO_3	0	1	0	1	0	1	0
NO_3	0	1	0	1	0	1	0
PM	0	1	0	1	0	1	0
CO	0	1	0	0	0	0	0
VOC	0	1	0	0	0	0	0
NO_X	0	1	0	1	0	1	0
TRS	0	1	0	0	0	0	0
PM_{10}	0	1	0	1	0	1	0
TPM	0	1	0	1	0	1	0

LDEBUG	F	F	Logical for debug output
IPFDEB	1	1	First puff to track
NPFDEB	1	1	Number of puffs to track
NN1	1	1	Met. Period to start output
NN2	10	10	Met. Period to end output

Table A15: CALPUFF Model Options Input Group 6 – Subgrid-scale Complex Terrain Inputs

No Subgrid-scale Complex Terrain was modelled.

Parameter	Default	Project	Comments
NHILL	0	0	Number of terrain features
NCTREC	0	0	Number of special complex terrain receptors
MHILL	-	2	Terrain and CTSG receptor data for CTSG hills input in CTDM format?
XHILL2M	1.0	1.0	Factor to convert horizontal dimensions
ZHILL2M	1.0	1.0	Factor to convert vertical dimensions
XCTDMKM	-	0	X-origin of CTDM system relative to CALPUFF coordinate system (km)
YCTDMKM	-	0	Y-origin of CTDM system relative to CALPUFF coordinate system (km)

Table A16: CALPUFF Model Options Input Group 7 – Chemical Parameters for Dry Deposition of Gases

Species	Diffusivity	Alpha Star	Reactivity	Mesophyll Resistance	Henry's Law Coefficient
SO_2	0.1509	1,000	8	0	0.04
NO	0.1345	1	2	25	18
NO_2	0.1656	1	8	5	3.5
HNO_3	0.1628	1	18	0	0.0000001
NO_X	0.1656	1	8	5	3.5

Table A17: CALPUFF Model Options Input Group 8 – Size Parameters for Dry Deposition of Particles

Species Name	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)
SO_4	0.48	2.0
NO_3	0.48	2.0
PM	0.48	2.0
PM_{10}	0.48	9.3
TPM	0.48	9.3

Table A18: CALPUFF Model Options Input Group 9 – Miscellaneous Dry Deposition Parameters

Parameter	Default	Project	Comments
RCUTR	30	30.0	Reference cuticle resistance (s/cm)
RGR	10	10.0	Reference ground resistance (s/cm)
REACTR	8	8.0	Reference pollutant reactivity
NINT	9	9	Number of particle-size intervals used to evaluate effective particle deposition velocity
IVEG	1	1	Vegetation state in un-irrigated areas

Table A19: CALPUFF Model Options Input Group 10 – Wet Deposition Parameters

Pollutant	Liquid Precipitation	Frozen Precipitation
SO_2	3.0E-05	0.0E00
SO_4	1.00E-04	3.0E-05
NO	0.0E00	0.0E00
NO_2	0.0E00	0.0E00
HNO_3	6.00E-05	0.0E00
NO_3	1.00E-04	3.0E-05
NO_X	0.0E00	0.0E00
PM	1.00E-04	3.0E-05
VOC	1.00E-04	3.0E-05
PM_{10}	1.00E-04	3.0E-05
TPM	1.00E-04	3.0E-05

Table A20: CALPUFF Model Options Input Group 11 – Chemistry Parameters

Parameter	Default	Project	Comments
MOZ	1	1	Used background ozone provided by AER (rural dataset)
RNITE1	0.2	0.2	Nighttime SO_2 loss rate
RNITE2	2.0	2.0	Nighttime NO_x loss rate
RNITE3	2.0	2.0	Nighttime HNO_3 formation rate
MHN3	0	0	Use monthly ammonia values
MH2O2	1	1	H_2O_2 data input option
BCKNH3	12*10	10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0	Monthly NH_3 concentrations, CALPUFF Default
BCKH2O2	12*1	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00	Monthly H_2O_2 concentrations, CALPUFF default

Table A21: CALPUFF Model Options Input Group 12 – Miscellaneous Dispersion and Computational Parameters

Parameter	Default	Project	Comments
SYTDEP	550 (EPA default)	5.5E02	Horizontal size of puff (m) beyond which time-dependent dispersion equations (Heffter) are used to determine sigma-y and sigma-z
MHFTSZ	0 (EPA default)	0	Switch for using Heffter equation for sigma-z as above
JSUP	5	5	Stability class used to determine plume growth rates for puffs above the boundary layer
CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
CONK2	0.1	0.1	Vertical dispersion constant for neutral/unstable conditions
TBD	0.5	0.5	Factor for determining Transition-point from Schulman-Scire to Huber-Snyder building downwash scheme
IURB1	10	10	Range of land use categories for which urban dispersion is assumed
IURB2	19	19	Range of land use categories for which urban dispersion is assumed
Site characterization parameters for single-point Met data files: – not used			
ILANDUIN	20	20	Land use category for modeling domain, not used
Z0IN	0.25	0.25	Roughness length (m) for modeling domain, not used
XLAIIN	3.0	3.0	Leaf area index for modeling domain, not used
ELEVIN	0.0	0.0	Elevation above sea level, not used
XLATIN	-999	-999	Latitude (degrees) for met location, not used
XLONIN	-999	-999	Longitude (degrees) for met location, not used
Specialized information for interpreting single-point Met data files: - not used			
ANEMHT	10	10	Anemometer height (m)
ISIGMAV	1	1	Form of lateral turbulence data in PROFILE.DAT file

Parameter	Default	Project	Comments
IMIXCTDM	0	0	Choice of mixing heights
XMXLEN	1.0	1.0	Maximum length of slug (met. grid units)
XSAMLEN	1.0	1.0	Maximum travel distance of a puff/slug (in grid units) during one sampling step
MXNEW	99	99	Maximum number of slugs/puffs release from one source during one time step
MXSAM	99	99	Maximum number of sampling steps for one puff/slug during one time step
NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes gradual rise
SYMIN	1.0	1.0	Minimum sigma-y for a new puff/slug (m)
SZMIN	1.0	1.0	Minimum sigma-z for a new puff/slug (m)
SZCAP_M	5.0E06	5.0E06	Maximum sigma-z (m) allowed to avoid numerical problem in calculating virtual time or distance
SVMIN	Land: .50, .50 .50, .50, .50, .50 Water: .37, .37, .37, .37, .37, .37 (EPA default)	Land: .50, .50 .50, .50, .50, .50 Water: .37, .37, .37, .37, .37, .37	Default minimum turbulence velocities sigma-v for each stability class over land and over water (m/s)
SWMIN	Land: .20, .12, .08, .06, .03, .016 Water: .20, .12, .08, .06, .03, .016	Land: .20, .12, .08, .06, .03, .016 Water: .20, .12, 08, .06, .03, 016	Default minimum turbulence velocities sigma-w for each stability class over land and over water (m/s)
CDIV	0.0, 0.0	0.0, 0.0	Divergence criterion for dw/dz across puff used to initiate adjustment for horizontal convergence (1/s)
NLUTIBL	4	4	Search radius (number of cells) for nearest land and water cells used in the subgrid TIBL module
WSCALM	0.5	0.5	Minimum wind speed (m/s) allowed for non-calm conditions
XMAXZI	3000	3000	Maximum mixing height (m)
XMINZI	50	50	Minimum mixing height (m)
WSCAT	1.54, 3.09, 5.14, 8.23, 10.8	1.54, 3.09, 5.14, 8.23, 10.8	Default wind speed classes
PLX0	.07, .07, .10, .15, .35, .55	.07, .07, .10, .15, .35, .55	Default wind speed profile power-law exponents for stabilities 1-6
PTG0	0.020, 0.035	0.020, 0.035	Default potential temperature gradient for stable classes E, F (degK/m)
PPC	.50, .50, .50, .50, .35, .35	.50, .50, .50, .50, .35, .35	Default plume path coefficients for each stability class
SL2PF	10	10	Slug-to-puff transition criterion factor equal to sigma-y/length of slug
NSPLIT	3	3	Number of puffs that result every time a puff is split
ZISPLIT	100	100	Split is allowed only if last hour's mixing height (m) exceeds a minimum value
ROLDMAX	0.25	0.25	Split is allowed only if ratio of last hour's mixing ht to the maximum mixing ht experienced by the puff is less than a maximum value
NSPLITH	5	5	Number of puffs that result every time a puff is split
SYSPLITH	1.0	1.0	Minimum sigma-y (grid cells units) of puff before it may be split
SHSPLITH	2	2	Minimum puff elongation rate (SYSPLITH/hr) due to wind shear, before it may be split
CNSPLITH	1.0E-07	1.0E-07	Minimum concentration (g/m^3) of each species in puff before it may be split
EPSSLUG	1.0E-04	1.0E-04	Fractional convergence criterion for numerical SLUG sampling integration
EPSAREA	1.0E-06	1.0E-06	Fractional convergence criterion for numerical AREA source integration

Parameter	Default	Project	Comments
DSRISE	1.0	1.0	Trajectory step-length (m) used for numerical rise integration
HTMINBC	500	500	Minimum height (m) to which BC puffs are mixed as they are emitted
RSAMPBC	10	10	Search radius (km) about a receptor for sampling nearest BC puff
MDEPBC	1	1	Near-surface depletion adjustment to concentration profile used when sampling BC puffs?
SHSPLITH	2	2	Minimum puff elongation rate (SYSPLITH/hr) due to wind shear, before it may be split
CNSPLITH	1.0E-07	1.0E-07	Minimum concentration (g/m^3) of each species in puff before it may be split
EPSSLUG	1.0E-04	1.0E-04	Fractional convergence criterion for numerical SLUG sampling integration
EPSAREA	1.0E-06	1.0E-06	Fractional convergence criterion for numerical AREA source integration

Table A22: CALPUFF Model Options Input Group 13 – Point Source Parameters

Parameter	Default	Project	Comments
NPT1	-	Varies	Number of point sources modelled as provided in the report
IPTU	1	1	Units used for point source emissions, g/s
NSPT1	0	Varies	Number of source-species combinations with variable emissions scaling factors provided (13d)
NSPT2	-	0	Number of point sources with variable emission parameters provided in external file

Table A23: CALPUFF Model Options Input Group 14 – Area Source Parameters

Parameter	Default	Project	Comments
NAR1	-	Varies	See report for # of area sources modelled
IARU	1	1	Units for area source emissions, $g/m^2/s$
NSAR1	0	Varies	Number of source-species combinations with variable emissions scaling factors provided (14d)
NAR2	-	0	Number of buoyant polygon area sources with variable location and emission parameters

Table A24: CALPUFF Model Options Input Group 15 – Line Source Parameters

No line sources were modelled.

Parameter	Default	Project	Comments
NLN2	-	0	Number of buoyant line sources with variable location and emission parameters
NLINES	-	0	Number of buoyant line sources
ILNU	1	1	Units used for line source emissions
NSLN1	0	0	Number of source-species combinations with variable emissions scaling factors provided in 15c
MXNSEG	7	7	Maximum number of segments used to model each line
NLRISE	6	6	Number of distances at which transitional rise is computed
XL	-	0	Average building length
HBL	-	0	Average building height
WBL	-	0	Average building width
DXL	-	0	Average line source width
FPRIMEL	-	0	Average buoyancy parameter

Table A25: CALPUFF Model Options Input Group 16 – Volume Source Parameters

No volume sources were modelled.

Parameter	Default	Project	Comments
NVL1	-	0	Number of volume sources with parameters provided in 16b, c
IVLU	1	1	Units used for volume source emissions in 16b
NSVL1	0	0	Number of source-species combinations with variable emissions scaling factors in 16c
NVL2	-	0	Number of volume sources with variable location and emission parameters

Table A26: CALPUFF Model Options Input Group 17 -FLARE source control parameters (variable emissions file)

NA to this project

INPUT GROUPS: 18a, 18b, 18c -- Road Emissions parameters

No Road emission sources were modelled

INPUT GROUPS: 19a, 19b -- Emission rate scale-factor tables

MONTH12 and HOUR24_MONTH12 scaling factors used based on variable months/hours that the Project is expected to operate.

INPUT GROUPS: 20a, 20b, 20c– Non-gridded (Discrete) Receptor Information

Parameter	Default	Project	Comments
NREC	-	4491	Number of non-gridded receptors modelled
NRGRP	0	4	Number of receptor group names (NRGRP)

Subgroup (20b)

Group Name

```
! RGRPNAM =  RISK        !   !END!
! RGRPNAM =  inside      !   !END!
! RGRPNAM =  FENCEPRI    !   !END!
! RGRPNAM =  FENCEINT    !   !END!
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Reference

Government of Alberta (GoA). 2021. *Air Quality Model Guideline*. Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. http://environment.alberta.ca/01004.html

APPENDIX B
Existing and Approved Emission Sources Details

Point Sources

Operator	Facility	Source	Elevation (mASL)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp (K)	Datum	Zone	UTM Easting (m)	UTM Northing (m)	NO_x (t/d)	$PM_{2.5}$ (t/d)	TSP (t/d)	CO (t/d)
Canlin Energy Corporation	Compressor Station	Compressor Station	1407	7.2	0.3	34	770	NAD83	11	662152.0	5686465.0	0.137500	0.000003	0.000003	0.01070
Canlin Energy Corporation	Compressor Station	Compressor Station	1501	7.2	0.3	34	770	NAD83	11	663171.0	5686948.0	0.137500	0.000003	0.000003	0.01070
Canlin Energy Corporation	Gas Battery	Gas Battery	1431	7.2	0.3	34	770	NAD83	11	660366.0	5684834.0	0.013700	0.000000	0.000000	0.00110
Canlin Resources Partnership	Gas Battery	Gas Battery	1195	7.2	0.3	34	770	NAD83	11	664349.0	5676912.0	0.040800	0.000001	0.000001	0.00320
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Boiler 1	1194	12.7	1.52	10.2	618	NAD83	11	664351.0	5676805.0	0.052800	0.002900	0.002900	0.03170
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Boiler 2	1194	12.7	1.52	10.2	618	NAD83	11	664351.0	5676805.0	0.052800	0.002900	0.002900	0.03170
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Compressor	1194	15.2	0.59	20	700	NAD83	11	664351.0	5676805.0	0.372800	0.000000	0.000000	0.02900
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Compressor	1194	8.5	0.41	20	700	NAD83	11	664351.0	5676805.0	0.188700	0.000000	0.000000	0.01470
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Compressor	1194	8.5	0.41	20	700	NAD83	11	664351.0	5676805.0	0.188700	0.000000	0.000000	0.01470
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Regenerator Heater	1194	9	0.41	20	600	NAD83	11	664351.0	5676805.0	0.010200	0.000800	0.000800	0.00860
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Regenerator Heater	1194	9	0.41	20	600	NAD83	11	664351.0	5676805.0	0.010200	0.000800	0.000800	0.00860
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Stabilizer Reboiler	1194	7.5	0.4	20	600	NAD83	11	664351.0	5676805.0	0.001900	0.000100	0.000100	0.00160
Direct Energy Marketing Limited	Wildcat Hills Sour Gas Plant	Sulphur Recovery Incinerator	1194	76.2	2.11	8	708	NAD83	11	664351.0	5676805.0	0.618600	0.024700	0.024700	0.27350
Interpipeline Fund	Cochrane Extraction Plant	D101 Compressor Stack	1266	13.72	3.35	6.9	538	NAD83	11	674928.0	5677425.0	0.130500	0.000002	0.000002	0.01010
Interpipeline Fund	Cochrane Extraction Plant	D101 Compressor Stack	1266	13.72	3.35	6.9	538	NAD83	11	674935.0	5677425.0	0.130500	0.000002	0.000002	0.01010
Interpipeline Fund	Cochrane Extraction Plant	D102 Heater	1266	12.9	1	5.7	642	NAD83	11	674825.0	5677282.0	0.010400	0.000788	0.000788	0.00870
Interpipeline Fund	Cochrane Extraction Plant	D103 Heater	1266	43.9	2.51	0.6	584	NAD83	11	674802.0	5677458.0	0.011200	0.000449	0.000449	0.00500
Interpipeline Fund	Cochrane Extraction Plant	D152 Heater	1266	6.3	0.75	4.1	687	NAD83	11	674807.0	5677480.0	0.004600	0.000350	0.000350	0.00390
Interpipeline Fund	Cochrane Extraction Plant	D152 Heater	1266	6.3	0.75	4.1	687	NAD83	11	674813.0	5677480.0	0.004600	0.000350	0.000350	0.00390
Interpipeline Fund	Cochrane Extraction Plant	D190 Heater	1266	20.6	2.84	6.1	474	NAD83	11	674824.0	5677428.0	0.247700	0.018822	0.018822	0.20800
Interpipeline Fund	Cochrane Extraction Plant	D190 Heater	1266	20.6	2.84	6.1	474	NAD83	11	674818.0	5677428.0	0.247700	0.018822	0.018822	0.20800
Interpipeline Fund	Cochrane Extraction Plant	D190 Heater	1266	20.6	2.84	6.1	474	NAD83	11	674812.0	5677428.0	0.247700	0.018822	0.018822	0.20800
Interpipeline Fund	Cochrane Extraction Plant	D1904 Lo-Cat Vent Stack	1266	18	0.33	29.3	293	NAD83	11	674910.0	5677578.0	0.000000	0.000000	0.000000	0.00000
Interpipeline Fund	Cochrane Extraction Plant	D191 Heater	1266	11.3	1	11.3	606	NAD83	11	674837.0	5677307.0	0.015100	0.001149	0.001149	0.01270
Interpipeline Fund	Cochrane Extraction Plant	D191 Heater	1266	11.3	1	11.3	606	NAD83	11	674837.0	5677296.0	0.015100	0.001149	0.001149	0.01270
Interpipeline Fund	Cochrane Extraction Plant	D701 Heater	1266	5.2	0.36	7.3	394	NAD83	11	675002.5	5677385.0	0.002400	0.000183	0.000183	0.00200
Interpipeline Fund	Cochrane Extraction Plant	D750 Heater	1266	7.34	0.51	4.5	394	NAD83	11	674947.0	5677451.0	0.000009	0.000001	0.000001	0.00001
Interpipeline Fund	Cochrane Extraction Plant	D790 Heater	1266	6.8	0.36	7.3	394	NAD83	11	674999.0	5677385.0	0.010400	0.000788	0.000788	0.00870
Interpipeline Fund	Cochrane Extraction Plant	KGT300/301/HRU300 Compressors	1266	15.24	2.74	57.1	616	NAD83	11	674835.0	5677652.0	3.481900	0.000066	0.000066	0.27050
Manitok Energy Inc.	Compressor Station	Compressor Station	1393	7.2	0.3	34	770	NAD83	11	663737.0	5684713.0	0.137500	0.000003	0.000003	0.01070
Manitok Energy Inc.	Compressor Station	Compressor Station	1193	7.2	0.3	34	770	NAD83	11	664843.0	5676877.0	0.137500	0.000003	0.000003	0.01070
Manitok Energy Inc.	Gas Battery	Gas Battery	1193	7.2	0.3	34	770	NAD83	11	664843.0	5676877.0	0.040800	0.000001	0.000001	0.00320
Nal Resources Limited	Oil Satellite	Oil Satellite	1297	7.2	0.3	34	770	NAD83	11	679809.0	5683369.0	0.005200	0.000000	0.000000	0.00040
Orlen Upstream Canada Ltd.	Oil Battery	Oil Battery	1298	7.2	0.3	34	770	NAD83	11	678632.0	5677136.0	0.012500	0.000000	0.000000	0.00100
Orlen Upstream Canada Ltd.	Oil Satellite	Oil Satellite	1299	7.2	0.3	34	770	NAD83	11	679250.0	5683166.0	0.005200	0.000000	0.000000	0.00040
Orlen Upstream Canada Ltd.	Oil Satellite	Oil Satellite	1315	7.2	0.3	34	770	NAD83	11	675573.0	5683182.0	0.005200	0.000000	0.000000	0.00040
Orlen Upstream Canada Ltd.	Oil Satellite	Oil Satellite	1277	7.2	0.3	34	770	NAD83	11	677193.0	5678210.0	0.005200	0.000000	0.000000	0.00040
Orlen Upstream Canada Ltd.	Oil Satellite	Oil Satellite	1298	7.2	0.3	34	770	NAD83	11	678606.0	5677115.0	0.005200	0.000000	0.000000	0.00040
Ridgeback Resources Inc.	Oil Satellite	Oil Satellite	1299	7.2	0.3	34	770	NAD83	11	677899.0	5678196.0	0.005200	0.000000	0.000000	0.00040
Ridgeback Resources Inc.	Oil Satellite	Oil Satellite	1283	7.2	0.3	34	770	NAD83	11	679565.0	5678253.0	0.005200	0.000000	0.000000	0.00040
Ridgeback Resources Inc.	Oil Satellite	Oil Satellite	1277	7.2	0.3	34	770	NAD83	11	677193.0	5678210.0	0.005200	0.000000	0.000000	0.00040
Shell Canada Limited	Gas Battery	Gas Battery	1277	25	0.5	20	773	NAD83	11	665581.0	5675242.0	0.003400	0.000000	0.000000	0.00030
Shell Canada Limited	Gas Battery	Gas Battery	1280	25	0.5	20	773	NAD83	11	668670.0	5669957.0	0.003400	0.000000	0.000000	0.00030
Shell Canada Limited	Gas Battery	Gas Battery	1218	25	0.5	20	773	NAD83	11	664675.0	5678093.0	0.003400	0.000000	0.000000	0.00030
Shell Canada Limited	Gas Battery	Gas Battery	1234	25	0.5	20	773	NAD83	11	664059.0	5679573.0	0.003400	0.000000	0.000000	0.00030
Shell Canada Limited	Gas Battery	Gas Battery	1191	25	0.5	20	773	NAD83	11	665479.0	5676901.0	0.003400	0.000000	0.000000	0.00030
Shell Canada Limited	Gas Processing Plant	Gas Processing Plant Generic Stack	1216	7.2	0.3	34	770	NAD83	11	669255.0	5668728.0	0.266900	0.000005	0.000005	0.02070
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	B8-1 Boiler	1227.1	18.3	1.65	6.05	450	NAD83	11	669135.7	5668069.0	0.333500	0.018100	0.018100	0.20010
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	B8-2 Boiler	1227.1	18.3	1.65	6.05	450	NAD83	11	669135.4	5668075.2	0.333500	0.018100	0.018100	0.20010
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	BGEN Generator (Jenbacher JGS 616 GS-N.L)	1221.7	10.5	0.57	34.1	639	NAD83	11	669271.5	5668181.9	0.127900	0.001500	0.001500	0.01560
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	H2001 Sulphur Plant Inline Burner	1230	24.4	0.7	11.3	1123	NAD83	11	669165.8	5667962.5	0.011800	0.001800	0.001800	0.01970
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	H3002 Hot Oil Heater	1221.2	40.2	1.37	2.7	500	NAD83	11	669419.1	5667893.1	0.023300	0.003500	0.003500	0.03920
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	H3004 Propane/Butane Regeneration Gas Heater	1222.2	6.5	0.7	2.6	533	NAD83	11	669408.6	5667885.8	0.009200	0.001400	0.001400	0.01540
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	H3101 Dehydration Regeneration Gas Heater	1222.7	30	1.13	3.2	477	NAD83	11	669402.1	5667892.2	0.020200	0.003100	0.003100	0.03400
Shell Canada Limited	Jumping Pound Sour Gas Processing Plant	IN9-2 Sulphur Recovery Incinerator	1227	102	1.6	22	811	NAD83	11	669126.0	5668061.0	0.113000	0.002000	0.002000	0.00000
Spray Lake Sawmills (1980) Ltd.	Cochrane Sawmill/Wood Treatment Plant	Stack	1144	10	0.5	10	293	NAD83	11	676850.0	5673110.0	0.013700	0.006600	0.006600	0.01590

Area Sources

Operator	Facility	Source	Elevation (mASL)	Effective Height (m)	Initial Sigma z (m)	Datum	Zone	NW Corner UTM Easting (m)	NW Corner UTM Northing (m)	NE Corner UTM Easting (m)	NE Corner UTM Northing (m)	SE Corner UTM Easting (m)	SE Corner UTM Northing (m)	SW Corner UTM Easting (m)	SW Corner UTM Northing (m)	Area (m^2)	NO_X (t/d)	$PM_{2.5}$ (t/d)	TSP (t/d)	CO (t/d)
Donna and Ian Airth	Big Springs Gravel Pit	Gravel Pit	1297	2	5	NAD83	11	678604	5683008	679142	5683032	679152	5682750	678697	5682677	154677	0.0461	0.0111	0.1473	0.4037
John and Irene Robinson	Robinson Pit	Gravel or Sand Pit 1	1144	2	5	NAD83	11	678831	5671551	679318	5671567	679344	5670947	679019	5670928	254205	0.0758	0.0182	0.2421	0.6634
John and Irene Robinson	Robinson Pit	Gravel or Sand Pit 2	1142	2	5	NAD83	11	678946	5671934	679033	5671944	679318	5671567	678831	5671551	110166	0.0329	0.0079	0.1049	0.2875
Rocky View County	Cochrane Pit	Gravel or Sand Pit	1125	2	5	NAD83	11	677181	5672349	677603	5672431	677629	5672286	677185	5672255	52592	0.0157	0.0038	0.0501	0.1373
Rocky View County	Griffin Pit	Gravel or Sand Pit	1294	2	5	NAD83	11	663413	5681974	663748	5681834	663753	5681678	663288	5681854	64689	0.0193	0.0046	0.0616	0.1688