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Lehigh Hanson Materials Limited

Scott Property – Air Dispersion Modelling Assessment

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Date: June, 2020

Project #: 60610856

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June 24, 2020

Project #
60610856

Dear Ms. Haaf:

Subject: Scott Property – Air Dispersion Modelling Assessment

AECOM Canada Ltd. is pleased to provide Lehigh Hanson Materials Limited with the following Air Dispersion Modelling Assessment for the Scott Property Project. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,
AECOM Canada Ltd.

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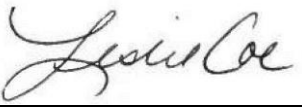

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Executive Summary

Lehigh Hanson Materials Limited (Lehigh) is proposing to construct and operate the Scott Property Project (the Project), which will be a Class I Aggregate Pit located in Rocky View County (RVC), in the rural community of Bearspaw, Alberta. The Project will occupy the majority of 05-26-02-W5M, with the exception of 33.9 acres located in the southwest corner (the Project Area). The Project Footprint refers to the proposed area of disturbance within the Project Area (see **Figure 1**). The property totals an area of approximately 600 acres (243 hectares [ha]), of which 395 acres (160 ha) are proposed for development as a sand and gravel pit. The Project will be constructed and operated in six phases with an anticipated operational lifespan of 25 to 30 years; each phase will be approximately five years in duration. Project development is planned to commence in 2022, with material extraction starting in 2024.

AECOM Canada Ltd. (AECOM) was retained by Lehigh to perform several environmental studies, including an Air Modelling Assessment, to satisfy the requirements of RVC Aggregate Development Requirements and Standards and Alberta Environment and Parks (AEP). AECOM conducted a conservative air quality assessment using an approved air quality dispersion model that considered the following assessment scenarios: a Baseline scenario that included background air quality measured in Calgary and the effects of regional aggregate operations; a Project-only scenario that considered the operating effects of the Scott Project alone; and an Application scenario that considered combined Baseline and Project-only impacts. The Application scenario is also a Cumulative Effects Assessment scenario which is provided in a standalone document.

To establish emissions from the Project, Lehigh considered several alternative emission cases that included options for stripping and clearing the land in stages, extracting aggregate and conglomerate, and transporting aggregate material on-site. Emissions from all cases were estimated and modelled to calculate air quality concentrations. The cases with the lowest emissions were then assessed in more detail in this report as part of the Project-only Scenario. The assessment moved forward with emissions in winter/early spring during which stripping and clearing took place and from spring to fall for excavation operations which included extraction equipment and a mechanical breaker to breakdown conglomerate, rather than blasting. A blasting case was evaluated, with results provided in an appendix. An in-pit conveyor was used to transfer material off-site, rather than haul trucks, and limited crushing was done in-pit to size material for conveyance. The emissions modelled included fugitive dust from all Project operations as well as emissions from diesel equipment on-site. For assessment purposes, the active pit operations were located in the extreme southwest corner of the Project Footprint.

A key conclusion of the assessment is that operation of the Project, as represented by the Application scenario, will result in negligible to low impacts to air quality at the Scott Property boundary due to emissions from equipment exhaust sources, which were predicted to meet Alberta’s ambient air quality objectives 100% of the time. When including the effects of existing vegetation between the modelled pit location and the Scott Property boundary, predicted concentrations of particulate were predicted to meet the ambient air quality objectives 99.95% of the time.

Based on the conservative nature of predictions, it is unlikely that concentrations of particulate on the Property boundary will exceed ambient air quality objectives due to extraction of the aggregate resource.

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Appendix A. Emissions Estimates Detail
Appendix B. Emission Case Options – Summary of Modelling Predictions
Appendix C. Isopleths of Modelling Results

1. Introduction

AECOM Canada Ltd. (AECOM) was retained by Lehigh Hanson Materials Limited (Lehigh) to complete environmental studies and reporting for various technical disciplines, including an Air Modelling Assessment report for the proposed Scott Property Project (the Project). This report describes the Project, outlines Project components and Project activities, summarizes regulatory requirements associated with air quality, and presents methods and results of the air quality modelling undertaken.

1.1 Project Description

Lehigh is proposing to construct and operate the Project, which will be a Class I Aggregate Pit located in RVC, in the rural community of Bearspaw, Alberta. The Project will occupy the majority of 05-26-02-W5M, except for 33.9 acres located in the southwest corner of the parcel (the Project Area). The Project is bound by 144 Avenue NW (also known as Burma Road) to the south, Range Road 24 to the East, and Range Road 25 (also known as Twelve Mile Coulee Road) to the west (see **Figure 1**).

The property totals an area of approximately 600 acres (243 hectares [ha]), of which 395 acres (160 ha) are proposed for development as a sand and gravel pit, with a maximum open pit area of 60 acres (24 ha) at any given time. The Project Footprint refers to the proposed area of disturbance within the Project Area. The Project will be operated in six phases with an anticipated lifespan of 25 to 30 years; each phase will be approximately five years in duration.

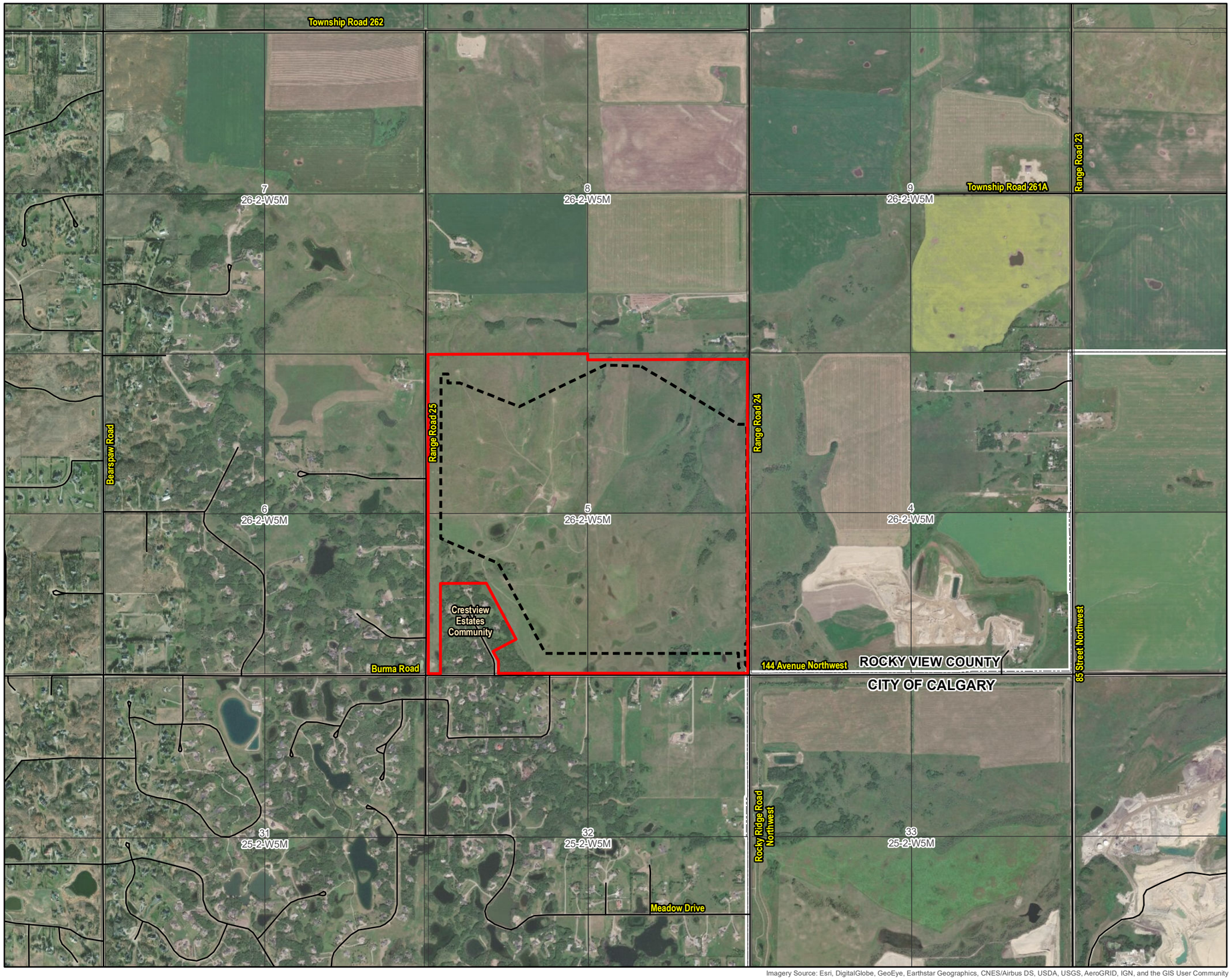
The Project location was selected for development as the lands are comprised of a significant quantity of high quality, close to market aggregate resources. The Project land use is currently pastureland with several wetlands and ephemeral water bodies throughout. Following operation, the Project lands will be reclaimed to an equivalent end land use.

The nearest residential development is Crestview Estates which the Project borders on its northeastern corner. The nearest residential property boundaries are 150 m from the Project Footprint.

1.1.1 Project Components

The Project will include the following key components. Please refer to the Master Site Development Plan (MSDP) for additional details:

- Crusher with in-pit conveyor
- Access roads
- Off-site conveyor system
- Operation & Maintenance Building
- Perimeter berms
- Site ponds for water management



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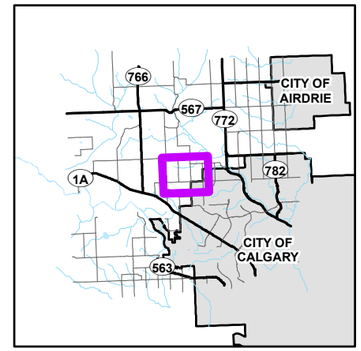

Legend

- Property Boundary
- Project Footprint
- City Boundary
- Road
- Quarter Sections

N
W E
S

1:20,000
NAD 1983 UTM Zone 11N

200 100 0 200 400 600 m

Sources: AltaLIS; NRCan

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Figure: 1

THE SCOTT PROPERTY PROJECT LOCATION

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

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1.1.2 Project Activities

Project activities affecting air quality are described in detail in the MSDP and include the following.

1.1.2.1 Site Preparation

- Initial topsoil, subsoil and overburden stripping and stockpiling for future reclamation.
- Berm construction.
- Establishing operating footprint (access roads, crusher, conveyors, stormwater ponds).

1.1.2.2 Operation

- Material excavation.
- Crushing and screening with use of in-pit conveyors to move material.
- Dust control.
- Conveying material to Inland's Spy Hill Property using off-site conveyor.
- Topsoil, subsoil and overburden stripping and stockpiling for future reclamation.
- Progressive reclamation.

1.1.2.3 Final Reclamation

- Replacing and recontouring reclamation materials.
- De-compaction.
- Removing infrastructure.
- Seeding and weed control.

Additional details pertaining to the timing of the activities and their resulting emissions are presented in **Appendix A**.

1.1.3 Project Schedule

Pending regulatory approval, Project development is planned to commence in 2022, with material extraction starting in 2024. The anticipated schedule for each Project activity (as described in **Section 1.1.2**) is provided below in **Table 1**.

Table 1: Project Schedule

Project Activity	Period
Site Preparation	Commencing in 2022 for an estimated period of 2 years.
Operation (including Progressive Reclamation)	Commencing in 2024 for an estimated period of 25 – 30 years.
Final Reclamation	Commencing following operational activities for an estimated period of 3 years.

2. Methods

2.1 Regulatory Environment

A summary of the applicable documents considered for the air dispersion modelling assessment is presented in **Table 2**.

Table 2: Regulatory Documents considered for the Air Dispersion Modelling Assessment

Document	Agency	Rationale for Air Quality Assessment
South Saskatchewan Regional Plan (AEP 2017)	Alberta Environment and Parks (AEP)	The South Saskatchewan Regional Plan establishes a long-term vision for the South Saskatchewan Region and aligns provincial policies at the regional level to balance Alberta's economic, environmental (including air quality) and social goals.
Air Quality Model Guideline (AEP 2013a)	AEP	This guideline is a resource that will help ensure that air quality dispersion modelling is consistent with regulatory applications.
Clarification Notice Regarding Minimum Area to Include Industrial Sources (AEP 2014)	AEP	This document assists with establishing a study area appropriate for the air quality dispersion modelling in the regional context.
Alberta Ambient Air Quality Objectives and Guidelines (AEP 2019)	AEP	This guideline was developed under the Alberta *Environmental Protection and Enhancement Act* to protect the province's air quality.
A Guide to the *Code of Practice for Pits* (Government of Alberta 2004)	AEP	This guide explains how sand and gravel pits on private land are regulated through the *Code of Practice for Pits*.
Canadian Air Quality Management System (AQMS) and Canadian Ambient Air Quality Standards (CAAQS) (CCME 2017)	Canadian Council of Ministers of the Environment	The document aim is to reduce emissions and ambient concentrations of various pollutants across Canada through four steps: air zone management, airshed co-ordination, industrial emissions reduction, and mobile source emission reduction.
BC ENV Ambient Air Quality Objective (BC Env 2018)	British Columbia Ministry of Environment	PM_{10} concentrations, unregulated in Alberta, were assessed using objectives in British Columbia

2.2 Ambient Air Quality Objectives

Alberta Environment and Parks (AEP) developed the Alberta ambient air quality objectives (AAAQOs) (AEP 2019) to determine adequacy of facility design, to establish required release conditions, to assess compliance, and to evaluate facility performance. Objectives and guidelines are developed based on the evaluation of the scientific literature and considering social, technical and economic factors. All industrial facilities in the province must be designed and operated in such a manner that the ambient air quality remains below AAAQOs. AAAQOs exist for nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particulate matter (TSP),particulate with diameter below 2.5 µm ($PM_{2.5}$), benzene and Benzo(a)Pyrene (BaP) and are outlined in **Table 3** below. In the absence of AAAQOs for specific compounds, objectives from other jurisdictions can be used; for example, PM_{10} is regulated by BC ENV (2018).

In addition to the AAAQO, Alberta sets out additional ambient air quality guidelines that are to be used for airshed planning and management, as a general performance indicator and to assess local concerns but should not be used for regulatory approvals. The 1-hour average guideline for $PM_{2.5}$ is outlined under the act and is also included in **Table 3** below. Similarly, federal standards were developed for airshed management (Canadian Ambient Air Quality Standards – CCME 2017).

Taken together, these Ambient Air Quality Objectives (AAQOs) were used to evaluate the potential effects of air emissions from the aggregate operations of the Project. For the current application, federal standards were only applied to $PM_{2.5}$.

Table 3: Ambient Air Quality Objectives, Guidelines, and Standards

Compound	Averaging Period	Objective, Guideline, or Standard[1]	
		µg/m³	ppb_v
Nitrogen Dioxide (NO_2)	1-hour	300 -	159 60[2]
	Annual	45 -	24 17.0[2]
Sulphur Dioxide (SO_2)	1-hour	450	172
	24-hour	125	48.0
	30-day	30	11
	Annual	20	8.0
Carbon Monoxide (CO)	1-hour	15,000	13,000
	8-hour	6,000	5,000
Total Suspended Particulate Matter (TSP)	24-hour	100	NA
	Annual	60	NA
Fine Particulate Matter (Diameter < 10 µm) (PM_{10})	24-hour	50[3]	NA
Fine Particulate Matter (Diameter < 2.5 µm) ($PM_{2.5}$)	1-hour	80[4]	NA
	24-hour	29 27[2]	NA NA
	Annual	8.8[2]	NA
Benzene	1-hour	30	9.0
	Annual	3	0.9
Benzo(a)pyrene (BaP)	Annual	0.3 ng/m³	2.9×10^{-5}

Sources:
1. *AEP (2019), unless noted otherwise*
2. *Canadian Ambient Air Quality Standards(CAAQS) – Specific Statistical form of the numerical standard is outlined in CCME (2017)*
3. *BC ENV (2018)*
4. *AEP (2019), guideline not an objective (not to be used for regulatory approvals)*

2.3 Assessment Scenarios

The following normal operations scenarios were assessed

- Baseline. The baseline scenario consisted of the following:
  - Measured “natural background” concentrations largely from air quality monitoring stations within the city of Calgary, which was considered as a conservative basis for this component of the Baseline. Although AEP (2013a) requires that a conservative assessment be prepared, so that the effects of the Project on air quality are not under-estimated, it is expected that current air quality near the Project is better than indicated by the natural background.
  - An estimate of “industrial background” concentrations from all operating aggregate pits in the area, from previous modelling of potential operations at the Project. The nearest aggregate pit is 400 m east of the Project footprint; all other pits are over 2 km away. This is considered a worst-case assessment given that not all emissions from all current operations would impact the Project at the same location at the same time. This component of the Baseline is discussed in **Section 3.5**.

- Project Only. This scenario included all emissions from the Project only. As discussed below in **Section 4.1**, Lehigh considered several alternative approaches to aggregate extraction and the prior clearing and stripping of land, and quantified the emissions and air quality predictions associated with them, to better manage the Project impact. The emissions associated with the alternative cases are presented in **Appendix A** and the model predictions of the alternatives are presented in **Appendix B**.
- Application. The Application scenario represents the sum of Baseline and Project effects. The Application scenario also represents a Cumulative Effects scenario, described in a standalone document.

AEP (2013a) also requires that abnormal conditions that may be caused by Project start-up or upset, or by extreme, unexpected meteorological conditions be assessed. These scenarios are discussed in more detail in **Section 4.2**.

The emissions from the Project were assessed based on information provided by Lehigh. These emissions were then used in the CALPUFF dispersion model to predict maximum modelled ground-level concentrations. In part to offset the conservativeness of dispersion models, AEP (2013a) requires that predictions be disregarded for hours with the most extreme weather conditions. Therefore, the hourly and 8-hour objectives are applied to the 9th highest hourly model predictions (99.9th percentile) in each year. However, daily and monthly objectives are applied to the highest daily (monthly) prediction in each year.

2.4 Dispersion Modelling

2.4.1 Choice of Model

Air dispersion models are important tools that can be used to assess the possible effects of an operation on the air quality at a particular location. These dispersion models mathematically predict the behaviour of emitted plumes by accounting for emission rates, physical characteristics of the release, geometry and location of the sources, terrain effects, meteorology, and atmospheric dispersion.

The air dispersion modelling assessment for the Project was completed using the CALPUFF dispersion model (Model Version 7.3.2) with the CALMET meteorological model (Model Version 6.4.0). CALPUFF with CALMET is specified by the AQMG as a refined model for air dispersion modelling assessments in complex terrain (AEP 2013a).

CALPUFF determines predicted air quality through air dispersion of emissions using boundary layer turbulence structure and scaling concepts. CALPUFF was selected for this application because of the advantages it offers compared to less sophisticated models (e.g., AERMOD):

1. Three-dimensional wind fields more accurately predicting concentrations near mountains and hills.
2. Advanced internal calculation of dust and acid deposition velocities (using CALMET data along with inputs) to appropriately model gas and particulate deposition.
3. Additional particulate fractions of dust are modelled leading to more realistic particulate concentrations.
4. Secondary particulate formation via chemical reactions (nitrates [NO_3] and sulphates [SO_4]) that lead to more accurate $PM_{2.5}$ predictions.
5. Roadway source implementation for more realistic accounting of roadway emissions.
6. Ability to model multiple variable emission rates dependent on wind speed, time of day and/or month of year.

2.4.2 Modelled Compounds

The following compounds were modelled and assessed based on expected Project activities. Dust particulate emissions which include:

- Particulate matter with diameter less than 2.5 µm ($PM_{2.5}$)
- Particulate matter with diameter less than 10 µm (PM_{10})
- Particulate matter with diameter less than 30 µm (TSP)

Diesel combustion equipment will emit fine particulate and gases:

- SO_2
- NO_X
- CO
- Benzene
- Benzo(a)Pyrene (BaP)

2.4.3 Spatial and Temporal Boundaries

In accordance with the AQMG (AEP 2013a), the following boundaries were used to assess modelled concentrations of air emissions from the Project. Boundaries for the air quality modelling assessment are identified in two ways: spatial and temporal. The modelled ground-level concentrations from the Project, compared against the AAQO, were investigated within these defined boundaries.

2.4.3.1 Spatial Boundaries

The study area for this assessment was the zone of influence of Project air emissions, including potential sensitive receptors near the Project. A CALPUFF study area of 14 km by 14 km centred on the modelled mining block was used for this analysis; the appropriateness of this boundary selection was confirmed by the model outputs which showed that maximum concentrations were found on the property boundary. The southwest corner of the CALPUFF computational domain was placed at UTM11 685.196 km E and 5,667.306 km N. The latitude and longitude of the proposed mining block selected for air quality modelling were: 51°, 11', 16.28" N and 114°, 14', 58.66" W (UTM 11: 692.202 km W and 5674,308 km N). The CALPUFF computational domain covers 14 km × 14 km. The southwest corner of the modelling domain was placed at UTM11 685.196 km E and 5,667.306 km N (**Figure 2**).

As Project emissions are relatively small and most are released below grade, the maximum effects from dispersion modelling are expected adjacent to sources. Thus, the minimum study area for dispersion modelling of 10 km by 10 km would apply (AEP 2013a). However, due to the proximity of the city of Calgary, the CALPUFF computational area was extended such that a portion of Calgary was included. The off-site conveyor system from Scott Pit extends from the active pit about 5 km to Lehigh's Spy Hill Property, which also warrants a larger computational area.

The southwestern corner of the CALMET modelling domain, which covers 20 km × 20 km, was placed at UTM11 682.202 km E and 5,664.308 km N (**Figure 2**). Horizontal grid cells of 0.25 km × 0.25 km were adopted – this combination of grid size and number was chosen to capture major terrain feature influences on wind flow patterns.

2.4.3.2 Temporal Boundaries/Time Variations

Temporal boundaries for this assessment were developed in consideration of continuous operations and emissions from the Project.

Each winter (i.e., January 1 to March 31), a new mining block will be prepared for mining by stripping the soil and overburden (i.e., the Winter Case). The stripped material will be stored in the previous years' pit (also referred to as "the reclamation area").

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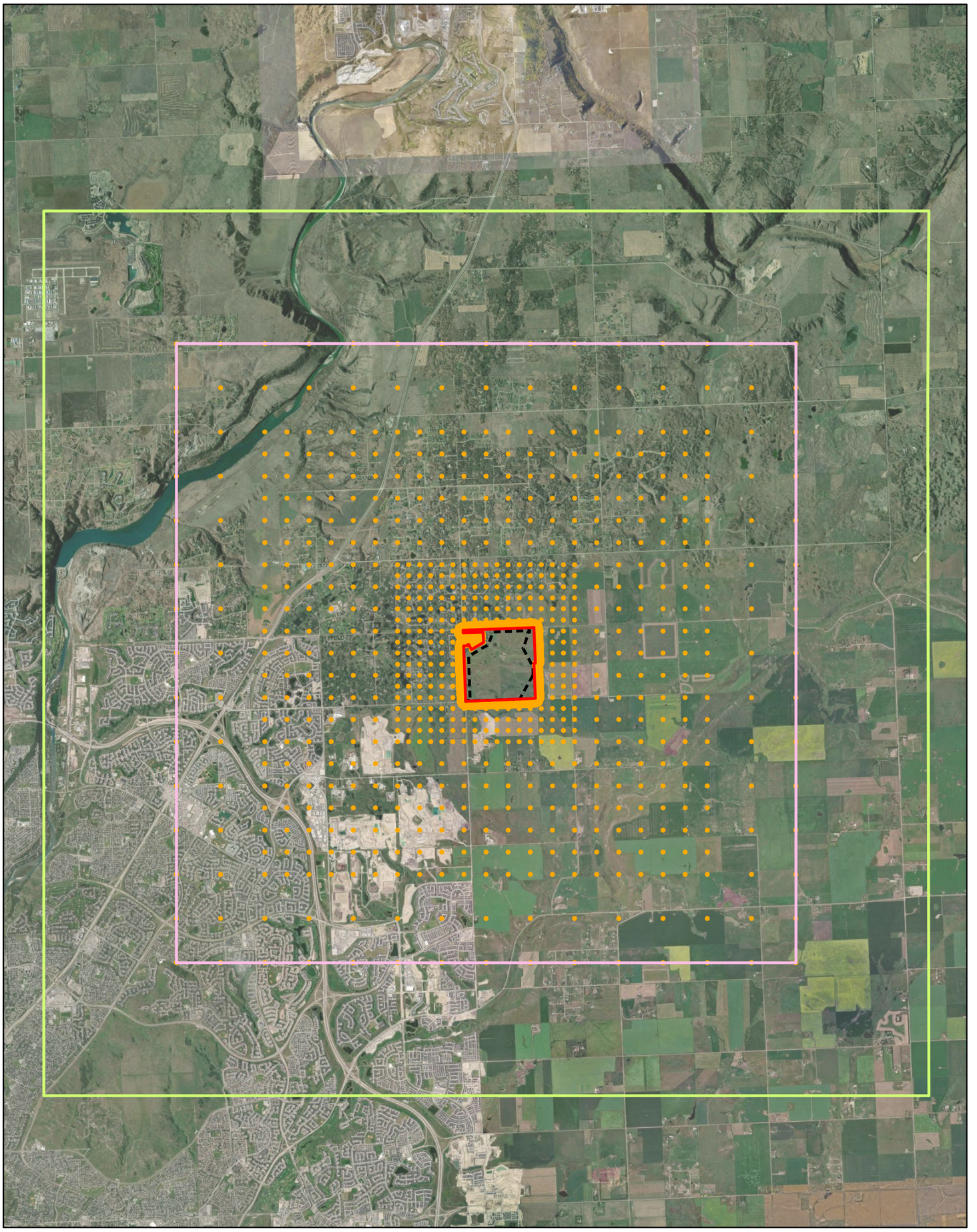
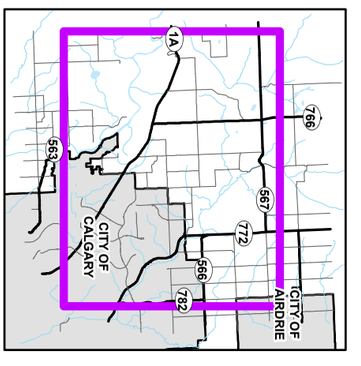


Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- Property Boundary
- Project Footprint
- CALMET Boundary (20x20 km)
- CALPUFF Boundary (14x14 km)
- Receptor

N
W
E
S

1:90,000
NAD 1983 UTM Zone 11N

900 450 0 900 1,800 2,700
m

Sources: AltaLIS, NRCan

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LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

LOCATION OF CALMET AND CALPUFF BOUNDARIES AND VARIABLE RECEPTOR GRID

AECOM

Figure 2

Each spring, summer, and fall (i.e., April 1 to November 30), this newly stripped mining block will be mined systematically. For simplicity, this period of pit operations is referred to as the Summer Case. No operational activities are planned during the month of December of each year.

All active pit stripping and extraction operations were modelled for a period of 11 hours a day. Wind speed generated emissions from pit and reclamation areas were modelled 24 hours each day.

Winter preparations (essentially the site preparation – Winter Case) and active pit mining (Summer Case) were modelled in this assessment. Emissions during the final reclamation phase were not modelled as it was assumed that they would be significantly less than those during the site preparation or the operation phases.

2.4.4 Receptors

The modelled receptor grid with the following spacing and distances was used, as per the AQMG (AEP 2013a) and shown in **Figure 2**:

- 20 m receptor spacing in the general area of maximum impact and the property boundary;
- 50 m receptor spacing within 0.5 km from the source;
- 250 m receptor spacing within 2 km from the sources of interest;
- 500 m spacing within 5 km from the sources of interest; and
- 1,000 m spacing beyond 5 km.

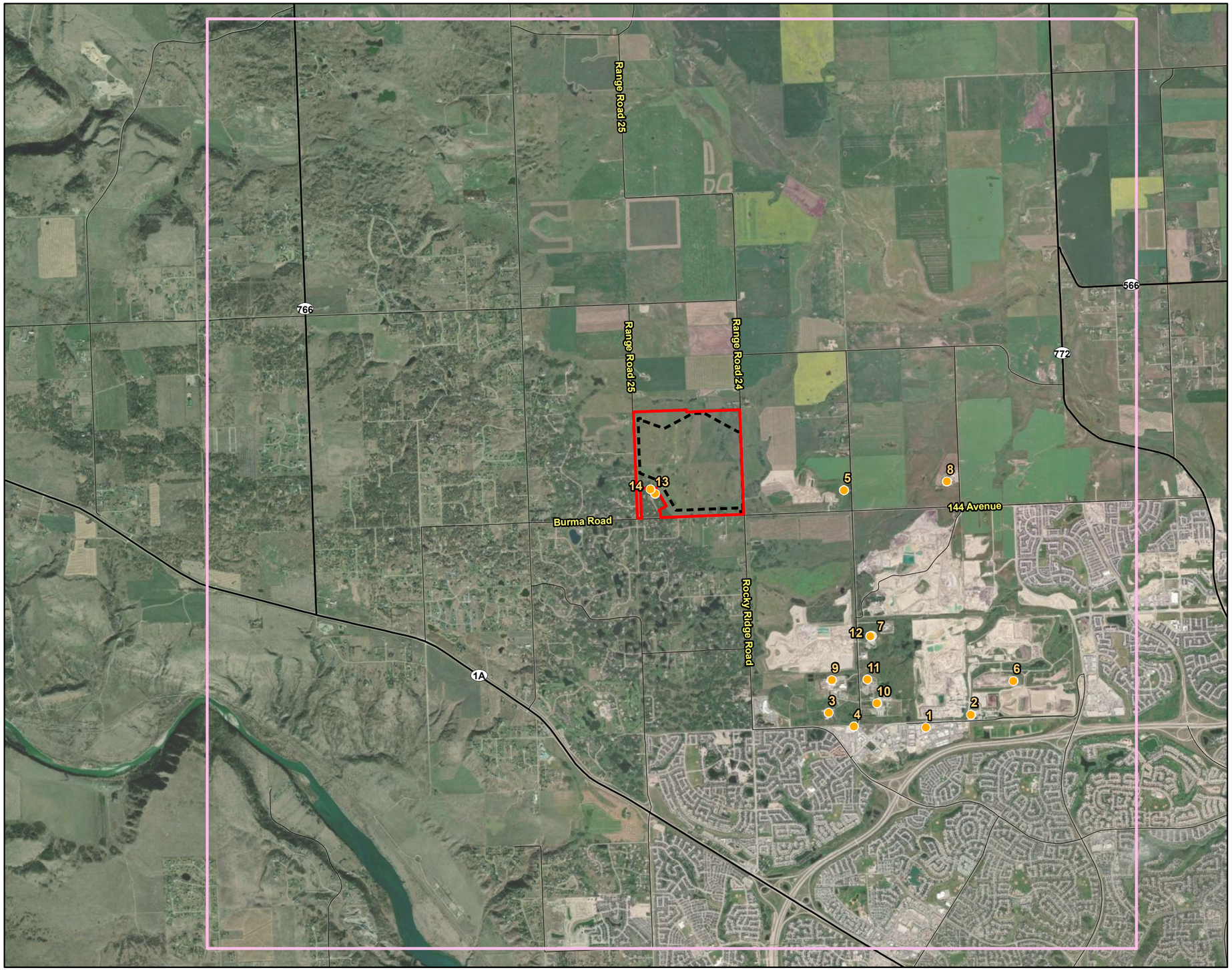
Special receptor points were added to the model in addition to the receptor grid described above to provide predictions specific to those locations. These sensitive receptor locations are listed in **Table 4** and shown in **Figure 3.**

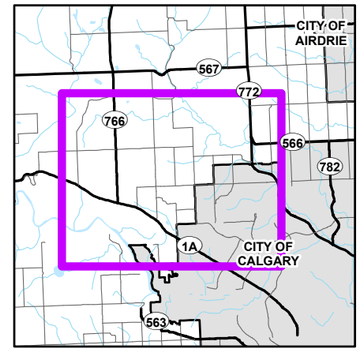
Table 4: Sensitive Receptors

Sensitive Receptor	Approximate Distance from Scott Pit (km)	UTM co-ordinate (km E)	UTM co-ordinate (km N)
1. Spy Hill Bottle Depot (76 Street NW)	5.3	696.022	5670.634
2. Inland Pit (69 Street NW)	5.7	696.701	5670.827
3. Medical Facility	4.2	694.560	5670.856
4. Walmart (85 Street NW)	4.6	694.939	5670.65
5. Farm (144 Ave NW & RR23)	2.6	694.790	5674.210
6. Spy Hill Gravel Pit	5.9	697.344	5671.338
7. 85 Street NW Facility	3.8	695.210	5672.015
8. Bearspaw Christian School (144 Avenue NW)	4.1	696.341	5674.341
9. U of C Facility	3.8	694.608	5671.350
10. Calgary Correctional Facility	4.5	695.290	5671.000
11. Calgary Remand Centre	4.2	695.143	5671.356
12. Youth Detention Centre	3.8	695.189	5672.013
13. No. 1 Crestview Estates	0.30	691.946	5674.156
14. No. 2 Crestview Estates	0.34	691.873	5674.223

All sensitive receptors represent either residences near the mining block or businesses in the area at which people stay a significant part of the day. The receptors include the nearest school to the Project (Bearspaw Christian School), a farm east of the Project and several locations on the outskirts of Calgary. Two receptors were included within the Crestview Estates community, the homes closest to the modelled Phase 2 mining block.

It is acknowledged that there are additional residences in the area that could be considered sensitive receptors. In particular, additional receptors could have been chosen south, west and north of the property boundary. However,





Legend

- Property Boundary
- Project Footprint
- CALPUFF Boundary (14x14 km)
- Highway
- Road

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800 m

Sources: AltaLIS; NRCan

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Figure 3

LOCATION OF SENSITIVE RECEPTORS

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

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the residences selected as sensitive receptors for the purpose of this assessment represent the points where the Project had the potential to create the greatest impact; the remaining residences will experience lower concentrations than the two sensitive receptors nearest the modelled mining block. Furthermore, the effects at other locations can be characterized by predictions on the standard grid of receptors.

2.4.5 Topography, Land Use and Terrain

The terrain around the pit is characterized by rolling hills covered by grass and sparse bushes and trees. However, some parts are covered by more dense patches of trees, especially surrounding houses. The terrain is lower in the northern part of the property.

Digital terrain and land use data covering the model domain were included in the CALMET input data set. Digital terrain files with a 1:50,000 scale, obtained from the NRCan (2020a) were used to generate elevation inputs for each CALMET grid point, receptor, and sources.

Land use characteristics for each grid cell were obtained from shape files (NRCan 2020b). These files were obtained from the 2010 databases and refined based on satellite imagery. The Agriculture and Agri-Food Canada (AAFC) land use class codes were translated into the land use class codes used by CALMET according to the procedures in the AQMG.

To determine meteorological parameters in the boundary layer, the CALMET model requires a physical description of the ground surface. The geophysical parameters used for this assessment include land use category, terrain elevation, roughness length, Albedo, Bowen ratio, surface heat flux parameter, anthropogenic heat flux and leaf area index (LAI). These parameters vary with the season. Four seasons were used in accordance with the AQMG:

- **Winter:** ..... November 15 to March 31 (ground could be snow-covered and/or frozen)
- **Spring:** ..... April 1 to May 14 (snow melted, ground moisture is higher than average, there are no leaves on trees and bushes)
- **Summer:** ... May 15 to September 14 (leaves on shrubs and trees; dry)
- **Fall:** ..... September 15 to November 14 (leaves fall from deciduous vegetation and ground moisture increases)

Standard (AEP 2013a) land use factors (**Table 5**) were based on the “cultivated land” category.

Table 5: Land Use Factors

Season	Surface Roughness[1] (m)	Albedo[1]	Bowen[1]
Spring	0.03	0.14	0.3
Summer	0.20	0.20	0.5
Autumn	0.05	0.18	0.7
Winter	0.01	0.60	1.50

Note: 1. Values from AQMG (AEP 2013a)

2.4.6 Meteorology for Modelling

Air quality is dependent on the rate of pollutant emissions into the atmosphere and the ability of the atmosphere to disperse the pollutant emissions. The dispersion of air pollutants is affected by local meteorological patterns.

2.4.6.1 Wind

The wind direction controls the path that air pollutants follow from the point of emission to the receptors. In addition, wind speeds affect the time taken for pollutants to travel from source to receptor, and the distance over which air pollutants travel. As a result, wind speeds also impact the dispersion of air pollutants; therefore, it is important to consider local meteorological patterns when assessing potential air quality effects from an emission source.

The CALMET model used the 2002-2006 Mesoscale Meteorological System (MM5) surface and upper air regional meteorological dataset provided by and mandated for use by AEP (2013a) to standardize dispersion modelling in the province. CALMET processes the MM5 data to obtain site specific air flows at finer scales, using land use and terrain features. **Figure 4** presents seasonal wind roses obtained from the CALMET meteorological data in the model grid cell 0 to 20 m above the surface of the mining block.

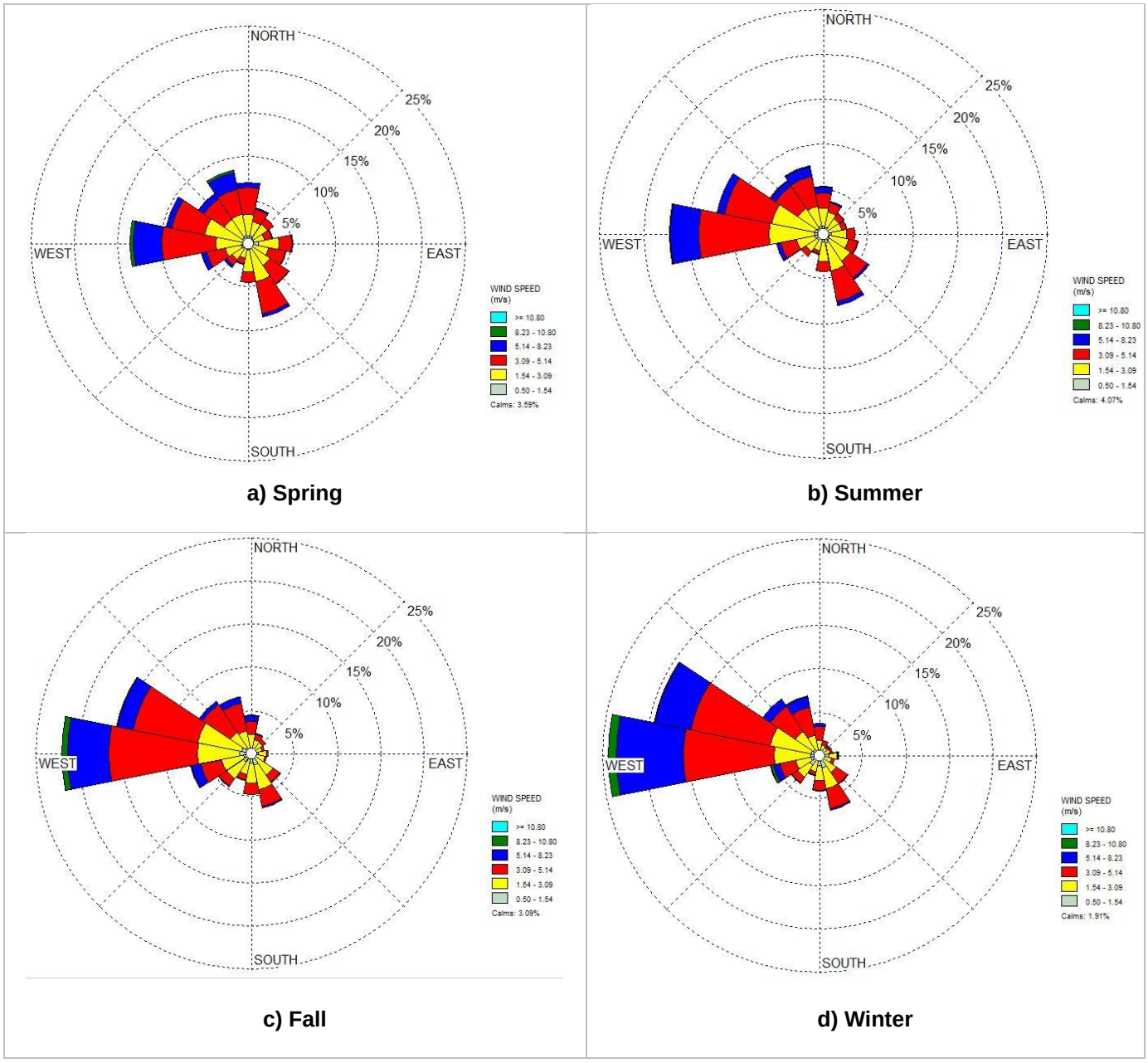
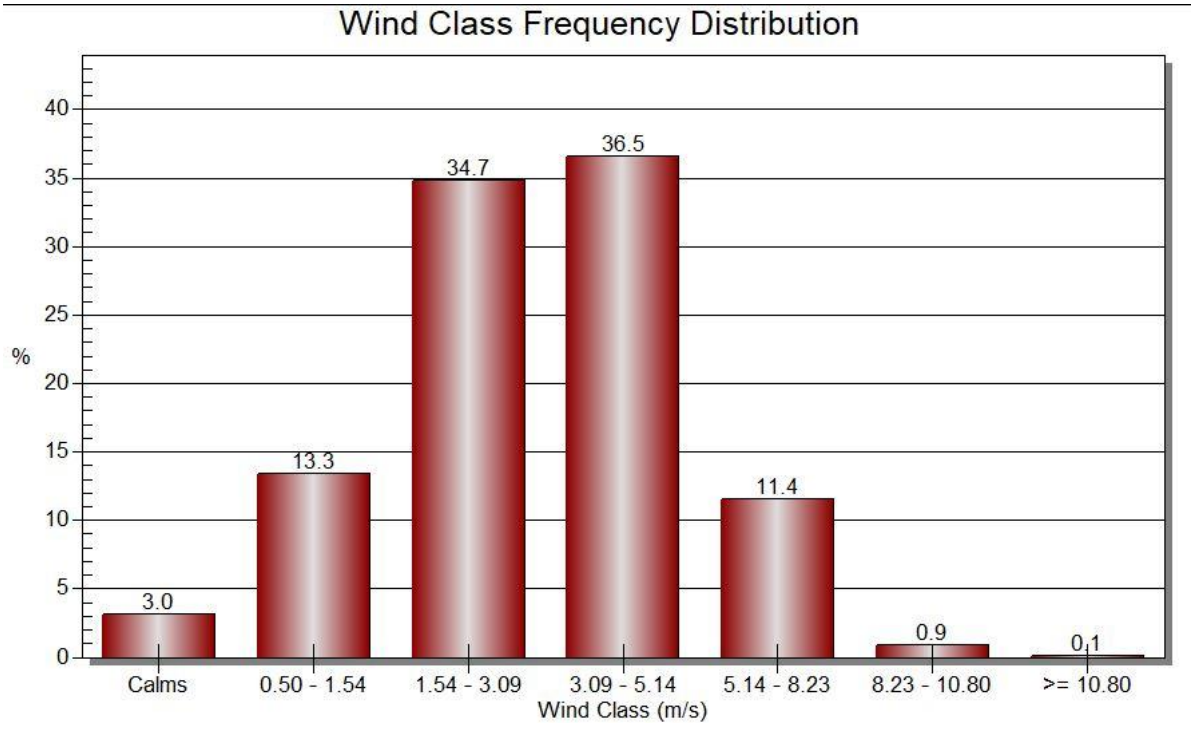
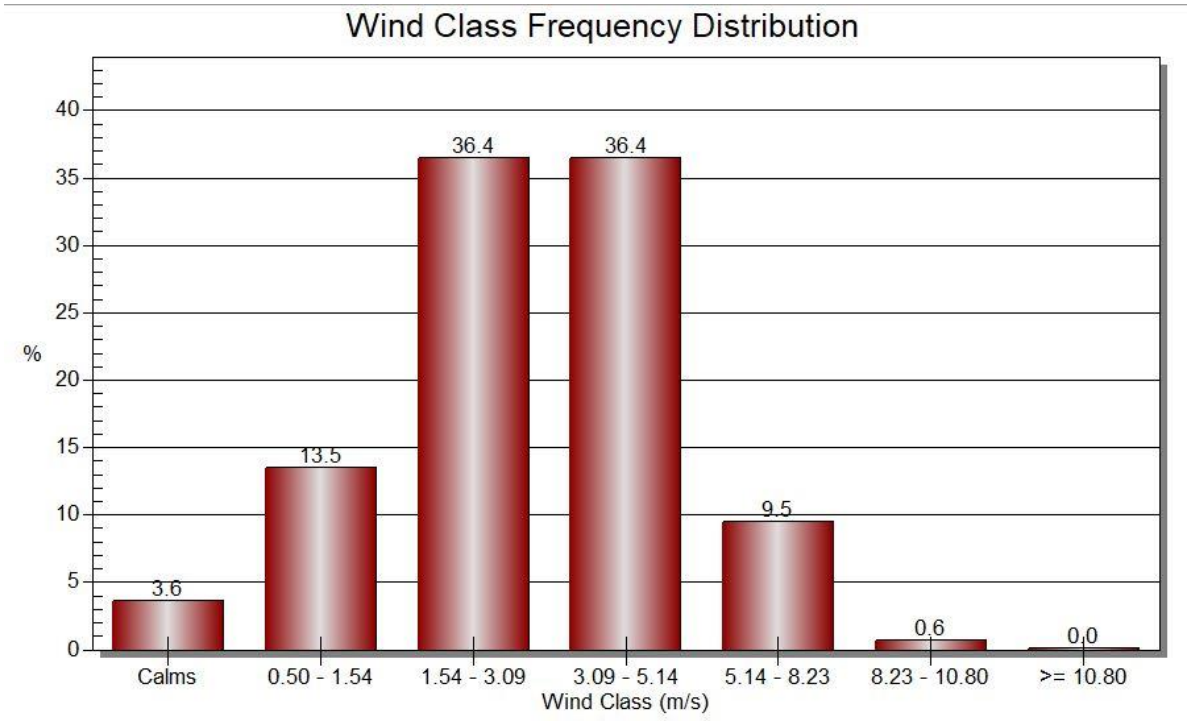


Figure 4: Seasonal Wind Roses at the Mining Block from CALMET Data

Figure 5 presents seasonal wind speeds based on CALMET meteorological file for CALMET cell from 0 to 20 m above mining block surface at pit location chosen for modelling for active pit and winter operations.



a) Winter Operations – January to March



b) Summer Active Pit Operations – April to November

Figure 5: Wind Speeds at the Mining Block from CALMET Data

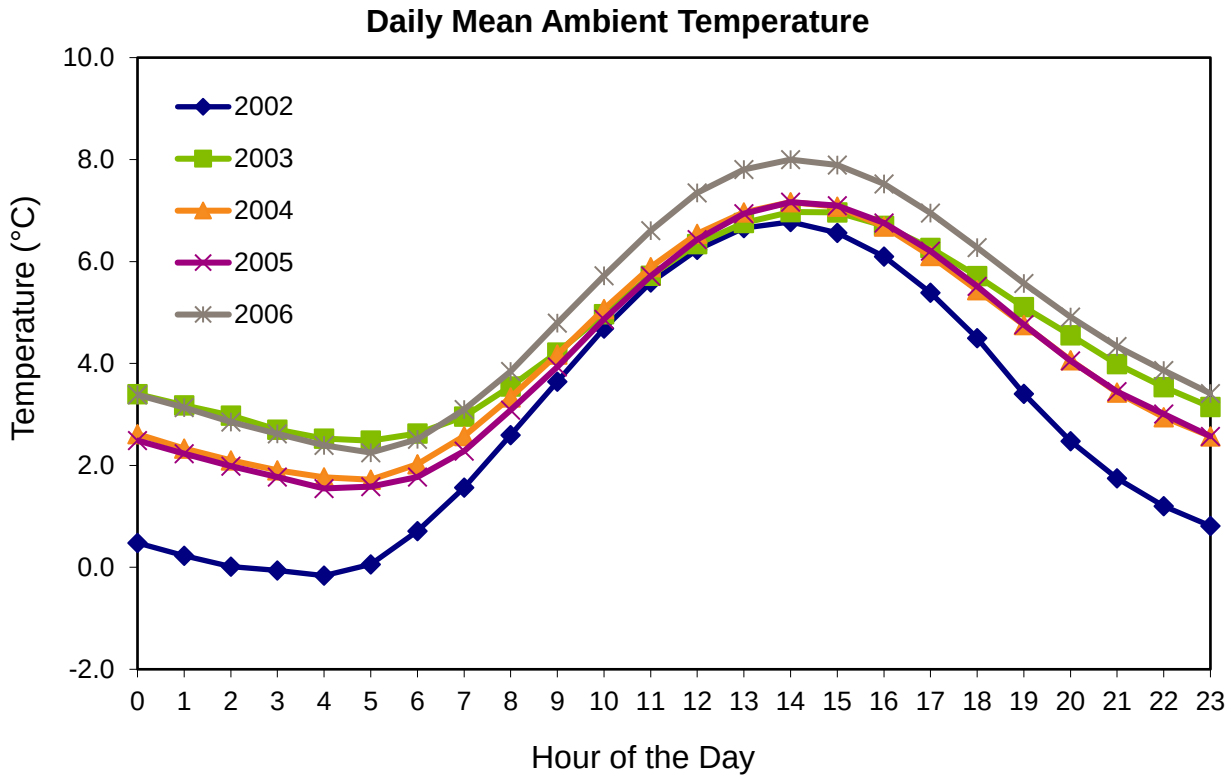
The prevailing wind is from west and west-northwest for every season. However, wind speeds are higher and there is a higher frequency of winds from the west and west-northwest in the fall (38% of the time) and winter (43%).

Most winds range between 1.54 and 5.14 m/s (71% during winter operations and 73% during active pit operations in the summer). There are slightly more winds above 5.14 m/s in the winter (12%) compared to active pit operations (10%) in the summer. The wind speed 5.14 m/s is a threshold, below which as we assume there are no wind-generated dust emissions (A&WMA 1992; NPI 2012).

2.4.6.2 Temperature

Figure 6 summarizes variations in temperature at the Project obtained from the CALMET meteorological data. The top graph shows daily mean ambient temperature by hour of the day for each modelled year (i.e., 2002 to 2006). The highest temperatures are in the afternoon (14:00 and 15:00); whereas, the lowest temperatures are just before sunrise (3:00 to 5:00). The highest hourly averages were calculated in 2006 and then in 2003, for high and low temperatures, respectively. The lowest diurnal temperatures were obtained for 2002.

The bottom graph shows the monthly variation in average temperature by year. The highest monthly temperatures were in July each year, except 2003, when the temperatures in August were slightly higher than in July. The average monthly temperatures from October to March are near or below zero degree Celsius. The lowest monthly temperature was recorded in March 2002 (-15°C). The higher monthly average temperatures were calculated in July 2002 and 2006 (at approximately +20°C).



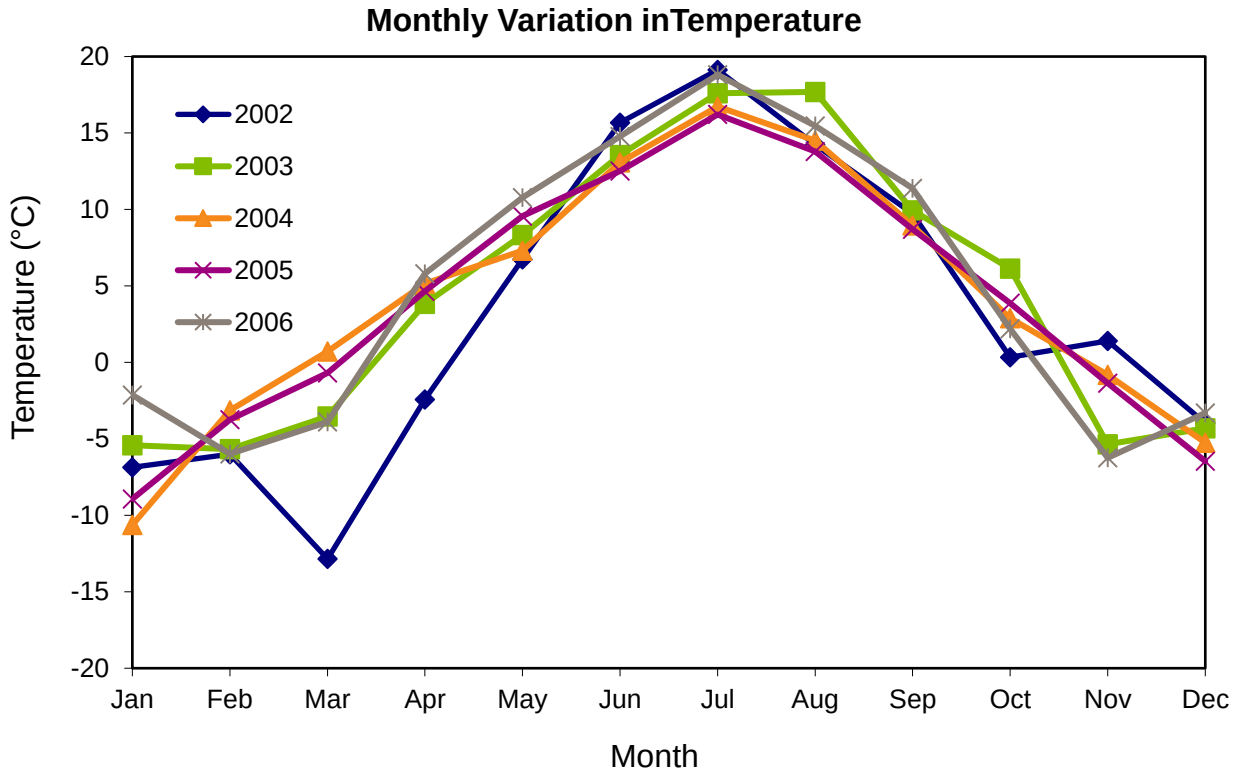


Figure 6: Temperatures at the Mining Block from CALMET Data

2.4.6.3 Precipitation

Table 6 summarizes the monthly precipitation for years 2002 to 2006, total annual precipitation and the average monthly precipitation is shown in **Figure 7**. The highest precipitation occurs in June (up to 237 mm in June 2005, average for 5 years – 138 mm). There was also precipitation above 100 mm in May 2004 (112 mm) and August 2004 (152 mm). The average precipitation for June from 5 years of CALMET data are 138 mm, for May is 85 mm and for August is 78 mm. The lowest precipitation is from October to March (monthly averages 18 mm for December to 43 mm for March). There was the lowest precipitation in 2002 (358 mm) and the highest in 2005 (764 mm). The average annual precipitation is 633 mm.

There are 122 days on average in the area with trace or greater precipitation amounts in the April to November period covering 244 days. In other words, during this period, precipitation falls 50% of the time.

Table 6: Total Monthly Precipitation at the Mining Block from CALMET Data

Month	2002	2003	2004	2005	2006	2002-2006 Average
January	11	27	39	30	19	25
February	10	40	4	23	36	23
March	32	56	38	58	31	43
April	17	100	49	29	72	53
May	84	77	112	61	92	85
June	56	119	139	237	142	138
July	16	60	69	70	67	56

Table 6: Total Monthly Precipitation at the Mining Block from CALMET Data

Month	2002	2003	2004	2005	2006	2002-2006 Average
August	55	32	152	99	53	78
September	38	60	40	92	55	57
October	13	39	35	30	52	34
November	9	24	16	27	35	22
December	19	5	41	9	15	18
Total	358	639	734	764	668	633

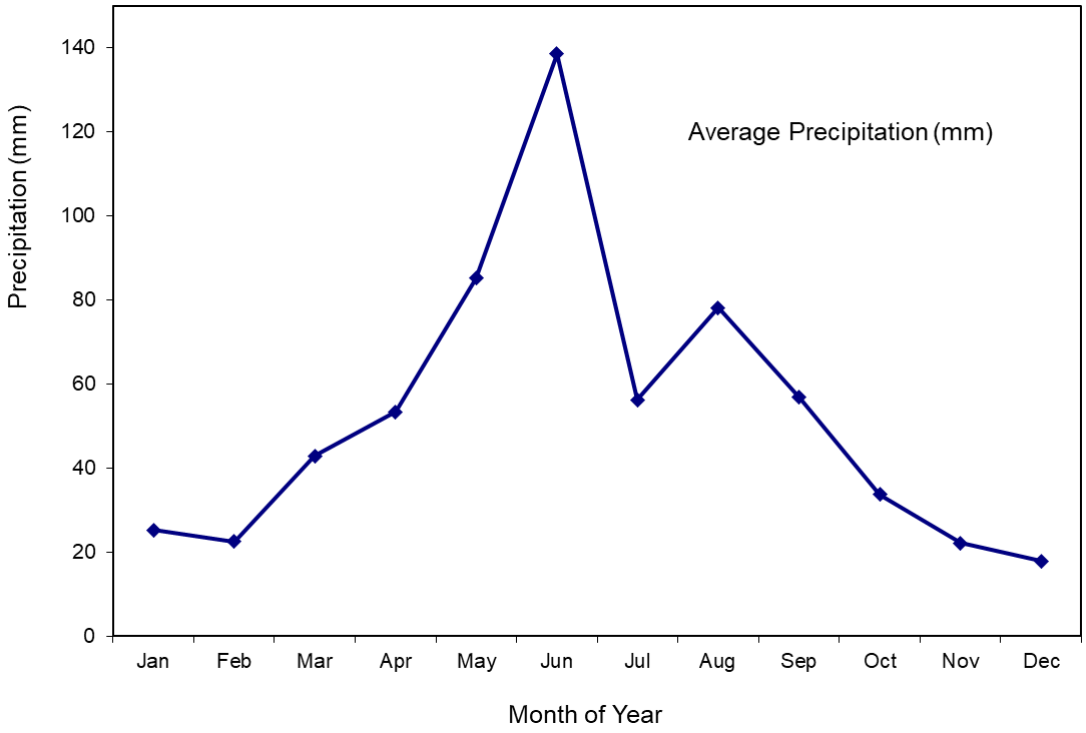


Figure 7: Monthly Precipitation at the Mining Block from CALMET Data (Average from 2002 to 2006)

2.4.6.4 Turbulence

Turbulence determines the rate at which plume dispersion occurs. Pasquill-Gifford (PG) stability classifications are useful to describe the amount of turbulence present in the atmosphere. These classes range from unstable (classes A, B, C) through neutral (D) to stable (E, F). Unstable conditions are primarily associated with daytime heating conditions that result in enhanced turbulence. Stable conditions occur during night-time cooling and indicated suppressed turbulence. Neutral conditions occur in cloudy or windy conditions.

Stability class was derived following the approach of US EPA (2000) where the final stability class changes are limited to one category per hour. For this reason, the final PG stability classes can include a few hours with stable conditions occurring in daylight hours, and or unstable conditions in evening hours.

Figure 8 presents PG stability classes as functions of time of day for the period 2002-2006 in spring and summer and **Figure 9** presents PG stability classes as functions of time of day for the period 2002-2006 in fall and winter.

All PG stability classes are obtained from CALMET data in the layer 0 to 20 m level above the surface of the mining block. The information indicates:

- neutral conditions (Stability Class D) can occur at any hour of the day and occur about 33% (summer) to 43% of the time (fall, winter);
- unstable stability classes (A, B, and C) are limited to daytime hours and occur from 15% (winter) to 39% of the time (summer), while stable classes (E and F) occur during night-time hours (except as indicated above) and occur from 28% (summer) to 42% of the time (winter); and
- spring and summer have the largest percentage of stability Class A (very unstable) that can occur up to 3.5% of daylight hours. Winter and fall have the least stability Class A values as this class is associated with strong daytime heating.

The unstable and very unstable stability conditions (A, B, and C) promote dispersion, while stable classes (E and F) cause a more concentrated plume to travel for longer distances.

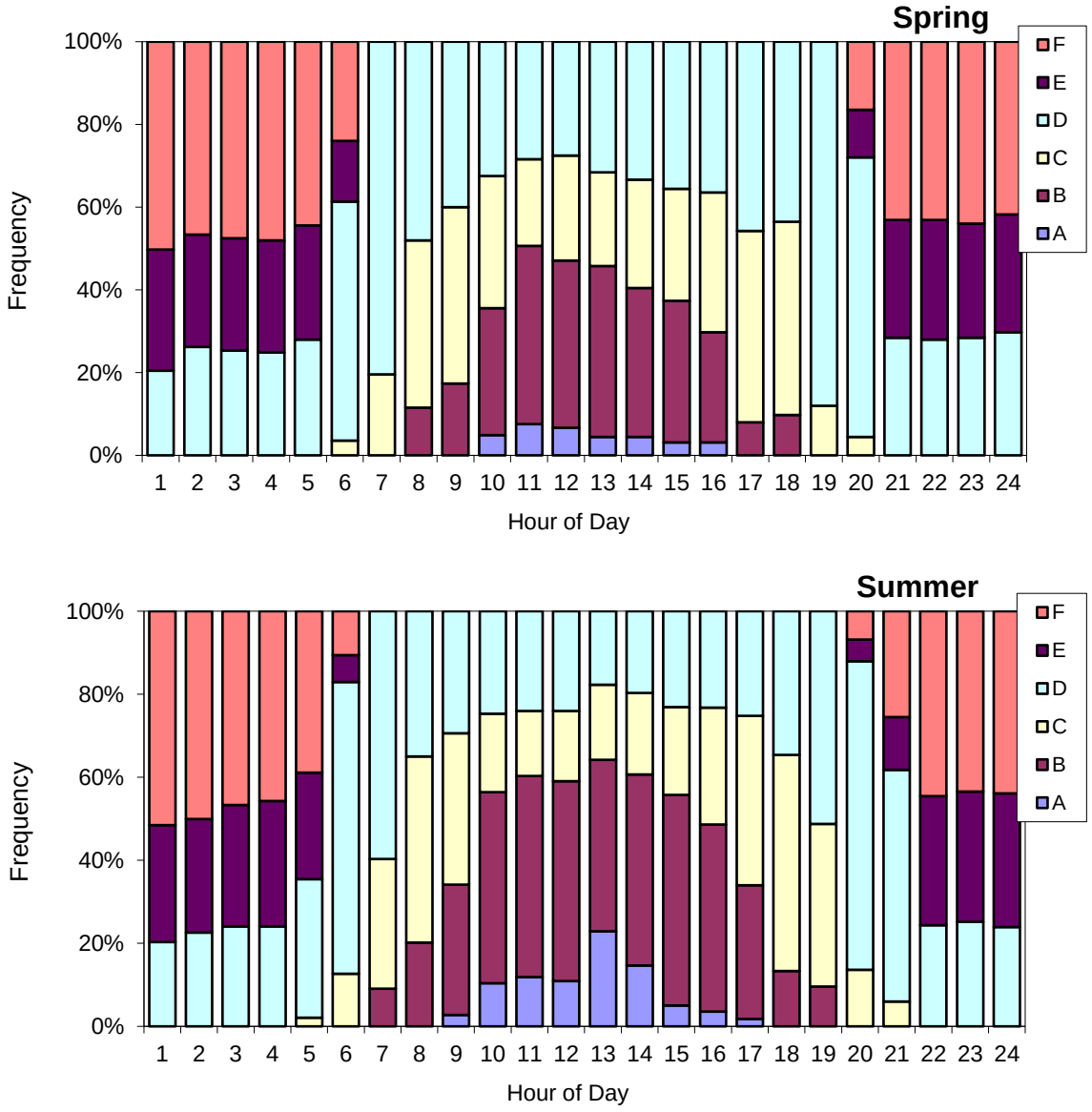


Figure 8: Diurnal and Seasonal Stability Classes at the Mining Block from CALMET Data (Spring and Summer)

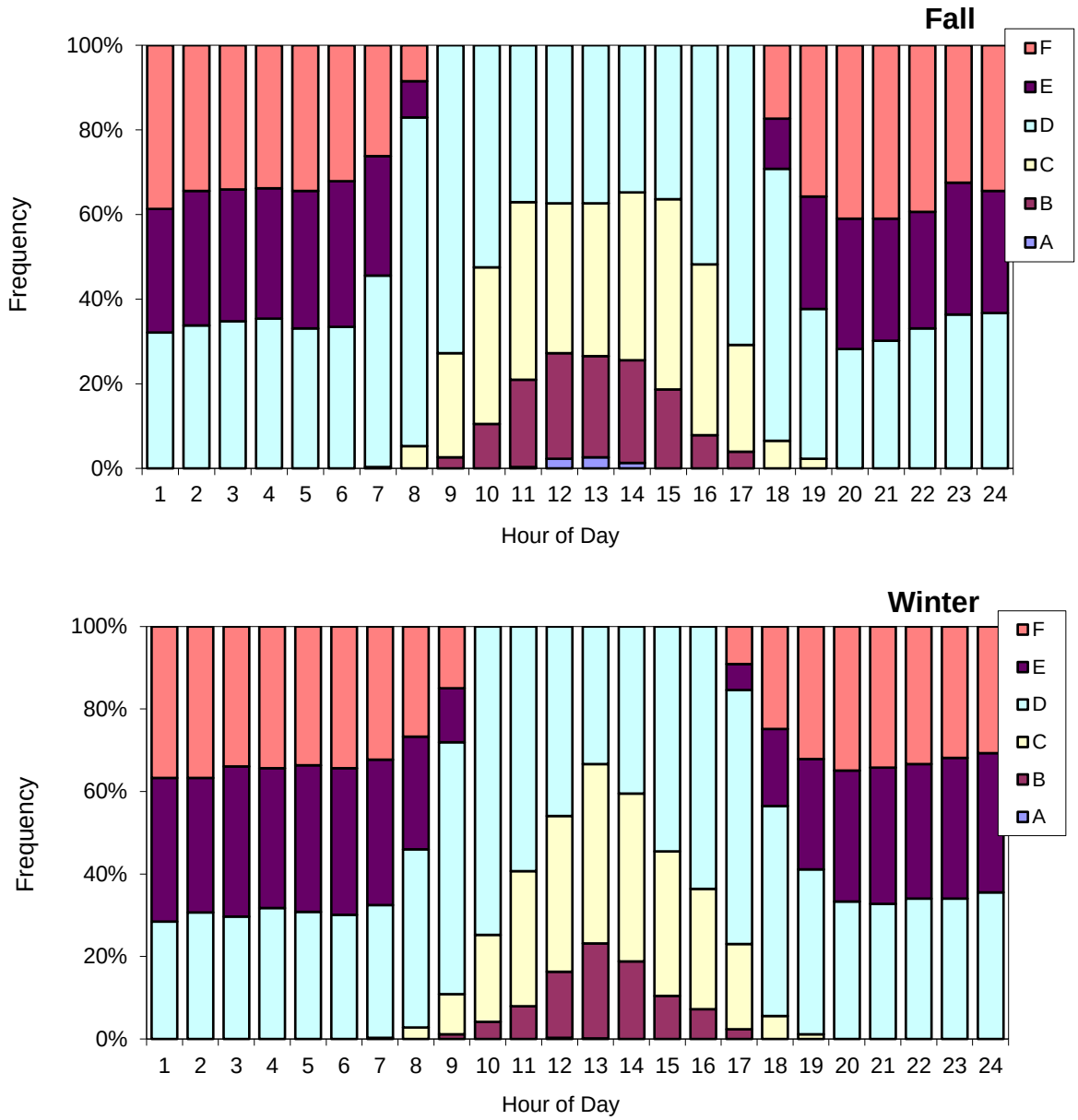


Figure 9: Diurnal and Seasonal Stability Classes at the Mining Block from CALMET Data (Fall and Winter)

2.4.7 Nitrogen Dioxide Modelling

Oxides of nitrogen are comprised of approximately 80% of nitric oxide (NO) and 20% NO_2. The NO_2/NO_X ratio of 0.2 is suggested for exhaust composition for diesel burning engines (Government of Newfoundland 2012). High temperature combustion processes primarily produce NO that in turn can be converted to NO_2 in the atmosphere through reactions with tropospheric ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Conversion of NO_x to NO_2 is estimated using the Ozone Limiting Method (OLM). This method states that if the ambient ozone concentration is greater than 90% of the predicted NO_x, then it is assumed that all the NO_x is

converted to NO_2. Otherwise, the NO_2 concentration is equal to the sum of the ozone and 10% of the predicted NO_x concentration. That is:

$$\text{If } [O_3] > 0.9\ [NO_x], \text{ then } [NO_2] = [NO_x]$$
$$\text{Otherwise, } [NO_2] = [O_3] + 0.1\ [NO_x]$$

These guidelines were established through the consideration of lowest observable effect levels on sensitive receptors. The OLM calculations are done for concentrations in ppm and then converted to $\mu g/m^3$.

Time series values of measured ozone in the province were used in modelling (AEP 2013a). Predicted concentrations of NOx, with baseline values added, were converted to NO_2 using ozone values measured at the Calgary Northwest monitoring station in 2018 (90 $\mu g/m^3$ = 48 ppb) as explained in **Section 3.2**. Following AEP (2013a), NO_2 concentrations are also reported using the total conversion method (all NO_x is converted to NO_2).

2.4.8 Chemical Transformation

The RIVAD/ARM3 scheme was used for chemical transformations of NO, NO_2, and SO_2 in the atmosphere. The transformation rates were computed internally within CALPUFF. Particulates and gaseous deposition were modelled to make more realistic predictions of gas and dust concentrations in the air. All particulate fractions (described in **Section A.2.4** of the **Appendix A**) were added to obtain TSP, PM_{10} and $PM_{2.5}$. Secondary $PM_{2.5}$ (SO_4 and NO_3) was added to the $PM_{2.5}$ predicted concentrations.

2.4.9 Effect of Vegetation Cover on Modelling of Particulate

Vegetation reduces the speed of wind blowing through it and enhances turbulence, both of which increase the deposition of particulates near the source (within 200 m of surface-based sources like gravel pits). This enhanced deposition reduces concentrations remaining in the air.

As explained in detail in **Section A.7** of **Appendix A**, the CALPUFF model, despite its wet and dry deposition algorithms, does not sufficiently account for deposition in forested areas, compared to measurements reported in the literature. For this reason, a 25% reduction due to grass, brush and sparse trees was applied to particulate predictions resulting from Project sources. This adjustment was not applied to Baseline concentrations since natural background was calculated from observations not from dispersion modelling results.

2.5 Emission Data Sources

The emissions for the Project were based on information supplied by Lehigh. The emissions from diesel engine combustion were based on publicly available equipment specifications (e.g., Caterpillar Equipment Catalogues), emission factors in the NONROAD model (part of the archive for the MOVES model), and methodology described in United States Environmental Protection Agency (US EPA) documents (US EPA 2008; US EPA 2010). Fugitive particulate emissions were calculated using US EPA Compilation of Air Pollutant Emission Factors (AP42) and Australian National Pollution Inventory (NPI 2012), commonly used in air quality assessments in Alberta.

3. Existing Air Quality

3.1 Regional Monitoring Stations

Background air quality concentrations due to natural sources and unidentified, possibly distant sources, were added to model predictions. For this assessment, background emissions, as well as emissions from roadways and the Calgary Metropolitan area, were considered by adding concentrations measured in the Calgary Region Airshed Zone (CRAZ) – Calgary Varsity (Northwest) (AEP 2020a) or Calgary Southeast station (AEP 2020b).

Benzene background concentrations were analyzed using 2018-2019 hourly data from the Scotford Temporary station located in an industrial area near Fort Saskatchewan (AEP 2020c). This is the nearest station collecting benzene data within the last three years. Benzene was also measured at the CRAZ Calgary Central stations (Calgary Central and Calgary Central 2) from 1993 to 2008. These measurements were 24-hour averages measured every six days and were not included in this assessment because they do not relate to the 1-hour AAAQO for benzene.

The Scotford Temporary Monitoring Station is located in a rural area about 10 km east-southeast of Fort Saskatchewan and several kilometres from the nearest industry.

The location of background air quality stations is shown in **Figure 10** and **Table 7.** The measured concentrations from these stations are based on standard provincial protocols and carefully quality-checked. Although AEP (2013a) requires that a conservative assessment be prepared, so that the effects of the Project on air quality are not under-estimated, it is expected that current air quality near the Project is better than indicated by the data collected at the regional stations used in the assessment.

Table 7: Summary of Air Quality Monitoring Stations used for Background Determination

AQ Station	Longitude	Latitude	Effective Date	Termination Date
CRAZ Northwest	-114.142°	51.079°	August, 1974	June, 2018
CRAZ Varsity	-114.139°	51.083°	June, 2018	Active
CRAZ Southeast	-113.970°	50.955°	April, 2014	Active
CRAZ Calgary Central	-114.073°	51.047°	May, 1979	February, 2008
CRAZ Calgary Central 2	-114.075°	51.047°	April, 2008	March, 2015
Scotford Temporary	-113.029°	53.757°	May, 2014	Active

3.2 Measurements at Regional Stations

The existing ambient air quality was characterized using measurements from the Calgary Varsity Monitoring Station (located in the northwest of the city) (AEP 2020a) or from the Calgary Southeast Monitoring Station (AEP 2020b). The measurement statistics from 2014-2019 (6 years of hourly measurements) are summarized in **Table 8** to **Table 12**.

It is important to reiterate that CRAZ stations are located within Calgary city limits, whereas the Project is located outside the city limits in Rockyview County. The area around the Project is not as densely populated as area around the Varsity and the Southeast stations; as a result, the background concentrations near the Project will be lower than represented in **Table 8** to **Table 12**.

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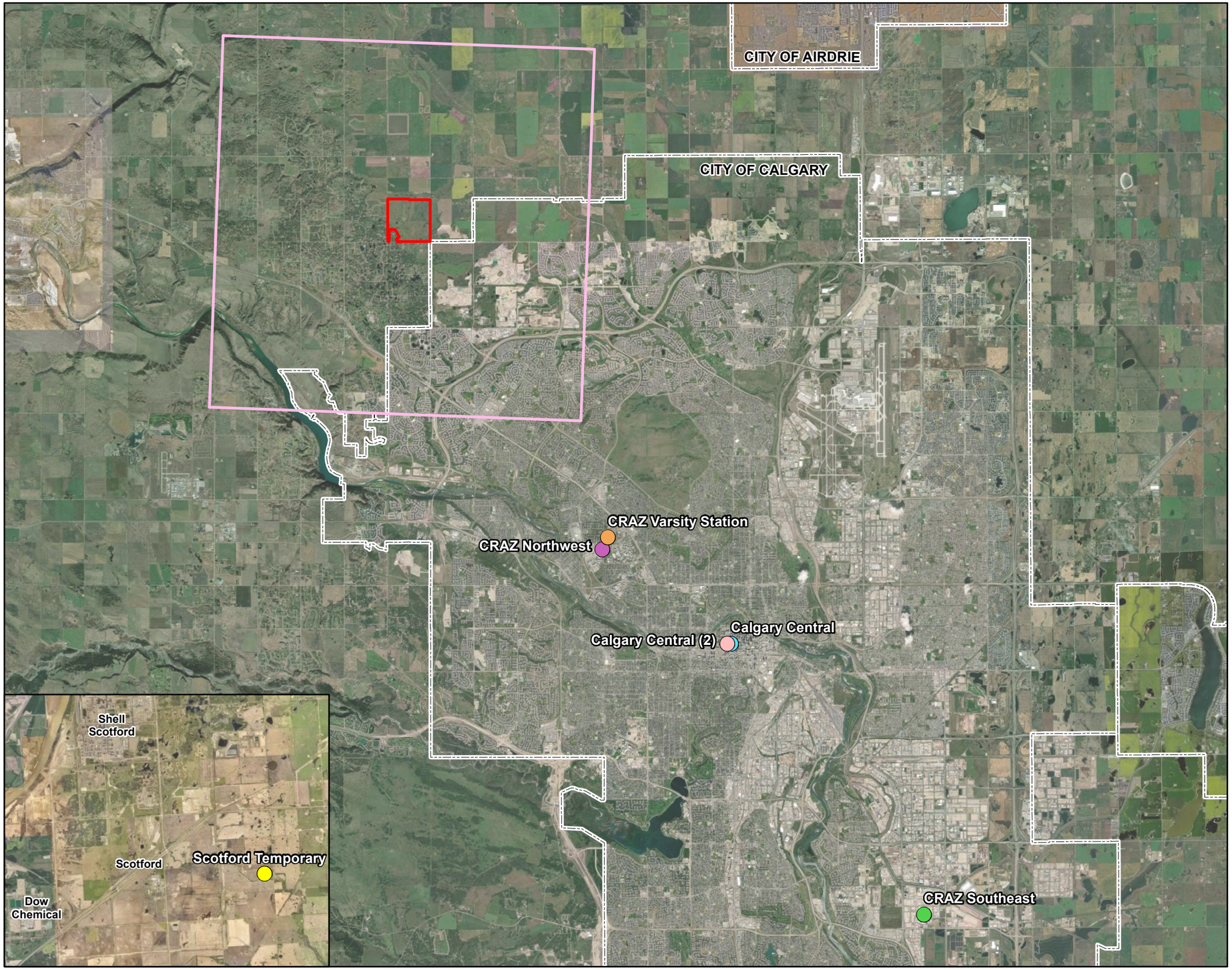

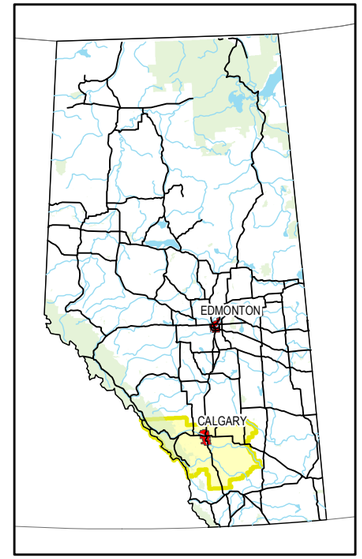

Legend

- City Boundary
- Approximate Calgary Region Airshed Zone (CRAZ)
- Scott Pit Study Area
- Property Boundary

Air Quality Monitoring Stations

- CRAZ Northwest
- CRAZ Southeast
- CRAZ Varsity Station
- Calgary Central
- Calgary Central (2)
- Scotford Temporary

N
W E
S

1:150,000
NAD 1983 UTM Zone 11N

2 1 0 2 4 6 km

Sources: AltaLIS; NRCan

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure 10

LOCATION OF AIR QUALITY MONITORING STATIONS

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-09

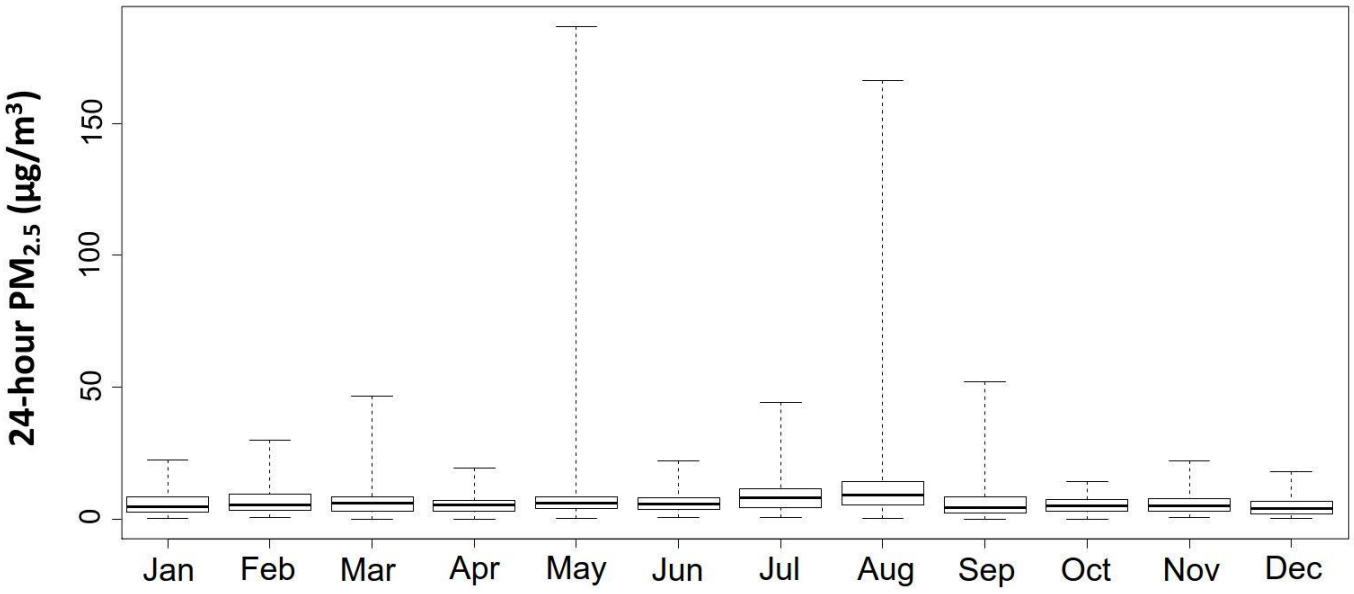
3.2.1 $PM_{2.5}$

$PM_{2.5}$ measurements are summarized in **Table 8** and **Figure 11.** Median daily values are approximately constant throughout the year at the Varsity station. Median values are slightly higher in July and August. The effects of forest fires are most evident in the 1-hour maximum observations in 2018 and 2019 in **Table 8**; these occurred in the second half of August 2018 and May 30-31, 2019 and resulted in exceedances of the AAAQO.

Table 8: Summary of Continuous $PM_{2.5}$ Measurements at the CRAZ Varsity Station (2014-2019)

Parameter	Averaging Period	Summary Statistics	Year						AAQO
			2014	2015	2016	2017	2018[1]	2019[2]	
$PM_{2.5}$ ($\mu g/m^3$)	**1-hour**	Maximum	66	189	66	197	270	396	80[3]
		90th Percentile	16	18	10	16	18	14	80[3]
		Minimum	0	0	0	0	0	0	-
	24-hour	Maximum	44	141	21	68	166	187	29[4]
		Maximum for 90th Percentile Data 1-hour Removed	15	16	9	13	16	12	29[4]
		98th Percentile	21	26	13	36	54	19	-
		Rolling 3 Years Average	-	-	20	25	34	36	27[5]
	Annual	Average	7.9	8.7	4.6	7.3	9.6	6.5	-
		Rolling 3 Years Average	-	-	7.0	6.8	7.1	7.8	8.8[6]

Notes:
1. *Calgary Northwest had a change in $PM_{2.5}$ instrumentation in late May 2018. While both are considered Federal Equivalent Methods, there may be some trend variations when the transitions occurred. The Calgary Northwest station was moved to Calgary Varsity in June 2018. Changes in the data trend may occur as a result.*
2. *Data from September to December 2019 were downloaded from the CRAZ website and have not gone through the data validation procedures of the AMD. These data were edited for missing data only.*
3. *AEP (2019), guideline not an objective (not to be used for regulatory approvals)*
4. *AAQO (AEP, 2019).*
5. *CAAQS, 2020 Standard (CCME 2017)*
6. *CAAQS (CCME 2017)*



Note: Plot shows median values as solid lines with a box representing 25 and 75 percentiles and whiskers for minimum and maximum observations.

Figure 11: Seasonal Variation in Daily PM2.5 at the CRAZ Varsity Station (2014-2019)

Table 8 also summarizes measurements for a reduced dataset for comparison to AAAQO as well as the statistics used to compare to CAAQS. For comparing to AAAQOs, AEP (2013a) requires the 90th percentile hourly measurements to be used as background, and effectively removes the highest 10% of measured values from further consideration.

When comparing measurements to CAAQS, the metric is the 98th percentile of 24-hour averages. However, all hours with naturally occurring high values (e.g., from fires) are to be removed in this calculation before 98th percentile is calculated. This step has not been taken and thus the comparisons to CAAQS in the rolling averages presented in **Table 8** will err on the conservative side. Note also that due to the three-year rolling averages, the influence of the 2018 fire season, for example, would be seen in the statistics for 2017-2019 and 2016-2018.

Since the $PM_{2.5}$ observations are used to calculate natural background for PM_{10} and TSP (Section 3.4), it should be noted that conservative assumptions used here affect all particulate fractions. To summarize:

- Urban station measurements are used to calculate natural background in less populated area around the Project.
- The Calgary station data include longer periods of measurements obtained during wildfire season when $PM_{2.5}$ measurements are high.
- Backgrounds are based on 90th percentile measurements. On 9 days in 10, background concentrations will be lower.

Natural background concentrations of particulate are expected to be lower in the vicinity of the Project than values presented in this assessment.

3.2.2 Gases

All maximum carbon monoxide (CO) and nitrogen dioxide (NO_2) measurements presented in **Table 9** and **Table 10** at the Varsity Station are less than the AAQO. **Table 10** also summarizes nitrogen oxides (NO_X) (i.e., nitrogen oxide [NO]+ NO_2) measurements which are used in modelling, but which are not associated with an AAQO. **Table 11** summarizes ozone measurements which are used in converting NO_X predictions to NO_2 using the Ozone Limited Method (OLM) described in **Section 2.4.7**. The 90th percentile 1-hour ozone background concentration from 2018 (90 µg/m^3 = 48 ppb) was used for OLM conversion. **Table 12** summarizes SO_2 measurements at the Calgary Southeast Station, as there is no SO_2 measurements at the Varsity Station.

Table 9: Summary of Continuous CO Measurements at the CRAZ Varsity Monitoring Station (2014-2019)

Parameter	Averaging Period	Summary Statistics	Year						AAQO
			2014	2015	2016	2017	2018	2019	
CO (µg/m^3)	**1-hour**	Maximum	1,374	1,832	1,489	1,603	1,947	2,290	15,000
		90th Percentile	344	344	344	344	458	458	15,000
	8-hour	Maximum	902	1,331	1,002	1,145	1,746	1,933	6,000
		Maximum for 90th Percentile Data 1-hour Removed	344	344	344	344	458	458	6,000

Table 10: Summary of Continuous NO_2 and NO_X Measurements at the CRAZ Varsity Monitoring Station (2014-2019)

Parameter	Averaging Period	Summary Statistics	Year						AAQO
			2014	2015	2016	2017	2018	2019	
NO_2 (µg/m³)	**1-hour**	Maximum	115	97	102	112	119	115	300
		90th Percentile	49	43	41	41	49	42	300
	Annual	Maximum	21	20	18	19	21	19	45
		Maximum for 90th Percentile Data 1-hour Removed	16	15	13	15	16	14	45
NO_X (µg/m³)	**1-hour**	Maximum	265	296	304	217	228	336	-
		90th Percentile	58	54	51	49	58	54	-
	Annual	Maximum	26	25	22	23	25	24	-
		Maximum for 90th Percentile Data 1-hour Removed	19	18	28	17	18	16	-

Table 11: Summary of Continuous O_3 Measurements at the CRAZ Varsity Monitoring Station (2014-2019)

Parameter	Averaging Period	Summary Statistics	Year						AAQO
			2014	2015	2016	2017	2018	2019	
O_3 (ppb)	**8-hour**	Maximum	56	63	70	56	66	56	-
		4th Highest 8-hour Maximum Daily	52	57	56	53	61	51	-
		Rolling 3-Year Average	-	-	55	55	57	55	62[1]
O_3 (µg/m³)	**1-hour**	Maximum	155	147	177	133	173	134	150[2]
		Maximum for 90th Percentile Data 1-hour Removed	86	88	84	88	90	84	150[2]

Notes 1. Canadian Ambient Air Quality Standard (CAAQS)
2. Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

Table 12: Summary of Continuous SO_2 Measurements at the CRAZ Southeast Station (2014-2019)

Parameter	Averaging Period	Summary Statistics	Year						AAQO
			2014	2015	2016	2017	2018	2019	
SO_2 (µg/m³)	**1-hour**	Maximum	21	24	16	18	24	N/A	450
		Maximum for 90th Percentile Data 1-hour Removed	2.6	2.6	2.6	2.6	2.6	N/A	450
	24-hour	Maximum	4.7	6.9	8.1	5.4	7.3	N/A	125
		Maximum for 90th Percentile Data 1-hour Removed	2.6	2.6	2.6	2.6	2.6	N/A	125
	30-day	Maximum	1.2	2.2	1.9	1.7	2.7	N/A	30
		Maximum for 90th Percentile Data 1-hour Removed	1.0	1.5	1.1	1.1	1.5	N/A	30
	Annual	Maximum	0.8	0.9	0.7	0.8	1.1	N/A	20
		Maximum for 90th Percentile Data 1-hour Removed	0.6	0.5	0.4	0.5	0.7	N/A	20

Table 13 summarizes benzene measurements at the Scotford Temporary Monitoring Station from January 1, 2018 to September 30, 2019. As mentioned above, it is the nearest station recently measuring benzene concentrations in Alberta (AEP, 2020c).

Table 13: Summary of Continuous Benzene Measurements at the Scotford Temporary Station

Parameter	Averaging Period	Summary Statistics	Year		AAQO[1]
			2018	October 1, 2018 to September 30, 2019	
Benzene (µg/m^3)	**1-hour**	Maximum	9.58	22.4	30
		99th Percentile	3.19	0	30
		90th Percentile	0	0	30
	Annual	Average	0.06	0.05	0.3

Note: 1, Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

The reported detection limit of the benzene analyzer was 1 ppb (parts per billion by volume) which can be converted to a mass concentration of 3.19 µg/m^3. For this reason, there are many measurements below 1 ppb and reported by the station as zero. The 90th percentile values were zero in 2018 and in the last measured 12-month period: October 1, 2018 to September 30, 2019. However, the remaining non-zero measurements produced a non-zero, although small, annual average.

3.3 On-Site Measurements

In October 2016, hi-volume monitoring for Total Suspended Particulate (TSP) was conducted for the Project over a period of four days (**Table 14**). The first two measurements were collected within the Project Area; whereas, the last two were collected at the Lehigh Spy Hill aggregate operation.

Table 14: Summary of 24-hour TSP on Lehigh Property, October 2016

End Date	Location	Exposure (hours)	TSP Concentration (µg/m^3)
2016-10-04 13:48	Scott Property	25.2	10
2016-10-05 15:11	Scott Property	25.0	7
2016-10-06 15:47	Spy Hill Property	23.4	36
2016-10-06 23:37	Spy Hill Property	7.6	48

The data indicate that TSP concentrations were about four times higher on the Spy Hill Property than on the Project. The last measurement at Spy Hill may be biased to daytime operating hours at that pit, and not reflective of a 24-hour average. On-site meteorological conditions on sampling days are not available; nor are precise sampling locations.

3.4 "Natural Background" Concentrations

As recommended by AEP (2013a), for a refined modelling analysis, the modelled concentration for each compound was added to its corresponding background concentration to estimate a "total modelled concentration" that could then be compared to the AAQO. AEP (2013a) also specifies statistical forms of the baseline or background ambient air quality that should be used for certain averaging periods.

Background concentrations for the parameters of concern in the air quality assessment are shown in **Table 15**. The background concentrations of $PM_{2.5}$, CO and NO_2 obtained from the Calgary Varsity Monitoring Station used for this analysis were assessed on a basis of the 90th percentile for 2019, per AEP (2013a). As the effects of forest fires were less in 2019 than 2018, measurements from 2019 were used as background for modelling purposes.

Table 15: Natural Background Concentrations

Compound	Averaging Period	AAQO[1] (µg/m^3)	90th Percentile Background (µg/m^3)
Total Suspended Particulates (TSP)[2]	24-hour	100	41
	Annual	60	36
Coarse Particulate (PM_{10})[2]	24-hour	50	20
Fine Particulate ($PM_{2.5}$)[3]	1-hour	80	14
	24-hour	29	12
	Annual	8.8	7
Sulphur Dioxide (SO_2)[4]	1-hour	450	2.6
	24-hour	125	2.6
	30-days	30	1.5
	Annual	20	0.7
Nitrogen Oxides (NO_X)[3]	1-hour	300	54
	Annual	45	16
Ozone (O_3)	1-hour (ppb)	-	48
	1-hour (µg/m^3)	-	90
Carbon Monoxide (CO)[3]	1-hour	15,000	458
	8-hour	6,000	458
Benzene[5]	1-hour	30	0
	Annual	0.3	0.05
Benzo-a-pyrene (ng/m^3)[6]	Annual	0.3	0.052

Notes: 1. AEP (2019)

*2. TSP background air quality concentration data calculated as 2*PM_{10} background, which is PM_{10} = 1.7* $PM_{2.5}$, obtained from the Calgary Varsity Monitoring Station.*

3. Background air quality concentration data obtained from the Calgary Varsity Monitoring Station.

4. Background air quality concentration data obtained from the Calgary Southeast Monitoring Station.

5. From Scotford Temporary Station (October 1, 2018 to September 30, 2019); MEMS (2013) (based on Calgary Central, 2004-2008) were obtained from 24-hour measurements every 6 days, scaled down to 1-hour average by power law (very inaccurate approach and old data from station in downtown of Calgary)

6. MEMS (2013) (based on Calgary Northwest Station, 1996-2000)

TSP and PM_{10} are not measured at the CRAZ Calgary Varsity or Calgary East monitoring stations (**Figure 10** and **Table 7**). Since PM_{10} and $PM_{2.5}$ were measured at the former CRAZ Calgary Centre and Centre 2 stations from 2005 to 2010, the ratio between 90th percentile and median values at the Calgary Centre stations was used to estimate PM_{10} background concentrations at the Calgary Varsity station. The $PM_{10}/PM_{2.5}$, measured at Calgary Centre stations, ratio was approximately 1.7 for 90th percentile daily values – this ratio was used to estimate PM_{10} background based on 2019 $PM_{2.5}$ measurements at the Calgary Varsity station (PM_{10} = 1.7*$PM_{2.5}$).

TSP is not measured in Alberta airsheds; therefore, TSP concentrations were estimated by multiplying PM_{10} values by two based on median TSP and PM_{10} values measured in Canadian cities including Calgary (Brook et al. 1997).

3.5 Baseline Concentrations

There are several operating aggregate pits within the modelling domain. These pits are located approximately 10 km west of the CRAZ Calgary Varsity Monitoring Station, and their contribution to measurements at this station was negligible compared to nearby urban sources. For this reason, in addition to “natural background” measured at the air quality station, an “industrial background” was introduced.

MEMS (2013) estimated the maximum concentrations from each regional pit at the location of the Scott Property by dispersion modelling. The following pits were included: Government of Alberta STAR Pit, Lafarge Pit, Lehigh’s Spy Hill Pit, Volker Stevin Pit, and the Burnco Pit. These operational aggregate pits range from 0.5 km east of the Project to as far as 5 km.

The contribution from these regional pits at the Scott Property is listed in Table 16 (from Table 4.5 in MEMS 2013). Except for 1-hour average NOx, the maximum contribution of the regional pits to air quality is less than the natural background. The cause of the NOx exception is that the MEMS (2013) approach assumed all existing operations emit NOx at the same time during blasting. The overall approach was conservative, since the plumes from regional pits do not always overlap at the Project location because the wind conditions for this to occur are rare. Refer to MEMS (2013) for more detail about the industrial background approach.

Table 16 summarizes the natural and industrial background concentrations, and the resultant Baseline scenario concentrations.

Table 16: Natural and Industrial Background and Baseline Concentrations

Parameter	Averaging Period	AAQO[1] (µg/m^3)	Natural Background (µg/m^3)	Existing Industrial Background (µg/m^3)	Baseline Concentrations (µg/m^3)
Total Suspended Particulates (TSP)	24-hour	100	41	8.2	49.2
	Annual	60	36	0.6	36.6
Coarse Particulate (PM_{10})	24-hour	50	20	5.7	25.7
Fine Particulate ($PM_{2.5}$)	1-hour	80	14	1.4	15.4
	24-hour	29	12	1.2	13.2
	Annual	8.8	7	0.9	7.9
Sulphur Dioxide (SO_2)	1-hour	450	2.6	0.29	2.9
	24-hour	125	2.6	0.06	2.7
	30-days	30	1.5	0.01	1.5
	Annual	20	0.7	0	0.7
Nitrogen Oxides (NO_X)	1-hour	300	54	69	123
	Annual	45	16	1.2	17.2
Ozone (O_3)	1-hour (ppb)	-	48	0	48
	1-hour (µg/m^3)	-	90	0	90
Carbon Monoxide (CO)	1-hour	15,000	458	24	482
	8-hour	6,000	458	14	472
Benzene	1-hour	30	0	0	0
	Annual	0.3	0.05	0	0.05
Benzo-a-pyrene (ng/m^3)	Annual	0.3	0.052	0	0.052

4. Emissions

4.1 Emissions during Normal Operations

4.1.1 Emission Cases

The emissions of four cases were estimated and modelled for the Project. These cases represent alternative approaches for extracting aggregate and their associated impact on air quality. The cases were:

1. Winter Case: winter emissions for stripping soil and overburden in order to start a new mining block and dumping stripped material at the reclamation area (and soil on temporary stockpiles).
2. Summer Mechanical Breaker Case: during active pit operation, 35% of the aggregate (conglomerate) is expected to be mined from the mining block using mechanical breakers and crushed by the in-pit mobile crusher, with the remainder of the gravel mined by excavator and loaders. All aggregate (crushed conglomerate and gravel) will be loaded onto the in-pit conveyor for transfer via the off-site conveyor to the Spy Hill operation for further processing, washing and sales.
3. Summer Blasting Case: during active pit operation, 35% of aggregate would be mined from the mining block using drilling and blasting and subsequently crushed in-pit by the mobile crusher, with the remainder gravel mined by excavator and loaders. All aggregate is loaded onto the in-pit conveyor for transfer via the off-site conveyor to the Spy Hill operation for further processing, washing and sales.
4. Summer Truck Case: in the active pit, 35% of aggregate (conglomerate) would be mined from the mining block using mechanical breakers, with the remainder (gravel) mined by excavator and loaders. All aggregate is then loaded onto trucks and transported to the permanent crusher located near the centre of the Project Footprint. There, gravel is loaded directly onto the in-pit conveyor while the conglomerate material is loaded into the crusher, crushed and then loaded onto the off-site conveyor for transfer to the Spy Hill operation for further processing, washing and sales.

The highest particulate daily maximum emissions are from wind-generated emissions at very high wind speeds. However, these emissions are infrequent. For continuous operations, truck emissions are the highest, followed by bulldozers, the crusher, mechanical breakers. The lowest emissions are from excavating and loading operations.

Lehigh is proposing to extract aggregate using the Summer Mechanical Breaker Case mode of operations (for simplicity called the Summer Case although this operation is scheduled from April to November). Together with the Winter Case, this case has the lowest annual emissions and is the focus of the remainder of this report. The details of emission calculations, sources, parameters, and emissions for all cases are presented in **Appendix A**. A summary of model predictions for all emission cases is presented in **Appendix B**.

4.1.2 Winter Case Emissions

The following sources of emissions were identified for Winter Case:

- Winter Case: stripping soil and overburden at the new mining block and dumping material directly at the reclamation area or temporary stockpile
  - scrapers pick up overburden (and/or soil),

- scrapers transport overburden from new pit to the nearest mining block,
- scrapers dump overburden into the mining block reclamation area, or
- scrapers dump soil on temporary stockpile; and
- bulldozer works at the reclamation area location, distributes material evenly, and covers overburden with soil.

Table 17 summarizes daily maximum emissions modelled for 11 hours per day from January 1 to March 31 every year (Winter Case).

Table 17: Summary of Maximum Modelled Daily Emissions - Winter Case

Emissions	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Stripping Overburden at New Mining Block								
Loading	0	0	0	14.8	8.29	1.33	0	0
Wind Generated	0	0	0	97.4	54.7	8.81	0	0
Stripping Emissions with EEF Applied	**0**	**0**	**0**	**112.2**	**63.0**	**10.14**	**0**	**0**
Scraper Travel								
Diesel Combustion	0.06	19.8	9.88	1.79	1.79	1.73	0.048	1.82E-05
Wheel Entrainment	0	0	0	10.0	2.55	0.31	0	0
Scraper Emissions with EEF Applied	**0.063**	**19.8**	**9.88**	**11.8**	**4.34**	**2.04**	**0.048**	**1.82E-05**
Reclamation Area								
Diesel Combustion (Bulldozer)	0.026	15.3	5.87	0.70	0.70	0.68	0.009	3.35E-06
Bulldozing	0	0	0	3.47	1.12	0.84	0	0
Dumping of Overburden	0	0	0	10.5	7.10	1.33	0	0
Wind Generated	0	0	0	69.2	46.9	8.75	0	0
Reclamation Emissions with EEF Applied	**0.026**	**15.3**	**5.87**	**83.9**	**55.8**	**11.6**	**0.009**	**3.35E-06**
TOTAL								
TOTAL Winter Case	**0.089**	**35.1**	**15.8**	**208**	**123**	**23.8**	**0.057**	**2.16E-05**

*Note: EEF = pit emission escape fraction (as explained in Appendix A **Section A2.5**)*

4.1.3 Summer Case Emissions

The following sources of emissions were identified for the Summer Case:

- Excavator mechanical breaker attachment to break up conglomerate (35% of total aggregate)
- Excavator and wheel loaders strip aggregate. Gravel is loaded into an in-pit conveyor hopper and conglomerate is loaded into the mobile crusher (all emissions are unmitigated),
- All aggregate from the mobile crusher and the gravel are transferred onto the in-pit conveyor and transferred on off-site conveyor,
- Off-site conveyor transfers material from the Project to the Spy Hill operation for further processing.

Table 18 summarizes daily maximum emissions (for 11 hours per day) for the Summer Mechanical Breaker Case (April 1 to November 30 of every year).

Table 18: Summary of Maximum Daily Emissions – Summer Case

Emissions	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Mining Block (Mechanical Breaker, Bulldozer, Loading onto Mobile Crusher and Conveyor)								
Diesel Combustion	0.130	56.0	31.7	3.38	3.38	3.28	0.036	1.49E-05
Loading	0	0	0	40.0	25.3	4.41	0	0
Wind Generated	0	0	0	57.8	36.6	6.37	0	0

Table 18: Summary of Maximum Daily Emissions – Summer Case

Emissions	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Mechanical Breaker, Bulldozer & Mobile Crusher	0	0	0	24.3	11.4	3.84	0	0
Pit Emissions with EEF Applied	**0.13**	**56.0**	**31.7**	**125.5**	**76.7**	**17.9**	**0.036**	**1.49E-05**
Conveyor (No Exhaust)								
Transfer Points	0	0	0	5.67	2.23	0.67	0	0
Unload at Spy Hill Property	0	0	0	10.5	5.86	0.40	0	0
Wind Generated	0	0	0	64.9	34.7	5.63	0	0
Conveyor Emissions with EEF Applied	**0**	**0**	**0**	**81.1**	**42.8**	**6.7**	**0**	**0**
TOTAL								
TOTAL Summer Case	**0.13**	**56.0**	**31.7**	**207**	**119**	**24.6**	**0.036**	**1.49E-05**

Note: EEF = pit emission escape fraction

4.1.4 Annual Emissions

Table 19 summarizes annual emissions for the combined Winter and Summer Cases.

Wind generated particulate emissions from wind-exposed areas (and loading / unloading wind dependent emissions) are less significant for total annual emissions than for daily maximum emissions. There are few days in a year when wind speeds are high enough to cause high emissions.

Table 19: Summary of Total Modelled Annual Emissions - Summer and Winter Cases

Emissions	SO_2 (t/year)	NO_x (t/year)	CO (t/year)	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	Benzene (t/year)	BaP (t/year)
Summer Case								
Mining Block Total Emissions	0.032	13.7	7.75	6.75	3.61	1.74	8.67E-03	3.63E-06
Loading / Unloading	0	0	0	2.61	1.65	0.29	0	0
Wind Generated from Mining Block Surface	0	0	0	1.13	0.71	0.12	0	0
Conveyor Transfer Points and Unload	0	0	0	3.95	1.97	0.26	0	0
Conveyor Wind Generated	0	0	0	1.38	0.74	0.12	0	0
TOTAL for Summer Case	**0.032**	**13.7**	**7.75**	**15.8**	**8.68**	**2.53**	**8.67E-03**	**3.63E-06**
Winter Case								
Travelling Scrapers Total Emissions	0.0057	1.783	0.889	1.061	0.390	0.184	4.34E-03	1.64E-06
Bulldozer at Reclamation Area	0.0023	1.381	0.529	0.375	0.164	0.137	7.99E-04	3.02E-07
Loading / Unloading	0	0	0	0.624	0.380	0.066	0	0
Wind Generated from Pit and Reclamation Area	0	0	0	1.805	1.099	0.190	0	0
TOTAL for Winter Case	**0.0080**	**3.16**	**1.42**	**3.87**	**2.03**	**0.58**	**0.0051**	**1.94E-06**
TOTAL								
TOTAL for Summer and Winter Case	**0.040**	**16.8**	**9.16**	**19.7**	**10.7**	**3.11**	**0.014**	**5.57E-06**

4.2 Potential Emissions during Abnormal Operations

This section documents the effects on air quality resulting from upset or start-up emissions. Given the nature of aggregate operations, these conditions have been difficult to define. Start-up is planned to be staged over several years during which production rates will be less than the rates assumed in modelling and result in lower emissions, not higher.

Nevertheless, there may be weather conditions that create abnormal emissions. For example, temperatures below -25°C may cause the surface of the pit where scrapers travel to pulverize easily, resulting in higher emissions. This condition could also create additional emissions during placement of the stripped material into the

reclamation area. Winter Case emissions are significantly lower than emissions from Summer Case operations; and as such, based on other conservative assumptions in modelling, it is not expected that this situation would result in higher air quality emissions than predicted.

The second possible condition is Chinook weather. Dry westerly wind may dry surfaces, resulting in higher than calculated emissions from scrapers for the Winter Case. Additional mitigation such as watering is likely not conducted safely during this situation due to the possibility of freezing on travelled surfaces. However, these emissions are spread over a 250 m haul road which is 300 m to 500 m away from the nearest sensitive receptors (residences in Crestview Estates) and therefore are not expected to significantly change predictions for the Project. Again, Winter Case emissions are significantly lower than Summer Case emissions and the abnormal situation is not expected to result in higher predicted particulate concentrations than the Summer Case.

Air dispersion model predictions are expected to be conservative. The emission calculations and modelling assumed AP42 (or NPI) conservative emission factors. There were also conservative assumptions for days of operation. Both the Winter and Summer Case were modelled assuming seven days/week operations; whereas, the actual operations will be for six days/week (i.e., not operational on Sundays) and with reduced operations on Saturdays. Therefore, annual emissions are conservative, and the highest modelling predictions could occur on weekends when the Project is not operational.

4.3 Mitigation

All model predictions include the effects of the following mitigations designed into the Project:

- Use of an in-pit conveyor rather than haul trucks to reduce fugitive dust emissions and minimize water use for dust control;
- Use of blasting is not a preferred option to break conglomerate, although the results of modelling showed that blasting did not significantly affect particulate predictions;
- Placement of the crusher within the interior of the Project Footprint to minimize off-site dusting;
- If required, mist the crushed material on hot, dry days, to minimize crusher emissions. Misting was not included as mitigation in the air quality assessment but is an option during operations.
- Implement a 100 m setback distance for all extraction activities from the western property boundary and a 150 m setback from the southern boundary;
- Limit disturbance to vegetation within the setback to that required for constructing the berm and strip only as much soil as annually needed per Project phase. Vegetation helps reduce dust concentrations in the air.
- Conduct soil stripping operations, in preparation for aggregate extraction, in January to March when the ground is partially frozen to reduce emissions;
- Conduct tertiary crushing at Lehigh’s operational Spy Hill facility, eliminating a source of dust from the Project;
- Cover the off-site conveyor;
- Revegetate reclaimed areas as soon as possible to reduce windblown dust.

Rainfall, which would reduce or eliminate dust emissions, was not considered as mitigation in the assessment, to provide a conservative assessment.

5. Results

Air dispersion modelling results associated with all scenarios for Project operations are presented below. The maximum predicted concentrations along with background industrial and ambient concentrations were compared to corresponding standards to assess their potential impact on the area surrounding the Phase 2 mining block.

For Alberta regulated AAQOs, 1-hour average maximums presented as 99.9th percentiles were obtained for every year and the maximum from five years is presented in this section (**Table 23**, **Table 27**, **Table 30**, **Table 32** and **Table 34**). For Federal CAAQS, rolling averages of the 98th percentile of daily maxima and annual maxima from three consecutive years were obtained and maxima from these averages are presented in **Table 25** and **Table 26**. The results presented are for following scenarios:

- Baseline Scenario: natural and existing industrial background
- Project Only Scenario: Winter Case emissions
- Project Only Scenario: Summer Case emissions
- Application Scenario: Winter Case emissions plus natural and existing industrial background concentrations (1-hour, 8-hour, 24-hour and 30-days averages)
- “Unmitigated” and “Mitigated” Application Scenario: Summer Case emissions plus natural and existing industrial background concentrations (1-hour, 8-hour, 24-hour and 30-days averages)
- “Unmitigated” and “Mitigated” Application Scenario for annual average Winter and Summer Case emissions plus natural and existing industrial background

The study area is currently covered by shrubs, trees and grass. To account for the mitigating influences of vegetation, the predictions of $PM_{2.5}$, PM_{10} and TSP from Project sources were reduced by 25% (Pace 2005). Both unadjusted and adjusted predictions are listed but vegetation adjustments were not made for the Winter Case. Winter and Summer cases as well as a combined annual case are shown separately. The secondary production of NO_3 and SO_4 calculated by chemical reaction in the dispersion model was included in the predictions of TSP, PM_{10}, and $PM_{2.5}$.

The predicted concentration patterns for Application Scenarios are shown in **Appendix C**. Since predicted concentrations of SO_2, benzene and BaP predictions are small (near background concentration levels), they are not included in **Appendix C** but are presented in **Table 30**, **Table 31**, and **Table 34**.

5.1 Total Suspended Particulate

TSP 24-hour average predictions are summarized in **Table 20** at the maximum point of impingement (MPOI) and the 14 special receptors, for un-mitigated (no vegetation adjustment) results for Project Only and Application Cases (Winter and Summer) and for mitigated concentrations due to vegetation cover for the Application Summer Case. No vegetation adjustment is included for Winter Case emissions because it was assumed that grasses are snow covered and trees and shrubs have lost their leaves. TSP annual average predictions are summarized in **Table 21**.

TSP predictions can be summarized as follows:

- The Application scenario - Winter Case 24-hour average TSP predictions are all below AAQOs. Annual average Application TSP predictions are well below the AAQO.

- There is an Application scenario - Summer Case exceedance of the 24-hour average AAQO at the MPOI (103 µg/m^3). The exceedance occurred on one day in 5 years (0.05% of the time). AEP (2013a) requires that modelling be conducted without accounting for the effects of rain to mitigate predictions. According to the CALMET meteorology database, 2.3 mm of rain fell, with 1.7 mm from 7:00 to 17:00 during pit operations which was not included in the modelling. Had mitigation due to rain been applied on this day, particulate emissions from the pit would have been reduced significantly.
- 24-hour average predictions at most special receptors are near Baseline values. The highest TSP predictions for the Application scenario - Summer Case at Crestview Estates occurred on the same day as the MPOI predictions.
- Most 24-hour Project-Only scenario predictions are much less than Baseline except at the MPOI and near the mining block, which for modelling purposes was Phase 2 near Crestview Estates. Maxima were predicted at the Property boundary. Annual average Project-Only scenario predictions were also negligible except at the MPOI.

Table 20: Summary of TSP 24-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m^3)	Baseline (µg/m^3)	Un-Mitigated Project Only (µg/m^3)	Un-Mitigated Application (µg/m^3)	Mitigated Application (µg/m^3)
24-Hour Average - Winter Case					
Maximum Point of Impingement	100	49.2	20.7	70	-
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	100	49.2	0.4	49.6	-
2. Inland Pit (69 Street NW)			0.3	49.5	-
3. Medical Facility			1.0	50.2	-
4. Walmart (85 Street NW)			0.2	49.4	-
5. Farm (144 Ave NW & RR23)			1.7	50.9	-
6. Spy Hill Gravel Pit			0.3	49.5	-
7. 85 Street NW Facility			1.0	50.2	-
8. Bearspaw Christian School (144 Avenue NW)			0.7	49.9	-
9. U of C Facility			1.1	50.3	-
10. Calgary Correctional Facility			0.6	49.8	-
11. Calgary Remand Centre			0.7	49.9	-
12. Youth Detention Centre			1.0	50.2	-
13. No. 1 Crestview Estates			12.0	61.2	-
14. No. 2 Crestview Estates			14.6	63.8	-
24-Hour Average - Summer Case					
Maximum Point of Impingement	100	49.2	72	121	103[2]
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	100	49.2	1.6	50.8	50.4
2. Inland Pit (69 Street NW)			3.5	52.7	51.9
3. Medical Facility			1.0	50.2	50.0
4. Walmart (85 Street NW)			0.4	49.6	49.5
5. Farm (144 Ave NW & RR23)			2.4	51.6	51.0
6. Spy Hill Gravel Pit			5.1	54.3	53.0
7. 85 Street NW Facility			3.9	53.1	52.1
8. Bearspaw Christian School (144 Avenue NW)			0.6	49.8	49.7
9. U of C Facility			1.4	50.6	50.2
10. Calgary Correctional Facility			2.6	51.8	51.1
11. Calgary Remand Centre			1.9	51.1	50.6
12. Youth Detention Centre			3.9	53.1	52.1
13. No.1 Crestview Estates			61.4	110.6	95.3
14. No. 2 Crestview Estates			34.7	83.9	75.2

Notes: 1. AEP (2019)
2. Maximum predicted on a day anticipated to have rained

Table 21: Summary of TSP Annual Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
Annual Average (Winter and Summer)					
Maximum Point of Impingement	60	36.6	3.2	40	39
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	60	36.6	0.04	36.6	36.6
2. Inland Pit (69 Street NW)			0.1	36.7	36.6
3. Medical Facility			0.04	36.6	36.6
4. Walmart (85 Street NW)			0.003	36.6	36.6
5. Farm (144 Ave NW & RR23)			0.2	36.8	36.7
6. Spy Hill Gravel Pit			0.1	36.7	36.7
7. 85 Street NW Facility			0.1	36.7	36.7
8. Bearspaw Christian School (144 Avenue NW)			0.1	36.7	36.6
9. U of C Facility			0.05	36.6	36.6
10. Calgary Correctional Facility			0.05	36.6	36.6
11. Calgary Remand Centre			0.1	36.7	36.6
12. Youth Detention Centre			0.1	36.7	36.7
13. No.1 Crestview Estates			1.1	37.7	37.4
14. No. 2 Crestview Estates			0.9	37.5	37.3

Source: 1. AEP (2019)

In **Appendix C**, **Figures C1** and **C2** show the pattern for concentrations with vegetation adjustment to 24-hour average TSP for Application scenarios – Summer and Winter Cases. **Figure C3** shows the spatial pattern for the Application Scenario with annual emissions. **Figure C2** shows that the highest concentrations are associated with mining block operations with some influence from the in-field conveyor.

Figure C4 shows the Project-only scenario pattern for the Summer Case which represents the highest TSP emissions associated with the Project operation. It demonstrates all predictions are well below the AAQO.

5.2 PM_{10}

PM_{10} 24-hour average predictions at the MPOI and the 14 special receptors are summarized in **Table 22**. No vegetation adjustment is included for Winter Case emissions because it was assumed that grasses are snow covered and trees and shrubs have lost their leaves. In **Appendix C**, **Figure C5** and **C6** show the spatial pattern of mitigated concentrations for Summer and Winter Application Cases.

Table 22: Summary of PM_{10} 24-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
24-Hour Average - Winter Case					
Maximum Point of Impingement	50	25.7	10.2	36	-
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	50	25.7	0.3	26.0	-
2. Inland Pit (69 Street NW)			0.2	25.9	-
3. Medical Facility			0.6	26.3	-
4. Walmart (85 Street NW)			0.1	25.8	-
5. Farm (144 Ave NW & RR23)			1.2	26.9	-
6. Spy Hill Gravel Pit			0.3	26.0	-
7. 85 Street NW Facility			0.7	26.4	-
8. Bearspaw Christian School (144 Avenue NW)			0.5	26.2	-
9. U of C Facility			0.7	26.4	-

Table 22: Summary of PM_{10} 24-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
10. Calgary Correctional Facility			0.4	26.1	-
11. Calgary Remand Centre			0.5	26.2	-
12. Youth Detention Centre			0.7	26.4	-
13. No. 1 Crestview Estates			6.0	31.7	-
14. No. 2 Crestview Estates			7.2	32.9	-
24-Hour Average - Summer Case					
Maximum Point of Impingement	50	25.7	44	69	58[2]
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	50	25.7	1.4	27.1	26.8
2. Inland Pit (69 Street NW)			2.9	28.6	27.9
3. Medical Facility			1.0	26.7	26.4
4. Walmart (85 Street NW)			0.3	26.0	25.9
5. Farm (144 Ave NW & RR23)			2.1	27.8	27.2
6. Spy Hill Gravel Pit			3.9	29.6	28.6
7. 85 Street NW Facility			2.8	28.5	27.8
8. Bearspaw Christian School (144 Avenue NW)			0.5	26.2	26.0
9. U of C Facility			1.3	27.0	26.7
10. Calgary Correctional Facility			1.8	27.5	27.1
11. Calgary Remand Centre			1.4	27.1	26.8
12. Youth Detention Centre			2.8	28.5	27.8
13. No. 1 Crestview Estates			37.7	63.4	53.9
14. No. 2 Crestview Estates			22.1	47.8	42.3

Note: 1. Ambient Air Quality Objective: World Health Organization (WHO) and British Columbia Ministry of Environment (BC ENV, 2018)
2. Maximum predicted on a day anticipated to have rained

The CALPUFF model 24-hour average PM_{10} predictions can be summarized as follows:

- All PM_{10} Application scenario – Winter Case predictions are below the AAQO.
- In the Application scenario – Summer Case there is an exceedance of the 24-hour average AAQO PM_{10} at the MPOI (58 µg/m³). The exceedance occurred on one day in 5 years (the same day as the TSP exceedance).
- 24-hour average PM_{10} predictions at most special receptors are near Baseline values. The highest PM_{10} predictions for the Application scenario – Summer Case at Crestview Estates occurred on the same day as the MPOI predictions.
- Most 24-hour PM_{10} Project-Only scenario predictions are much less than Baseline except at the MPOI and near the active pit, which for modelling purposes was near Crestview Estates.

As discussed for TSP, had rainfall been considered on the Application scenario – Summer Case day with the exceedance, particulate PM_{10} emissions from the pit would have been reduced significantly.

CALPUFF model predictions at all locations are considered conservative because they include natural background concentrations from the City of Calgary and a worst-case industrial background.

5.3 $PM_{2.5}$

$PM_{2.5}$ 1-hour average predictions at the MPOI and the 14 special receptors are summarized in **Table 23** and are compared to the AAQG. **Table 24** summarizes 24-hour average predictions compared to the AAQO. **Table 25** summarizes 24-hour average $PM_{2.5}$ predictions compared to CAAQS. No vegetation adjustment is included for Winter Case emissions because it was assumed that grasses are snow covered and trees and shrubs have lost

their leaves. **Table 26** summarizes annual predictions compared to 2020 CAAQS. In **Appendix C**, **Figures C7** and **C8** show the spatial pattern for mitigated concentrations for 24-hour averages Winter and Summer Cases.

The $PM_{2.5}$ results can be summarized as follows:

- The Application scenario – Winter Case $PM_{2.5}$ predictions are below the Alberta AAQO.
- In the Application scenario – Summer Case (**Table 24**) there is a predicted $PM_{2.5}$ exceedance of the 24-hour average Alberta AAQO at the MPOI (33 µg/m^3) without mitigation. The exceedance occurred on one day in 5 years (the same day as the predicted TSP and PM_{10} exceedances).
- The Application scenario – Summer Case 24-hour $PM_{2.5}$ prediction, with adjustment for vegetation effects on wind, was less than the AAQO.
- The Application scenario 24-hour and annual average predictions for $PM_{2.5}$ (**Table 25** and **Table 26**) were less than the CAAQS at all locations for all Cases.

Predictions at all locations are considered conservative because they include natural background concentrations within the City of Calgary and a worst-case industrial background.

Table 23: Summary of $PM_{2.5}$ 1-hour Average Predicted Concentrations

Receptor	AAAQG[1] (µg/m^3)	Baseline (µg/m^3)	Un-Mitigated Project Only (µg/m^3)	Un-Mitigated Application (µg/m^3)	Mitigated Application (µg/m^3)
1-Hour Average - Winter Case					
Maximum Point of Impingement	80	15.4	28	44	-
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	80	15.4	0.8	16.2	-
2. Inland Pit (69 Street NW)			0.7	16.1	-
3. Medical Facility			1.5	16.9	-
4. Walmart (85 Street NW)			0.4	15.8	-
5. Farm (144 Ave NW & RR23)			4.4	19.8	-
6. Spy Hill Gravel Pit			0.7	16.1	-
7. 85 Street NW Facility			1.9	17.3	-
8. Bearspaw Christian School (144 Avenue NW)			1.0	16.4	-
9. U of C Facility			2.1	17.5	-
10. Calgary Correctional Facility			1.4	16.8	-
11. Calgary Remand Centre			1.6	17.0	-
12. Youth Detention Centre			1.9	17.3	-
13. No. 1 Crestview Estates			23	39	-
14. No. 2 Crestview Estates			23	39	-
1-Hour Average - Summer Case					
Maximum Point of Impingement	80	15.4	96	111	87[2]
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	80	15.4	1.1	16.5	16.2
2. Inland Pit (69 Street NW)			1.3	16.7	16.4
3. Medical Facility			1.3	16.7	16.4
4. Walmart (85 Street NW)			0.4	15.8	15.7
5. Farm (144 Ave NW & RR23)			4.7	20.1	18.9
6. Spy Hill Gravel Pit			1.6	17.0	16.6
7. 85 Street NW Facility			2.9	18.3	17.6
8. Bearspaw Christian School (144 Avenue NW)			0.9	16.3	16.1
9. U of C Facility			1.6	17.0	16.6
10. Calgary Correctional Facility			1.3	16.7	16.4
11. Calgary Remand Centre			1.7	17.1	16.7
12. Youth Detention Centre			2.9	18.3	17.6
13. No. 1 Crestview Estates			69	85	67
14. No. 2 Crestview Estates			67	82	65

Note: 1. Alberta Ambient Air Quality Guideline (AAAQG) – not an objective (cannot be used for regulatory approvals (AEP, 2019).
2. Maximum predicted on a day anticipated to have rained

Table 24: Summary of $PM_{2.5}$ 24-hour Average Predicted Concentrations Compared to AAQOs[1]

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
24-Hour Average - Winter Case					
Maximum Point of Impingement	29	13.2	4.8	18.0	-
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	29	13.2	0.2	13.4	-
2. Inland Pit (69 Street NW)			0.2	13.4	-
3. Medical Facility			0.3	13.5	-
4. Walmart (85 Street NW)			0.1	13.3	-
5. Farm (144 Ave NW & RR23)			0.7	13.9	-
6. Spy Hill Gravel Pit			0.2	13.4	-
7. 85 Street NW Facility			0.4	13.6	-
8. Bearspaw Christian School (144 Avenue NW)			0.2	13.4	-
9. U of C Facility			0.4	13.6	-
10. Calgary Correctional Facility			0.2	13.4	-
11. Calgary Remand Centre			0.3	13.5	-
12. Youth Detention Centre			0.4	13.6	-
13. No. 1 Crestview Estates			2.8	16.0	-
14. No. 2 Crestview Estates			3.5	16.7	-
24-Hour Average - Summer Case					
Maximum Point of Impingement	29	13.2	19	33	28[2]
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	29	13.2	0.6	13.8	13.6
2. Inland Pit (69 Street NW)			0.7	13.9	13.8
3. Medical Facility			0.6	13.8	13.6
4. Walmart (85 Street NW)			0.2	13.4	13.3
5. Farm (144 Ave NW & RR23)			1.2	14.4	14.1
6. Spy Hill Gravel Pit			0.8	14.0	13.8
7. 85 Street NW Facility			1.4	14.6	14.2
8. Bearspaw Christian School (144 Avenue NW)			0.2	13.4	13.3
9. U of C Facility			0.7	13.9	13.8
10. Calgary Correctional Facility			0.6	13.8	13.7
11. Calgary Remand Centre			0.8	14.0	13.8
12. Youth Detention Centre			1.4	14.6	14.3
13. No. 1 Crestview Estates			16.8	30.0	25.8
14. No. 2 Crestview Estates			10.3	23.5	21.0

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).
2. Maximum predicted on a day anticipated to have rained

Table 25: Summary of $PM_{2.5}$ 24-hour Average Predicted Concentrations Compared to 2020 CAAQS[1]

Receptor	CAAQS[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
24-Hour Average - Winter Case					
Maximum Point of Impingement	27	13.2	2.9	16.1	-
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	27	13.2	0.09	13.3	-
2. Inland Pit (69 Street NW)			0.08	13.3	-
3. Medical Facility			0.14	13.3	-
4. Walmart (85 Street NW)			0.03	13.2	-
5. Farm (144 Ave NW & RR23)			0.35	13.6	-
6. Spy Hill Gravel Pit			0.07	13.3	-

Table 25: Summary of $PM_{2.5}$ 24-hour Average Predicted Concentrations Compared to 2020 CAAQS[1]

Receptor	CAAQS[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
7. 85 Street NW Facility			0.22	13.4	-
8. Bearspaw Christian School (144 Avenue NW)			0.12	13.3	-
9. U of C Facility			0.18	13.4	-
10. Calgary Correctional Facility			0.13	13.3	-
11. Calgary Remand Centre			0.15	13.4	-
12. Youth Detention Centre			0.22	13.4	-
13. No. 1 Crestview Estates			1.99	15.2	-
14. No. 2 Crestview Estates			2.08	15.3	-
24-Hour Average - Summer Case					
Maximum Point of Impingement	27	13.2	5.3	18.5	17.2
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	27	13.2	0.05	13.25	13.24
2. Inland Pit (69 Street NW)			0.06	13.26	13.25
3. Medical Facility			0.07	13.27	13.25
4. Walmart (85 Street NW)			0.01	13.21	13.21
5. Farm (144 Ave NW & RR23)			0.32	13.52	13.44
6. Spy Hill Gravel Pit			0.07	13.27	13.26
7. 85 Street NW Facility			0.13	13.33	13.30
8. Bearspaw Christian School (144 Avenue NW)			0.09	13.29	13.27
9. U of C Facility			0.07	13.27	13.26
10. Calgary Correctional Facility			0.08	13.28	13.26
11. Calgary Remand Centre			0.09	13.29	13.27
12. Youth Detention Centre			0.13	13.33	13.30
13. No. 1 Crestview Estates			3.09	16.3	15.5
14. No. 2 Crestview Estates			3.52	16.7	15.8

Note: 1. Canadian Ambient Air Quality Standard (CAAQS).

Table 26: Summary of $PM_{2.5}$ Annual Average Predicted Concentrations Compared to 2020 CAAQS[1]

Receptor	CAAQS[1] (µg/m³)	Baseline (µg/m³)	Un-Mitigated Project Only (µg/m³)	Un-Mitigated Application (µg/m³)	Mitigated Application (µg/m³)
Annual Results of Winter and Summer Cases					
Maximum Point of Impingement	8.8	7.9	0.43	8.33	8.22
Special Receptors:					
1. Spy Hill Bottle Depot (76 Street NW)	8.8	7.9	0.01	7.91	7.91
2. Inland Pit (69 Street NW)			0.01	7.91	7.91
3. Medical Facility			0.01	7.91	7.91
4. Walmart (85 Street NW)			0.00	7.90	7.90
5. Farm (144 Ave NW & RR23)			0.05	7.95	7.94
6. Spy Hill Gravel Pit			0.01	7.91	7.91
7. 85 Street NW Facility			0.02	7.92	7.91
8. Bearspaw Christian School (144 Avenue NW)			0.01	7.91	7.91
9. U of C Facility			0.01	7.91	7.91
10. Calgary Correctional Facility			0.01	7.91	7.91
11. Calgary Remand Centre			0.01	7.91	7.91
12. Youth Detention Centre			0.02	7.92	7.91
13. No. 1 Crestview Estates			0.30	8.20	8.13
14. No. 2 Crestview Estates			0.26	8.16	8.10
14. No. 2 Crestview Estates			0.01	7.91	7.91

Note: 1. Canadian Ambient Air Quality Standard (CAAQS).

5.4 Nitrogen Dioxide

Table 27 lists predicted 1-hour average NO_2 concentrations using the Total Conversion Method (TCM) which are presented to meet the requirements of AEP (2013a) but are not used for comparison to AAQOs when predictions based on the OLM method are also provided.

Table 27: Summary of NO_2 1-hour Average Predicted Concentrations – TCM

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
1-Hour Average - Winter Case				
Maximum Point of Impingement	-	123	268	391
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	-	123	7.9	131
2. Inland Pit (69 Street NW)			6.8	130
3. Medical Facility			14	137
4. Walmart (85 Street NW)			4.1	127
5. Farm (144 Ave NW & RR23)			42	165
6. Spy Hill Gravel Pit			6.1	129
7. 85 Street NW Facility			18	141
8. Bearspaw Christian School (144 Avenue NW)			10	133
9. U of C Facility			19	142
10. Calgary Correctional Facility			12	135
11. Calgary Remand Centre			15	138
12. Youth Detention Centre			18	141
13. No. 1 Crestview Estates			211	334
14. No. 2 Crestview Estates			221	344
1-Hour Average - Summer Case				
Maximum Point of Impingement	300	123	730	853
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	-	123	7.0	130.0
2. Inland Pit (69 Street NW)			6.8	129.8
3. Medical Facility			8.1	131.1
4. Walmart (85 Street NW)			2.6	125.6
5. Farm (144 Ave NW & RR23)			33.1	156.1
6. Spy Hill Gravel Pit			7.7	130.7
7. 85 Street NW Facility			16.5	139.5
8. Bearspaw Christian School (144 Avenue NW)			5.8	128.8
9. U of C Facility			11	134.0
10. Calgary Correctional Facility			8.8	131.8
11. Calgary Remand Centre			11	133.5
12. Youth Detention Centre			16	139.4
13. No. 1 Crestview Estates			521	644
14. No. 2 Crestview Estates			425	548

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

Table 28 summarizes 1-hour predictions using the OLM method and **Table 29** summarizes annual average predictions. In **Appendix C**, **Figure C9** and **C10** show the spatial patterns of 24-hour average concentrations for Application scenario - Winter and Summer Cases, respectively. **Figure C11** shows the pattern for annual average Application scenario predictions. The highest predicted concentrations are associated with activity in the active pit.

The NO_2 results demonstrate that all modelling predictions are less than AAQOs, with Project contributions less than Baseline values at most locations.

Table 28: Summary of NO_2 1-hour Average Predicted Concentrations - OLM

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
1-Hour Average - Winter Case				
Maximum Point of Impingement	300	102.6	117	129
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	300	102.6	7.9	103.4
2. Inland Pit (69 Street NW)			6.8	103.3
3. Medical Facility			14	104.0
4. Walmart (85 Street NW)			4.1	103.0
5. Farm (144 Ave NW & RR23)			42	106.8
6. Spy Hill Gravel Pit			6.1	103.2
7. 85 Street NW Facility			18	104.4
8. Bearspaw Christian School (144 Avenue NW)			10	103.6
9. U of C Facility			19	104.5
10. Calgary Correctional Facility			12	103.9
11. Calgary Remand Centre			15	104.1
12. Youth Detention Centre			18	104.4
13. No. 1 Crestview Estates			111	124
14. No. 2 Crestview Estates			112	125
1-Hour Average - Summer Case				
Maximum Point of Impingement	300	102.6	163	176
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	300	102.6	7.0	103.3
2. Inland Pit (69 Street NW)			6.8	103.3
3. Medical Facility			8.1	103.4
4. Walmart (85 Street NW)			2.6	102.9
5. Farm (144 Ave NW & RR23)			33	105.9
6. Spy Hill Gravel Pit			7.7	103.4
7. 85 Street NW Facility			16	104.3
8. Bearspaw Christian School (144 Avenue NW)			5.8	103.2
9. U of C Facility			11	103.7
10. Calgary Correctional Facility			8.8	103.5
11. Calgary Remand Centre			11	103.7
12. Youth Detention Centre			16	104.3
13. No. 1 Crestview Estates			142	155
14. No. 2 Crestview Estates			133	145

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

Table 29: Summary of NO_2 Annual Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
Annual Average - Winter and Summer Case				
Maximum Point of Impingement	45	17.2	3.21	20.4
1. Spy Hill Bottle Depot (76 Street NW)	45	17.2	0.04	17.2
2. Inland Pit (69 Street NW)			0.04	17.2
3. Medical Facility			0.07	17.3
4. Walmart (85 Street NW)			0.01	17.2
5. Farm (144 Ave NW & RR23)			0.30	17.5
6. Spy Hill Gravel Pit			0.04	17.2
7. 85 Street NW Facility			0.10	17.3
8. Bearspaw Christian School (144 Avenue NW)			0.08	17.3
9. U of C Facility			0.08	17.3
10. Calgary Correctional Facility			0.06	17.3
11. Calgary Remand Centre			0.07	17.3
12. Youth Detention Centre			0.10	17.3
13. No. 1 Crestview Estates			2.3	19.5
14. No. 2 Crestview Estates			2.0	19.2

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

5.5 Sulphur Dioxide

SO_2 1-hour average predictions are summarized in **Table 30** at the MPOI and 14 special receptors. **Table 31** summarizes 24-hour predictions and predictions at MPOI for 30-day and annual averages. Predictions of SO_2 are low and for that reason, are not included in isopleths in **Appendix C**.

The SO_2 predictions can be summarized as follows:

- All SO_2 predictions are well below AAQOs. For example, the Application scenario - Summer Case 1-hour SO_2 prediction is 1% of the AAQO. The Application scenario - Summer Case 24-hour prediction at the MPOI is 2.4 % of the AAQO.
- SO_2 predictions at the MPOI are 1.6% and 1.1%, respectively, of the Baseline scenario values for Application Scenario 30-day averages and annual averages.
- All SO_2 maxima were predicted on the southwestern Property boundary for Winter and Summer activity.

The SO_2 results demonstrate that all CALPUFF predictions are much less than AAQOs for all averaging periods at all receptor locations.

Table 30: Summary of SO_2 1-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
1-Hour Results of Winter Case				
Maximum Point of Impingement	450	2.9	0.73	3.33
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	450	2.9	0.03	3.63
2. Inland Pit (69 Street NW)			0.02	2.93
3. Medical Facility			0.04	2.92
4. Walmart (85 Street NW)			0.01	2.94
5. Farm (144 Ave NW & RR23)			0.11	2.91
6. Spy Hill Gravel Pit			0.02	3.01
7. 85 Street NW Facility			0.04	2.92
8. Bearspaw Christian School (144 Avenue NW)			0.02	2.94
9. U of C Facility			0.05	2.92
10. Calgary Correctional Facility			0.03	2.95
11. Calgary Remand Centre			0.04	2.93
12. Youth Detention Centre			0.05	2.94
13. No. 1 Crestview Estates			0.63	2.95
14. No. 2 Crestview Estates			0.60	3.53
1-Hour Results of Summer Case				
Maximum Point of Impingement	450	2.9	1.70	4.60
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	450	2.9	0.03	2.93
2. Inland Pit (69 Street NW)			0.02	2.92
3. Medical Facility			0.04	2.94
4. Walmart (85 Street NW)			0.02	2.92
5. Farm (144 Ave NW & RR23)			0.13	3.03
6. Spy Hill Gravel Pit			0.02	2.92
7. 85 Street NW Facility			0.06	2.96
8. Bearspaw Christian School (144 Avenue NW)			0.02	2.92
9. U of C Facility			0.06	2.96
10. Calgary Correctional Facility			0.04	2.94
11. Calgary Remand Centre			0.05	2.95
12. Youth Detention Centre			0.06	2.96
13. No. 1 Crestview Estates			2.00	4.90
14. No. 2 Crestview Estates			1.44	4.34

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

Table 31: Summary of SO_2 24-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
24-Hour Results of Winter Case				
Maximum Point of Impingement	125	2.7	0.12	2.82
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	125	2.7	0.004	2.704
2. Inland Pit (69 Street NW)			0.004	2.704
3. Medical Facility			0.007	2.707
4. Walmart (85 Street NW)			0.001	2.701
5. Farm (144 Ave NW & RR23)			0.015	2.715
6. Spy Hill Gravel Pit			0.004	2.704
7. 85 Street NW Facility			0.009	2.709
8. Bearspaw Christian School (144 Avenue NW)			0.003	2.703
9. U of C Facility			0.008	2.708
10. Calgary Correctional Facility			0.006	2.706
11. Calgary Remand Centre			0.007	2.707
12. Youth Detention Centre			0.009	2.709
13. No. 1 Crestview Estates			0.066	2.766
14. No. 2 Crestview Estates			0.084	2.784
24-Hour Results of Summer Case				
Maximum Point of Impingement	125	2.7	0.33	3.03
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	125	2.6	0.008	2.708
2. Inland Pit (69 Street NW)			0.008	2.708
3. Medical Facility			0.009	2.709
4. Walmart (85 Street NW)			0.003	2.703
5. Farm (144 Ave NW & RR23)			0.020	2.720
6. Spy Hill Gravel Pit			0.008	2.708
7. 85 Street NW Facility			0.019	2.719
8. Bearspaw Christian School (144 Avenue NW)			0.003	2.703
9. U of C Facility			0.012	2.712
10. Calgary Correctional Facility			0.010	2.710
11. Calgary Remand Centre			0.012	2.712
12. Youth Detention Centre			0.019	2.719
13. No. 1 Crestview Estates			0.289	2.989
14. No. 2 Crestview Estates			0.182	2.882
30-Day Results of Summer Case				
Maximum Point of Impingement	30	1.5	0.024	1.524
Annual Results of Winter and Summer Case				
Maximum Point of Impingement	20	0.70	0.0076	0.71

Note: 1. Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

5.6 Carbon Monoxide

CO predictions for 1-hour and 8-hour averaging periods are summarized in **Table 32** and **Table 33**. Tables include Baseline, Project only, and Application scenario predictions, which are very low. In **Appendix C**, **Figures C12**, **C13**, **C14**, and **C15** show concentration spatial pattern 1-hour and 8-hour average CO for Application Summer and Winter Cases. The CO results can be summarized as follows:

- All CO predictions are well below AAQOs.
- Project Only scenario - Summer Case predictions of 1-hour average CO concentrations are 85% of Baseline concentrations and 8-hour average Project Only Scenario - Summer Case predictions are 36% of Baseline concentrations.
- Maximum predictions for the Application scenario - Summer Case are 6% of the AAQO for 1-hour averages and at most 11% for 8-hour averages.

The CO results demonstrate that all CALPUFF predictions are much less than AAQOs for all averaging periods at all receptor locations.

Table 32: Summary of CO 1-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
1-Hour Results of Winter Case				
Maximum Point of Impingement	15,000	482	124	606
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	15,000	482	3.5	486
2. Inland Pit (69 Street NW)			3.0	485
3. Medical Facility			6.2	488
4. Walmart (85 Street NW)			1.8	484
5. Farm (144 Ave NW & RR23)			18.7	501
6. Spy Hill Gravel Pit			2.7	485
7. 85 Street NW Facility			7.9	490
8. Bearspaw Christian School (144 Avenue NW)			4.2	486
9. U of C Facility			8.6	491
10. Calgary Correctional Facility			5.5	488
11. Calgary Remand Centre			6.6	489
12. Youth Detention Centre			8.1	490
13. No. 1 Crestview Estates			97	579
14. No. 2 Crestview Estates			102	584
1-Hour Results of Summer Case				
Maximum Point of Impingement	15,000	482	414	896
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	15,000	482	4.0	486
2. Inland Pit (69 Street NW)			3.9	486
3. Medical Facility			4.6	487
4. Walmart (85 Street NW)			1.5	483
5. Farm (144 Ave NW & RR23)			18.8	501
6. Spy Hill Gravel Pit			4.4	486
7. 85 Street NW Facility			9.4	491
8. Bearspaw Christian School (144 Avenue NW)			3.3	485
9. U of C Facility			6.2	488
10. Calgary Correctional Facility			5.0	487
11. Calgary Remand Centre			6.0	488
12. Youth Detention Centre			9.4	491
13. No. 1 Crestview Estates			295	777
14. No. 2 Crestview Estates			241	723

Note: 1. Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

Table 33: Summary of CO 8-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
8-Hour Results of Winter Case				
Maximum Point of Impingement	6,000	472	48	520
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	6,000	472	1.2	473
2. Inland Pit (69 Street NW)			1.1	473
3. Medical Facility			2.6	475
4. Walmart (85 Street NW)			0.5	472
5. Farm (144 Ave NW & RR23)			7.8	480
6. Spy Hill Gravel Pit			1.4	473
7. 85 Street NW Facility			3.5	475
8. Bearspaw Christian School (144 Avenue NW)			1.8	474

Table 33: Summary of CO 8-hour Average Predicted Concentrations

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
9. U of C Facility			2.7	475
10. Calgary Correctional Facility			1.9	474
11. Calgary Remand Centre			2.5	474
12. Youth Detention Centre			3.5	476
13. No. 1 Crestview Estates			32	504
14. No. 2 Crestview Estates			37	509
8-Hour Results of Summer Case				
Maximum Point of Impingement	6,000	472	171	643
Special Receptors:				
1. Spy Hill Bottle Depot (76 Street NW)	6,000	472	3.8	476
2. Inland Pit (69 Street NW)			4.1	476
3. Medical Facility			3.7	476
4. Walmart (85 Street NW)			1.5	474
5. Farm (144 Ave NW & RR23)			12.7	485
6. Spy Hill Gravel Pit			4.5	476
7. 85 Street NW Facility			9.6	482
8. Bearspaw Christian School (144 Avenue NW)			1.7	474
9. U of C Facility			5.3	477
10. Calgary Correctional Facility			4.5	477
11. Calgary Remand Centre			5.7	478
12. Youth Detention Centre			9.6	482
13. No. 1 Crestview Estates			148	620
14. No. 2 Crestview Estates			84	556

Note: 1 Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).

5.7 Benzene and Benzo(a)Pyrene

Benzene and BaP predictions for the 1-hour averaging period are summarized in **Table 34** and include Baseline, Project only, and Application scenario predictions at the MPOI only. Predictions are low and isopleths are not shown in **Appendix C**. Because predicted concentrations are low, values are shown only at the MPOI. Predictions of 1-hour benzene for Application scenario - Summer Case are less than 1.6% of the AAQO whereas annual predictions of benzene and Benzo(a)Pyrene are less than 18% of the AAQOs.

Benzene and BaP results demonstrate that all CALPUFF predictions are much less than AAQOs for all averaging periods at all receptor locations.

Table 34: Summary of Benzene and Benzo(a)Pyrene Predictions

Receptor	AAQO[1] (µg/m³)	Baseline (µg/m³)	Project Only (µg/m³)	Application (µg/m³)
1-Hour Benzene Results of Winter Case				
Maximum Point of Impingement	30	0[2]	0.50	0.50
1-Hour Benzene Results of Summer Case				
Maximum Point of Impingement	30	0[2]	0.46	0.46
Annual Benzene Results of Winter and Summer Case				
Maximum Point of Impingement	0.30	0.05[3]	0.0025	0.0525
Annual Benzo(a)Pyrene Results of Winter and Summer Case (ng/m³)				
Maximum Point of Impingement	0.30	0.052	0.0010	0.053

Notes: 1. Alberta Ambient Air Quality Objective (AAQO) (AEP, 2019).
2. 90th Percentile from hourly Scotford AQ Station observations – October 1st, 2018 to September 30th, 2019.
3. Average value from hourly Scotford AQ Station observations – October 1st, 2018 to September 30th, 2019.

6. Summary and Conclusions

6.1 Summary

Lehigh proposes to construct and operate the Scott Property Project (the Project), a Class I Aggregate Pit located in Rocky View County, in the rural community of Bearspaw. The Project will occupy the majority of 05-26-02-W5M, with the exception of 33.9 acres located in the southwest corner. The property totals an area of approximately 600 acres (243 hectares [ha]), of which 395 acres (160 ha) are proposed for development as a sand and gravel pit. The Project will be constructed and operated in six phases with an anticipated operational lifespan of 25 to 30 years; each phase will be approximately five years in duration. Project development is planned to commence in 2022, with material extraction starting in 2024.

This air modelling assessment was conducted to satisfy the requirements of AEP. The assessment was a conservative one using an approved air quality dispersion model that considered the following assessment scenarios: a Baseline scenario that included background air quality measured in Calgary and the effects of regional aggregate operations; A Project-only scenario that considered the operating effects of the Scott Project alone; and an Application scenario that considered combined Baseline and Project-only impacts. The Application scenario also represents a Cumulative Effects Assessment scenario.

To establish emissions from the Project, Lehigh considered several alternative emission cases that included options for stripping and clearing the land in stages, extracting aggregate and conglomerate, and transporting aggregate material on-site. Emissions from all cases were estimated and modelled to calculate air quality concentrations, including a case with blasting. The cases with the lowest emissions were then assessed in more detail in this report as part of the Project-only scenario. The assessment moved forward with emissions in winter/early spring during which stripping and clearing took place and from spring to fall for excavation operations which included extraction equipment and a mechanical breaker to break down conglomerate, rather than blasting. An in-pit conveyor was used to transfer material off-site, rather than haul trucks, and limited crushing was done in-pit to size material for conveyance. The emissions modelled included fugitive dust from all Project operations as well as emissions from diesel equipment on-site. For assessment purposes, the mining block was located in the extreme southwest corner of the Project Footprint.

Regarding particulate predictions, this air quality assessment is conservative for the following key reasons:

- The emission calculations used US EPA AP42 emission factors, which for particulate are considered to over-estimate actual emissions.
- Winter and summer emission cases were modelled assuming seven days/week operations to ensure worst-case meteorology was included; whereas, real operations will be conducted for five days/week. Therefore, annual emissions are overestimated.
- The model did not sufficiently account for the effects of wind speed reduction and turbulence in vegetated areas, and therefore over-estimated predicted concentrations compared to measurements reported in the literature. Therefore, a 25% reduction due to grass, bushes and sparse trees was applied to particulate predictions resulting from Project sources.
- It is expected that on days with precipitation, all dust emissions will be substantially reduced. The air quality modelling, following provincial guidance, did not account for emission reduction due to precipitation. For Project operations, this is a conservative limitation given there is likely to be rain on about 50% of days in the April to November period.

In the Application scenario, at the Scott Property boundary, air quality due to emissions from equipment exhaust sources was predicted to meet Alberta's ambient air quality objectives 100% of the time. When including the effects of existing vegetation between the modelled pit location and the Scott Property boundary, predicted concentrations of fugitive dust were predicted to meet the ambient air quality objectives 99.95% of the time.

Further information on air quality is provided in the Cumulative Effects Assessment (AECOM 2020).

6.2 Conclusions

A key conclusion of the air quality assessment is that operation of the Project in winter and summer will result in negligible to low impacts due to emissions from combustion sources. A further conclusion of the assessment is that the operation of the Project will result in low impacts due to fugitive dust (TSP, PM_{10} and $PM_{2.5}$) emissions.

Based on the conservative nature of predictions, it is unlikely that concentrations of particulate on the Property boundary will exceed provincial ambient air quality objectives due to extraction of the aggregate resource.

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Appendix A

Emissions Estimates Detail

Table of Contents

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A1. Introduction

This attachment summarizes methods used to estimate emissions by activity from the proposed Project during operations. Section 1.1.2 of the Air Dispersion Modelling Assessment summarizes Project activities. Figure A1 summarizes location of operational phases of the Project. Phase 2 of the Project was selected for assessment, as during this phase the mining block is closest to nearby residences located southwest of the mining block. Each winter (i.e., January 1 to March 31), a new mining block will be prepared for mining by stripping the soil and overburden (i.e., the Winter Case). The stripped material will be stored in the previous years' pit (also referred to as "the reclamation area"). The soil layer depth is approximately 0.5 m in this area, so stripping during operation will predominately remove overburden, which is about 12 m deep. Section 4.1 of the report provides detailed information about four cases, for which emission sources were identified, estimated, and modelled.

Dust particulate emissions include:

- Particulate matter with diameter less than 2.5 µm ($PM_{2.5}$)
- Particulate matter with diameter less than 10 µm (PM_{10})
- Particulate matter with diameter less than 30 µm (TSP)

Diesel combustion equipment will emit particulate and gases, of which the following compounds were modelled:

- Sulphur Dioxide (SO_2),
- Nitrogen Oxides (NO_X),
- Carbon Monoxide (CO),
- Benzene, and
- Benzo(a)Pyrene (BaP).

This attachment summarizes emissions from all sources and identifies the highest emission sources for a given compound. The main emission sources are haul trucks, excavators, bulldozers, loaders and other diesel combustion equipment. Emissions have been estimated based on available information, and were calculated using conservative assumptions, which represent the highest hourly, daily and annual values.

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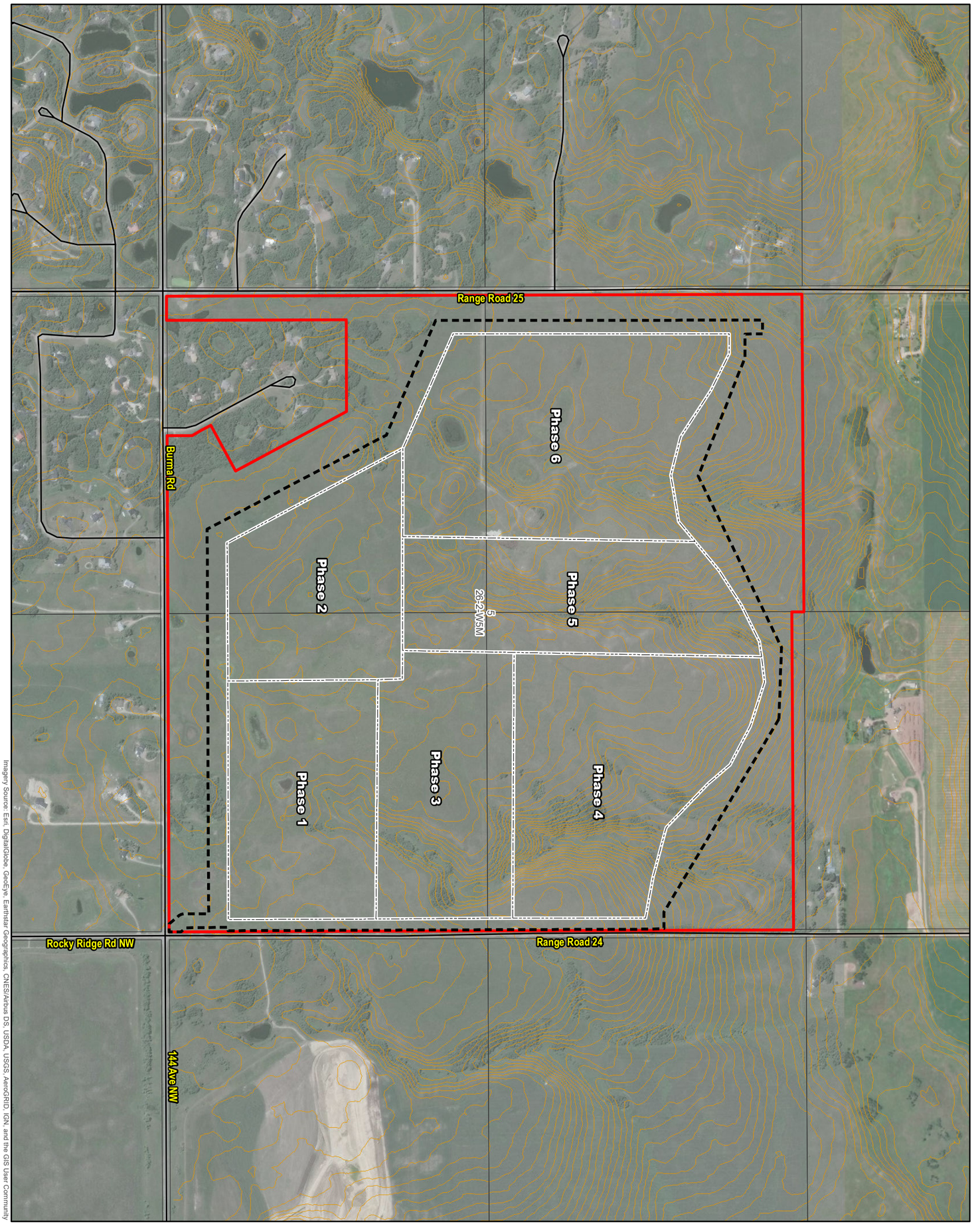

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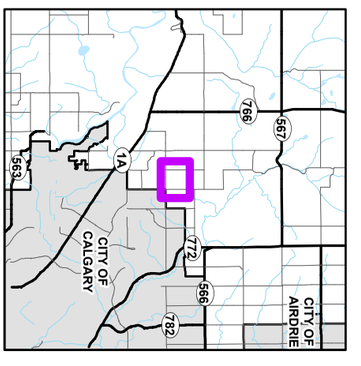
Legend
- Property Boundary
- Project Phases
- Contour
- Road

Key Map



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LEHIGH HANSON MATERIALS LIMITED
Project No.: 60610856 Date: 2020-06-19

PHASES OF THE PROJECT

AECOM

Figure: A1

A2. Supporting Information for Dust Emission Calculations

A2.1 Material Properties

Table A1 summarizes the material properties used for the emission estimates. For emission estimation purposes, the United States Environmental Protection Agency (US EPA) defines silt content as the fraction of particles smaller than 75 µm in diameter *available to be emitted from the haul road or pit surface* US EPA 2006a). The silt content is usually measured by lightly sweeping the surface of interest and measuring the mass fraction of particles smaller than 75 µm in diameter in the collected sample.

Table A1: Material Properties

Property / Material	Moisture Content (%)	Silt Content[1] (%)
Aggregate	4.0[1]	3.3[1]
Overburden, Soil (and Haul Road)	8.0[1]	3.3[2]

Notes: 1 MEMS (2013)
2 Assumes average silt content on road at sand and gravel processing facility (Table 13.2.2-1; U.S. EPA, 2006a)

The choice of haul road silt content (3.3%) is based on measurements from roads at sand and gravel processing plants, and is also within the range of silt content values for roads at stone quarrying and processing facilities listed in Compilation of Air Pollutant Emissions Factors (AP-42) prepared by US EPA (Table 13.2.2-1, US EPA 2006a) and for various limestone products (Table 13.2.4-1; US EPA 2006b).

A2.2 Hours of Operation

Stripping equipment will operate 11 hours a day, Monday to Friday (64 working days) each January to March. The mining block will be mined annually from April 1 to November 30, with full operations Monday to Friday and reduced operations on Saturday (i.e., assumed for modelling purposes to be 174 working days). A total of 244 calendar days were modelling for aggregate operations, whereas, 90 days (or 91 days during leap years) were modelled for soil and overburden stripping.

A2.3 Material Production

Aggregate production is expected to be 1.6 to 2.0 million tonnes per year (Mt/year). For this assessment it was assumed that 2.0 Mt/year of aggregate is produced and, as such, the assessment is conservative. Lehigh estimates that 1.1 Mt/year of overburden will be transferred from the mining block to the reclamation area. Daily maximum production, and, related to this production, daily maximum emissions, were calculated assuming operations per Section A2.2.

Approximately 65% of aggregate does not require crushing, as the material is comprised of loose gravel and/or sand appearing within some layers of the aggregate. **Table A2** summarizes the annual and maximum daily material production numbers estimated for the Project.

Table A2: Material Properties

Material	Annual Maximum (t/year)	Daily Maximum (t/day)
Total Aggregate	2,000,000	11,494
Conglomerate for Mobile Crusher	700,000	4,023
Gravel Transferred Directly to In-pit Conveyor	1,300,000	7,471
Overburden, Soil (and Haul Road)	1,100,000	17,188

A2.4 Particulate Size Distribution for Dust Emission Sources

Figure A2, sourced from Chow and Watson (1998), presents the size distribution of $PM_{2.5}$, PM_{10}, and TSP occurring in ambient air. The curve depicted in **Figure A2** was digitized, and the average relative mass concentration for each range of particle sizes was calculated and multiplied by the average size of the particle. There are five size ranges for the $PM_{2.5}$ particle fraction, two ranges for the fraction larger than $PM_{2.5}$ but smaller than or equal to PM_{10} and two ranges larger than PM_{10} but smaller than or equal to TSP. Six ranging from 0.625 µm diameter to 8 µm were sourced from British Columbia Air Quality Dispersion Modelling Guideline (Table 3-1; BC ENV, 2015). They were supplemented by an average 0.25 µm average diameter (for fraction smaller than or equal to 0.50 µm) and two fractions for particle diameters above 10 µm. All PM size ranges were modelled separately and summed for TSP, PM_{10}, and $PM_{2.5}$, as summarized in **Table A3**.

Table A3: PM Granulometry Distributions for Nine Particle Fractions

PM Fraction	Size Range (µm)	Average Diameter (µm)	Relative Fraction	Geometric Standard Deviation	Affiliation		
					$PM_{2.5}$	PM_{10}	TSP
PM2.5A	0.0 to 0.50	0.25	0.229	0	X	X	X
PM2.5B	0.50 to 0.75	0.625	0.212	0	X	X	X
PM2.5C	0.75 to 1.00	0.875	0.179	0	X	X	X
PM2.5D	1.00 to 1.25	1.125	0.124	0	X	X	X
PM2.5E	1.25 to 2.50	1.875	0.255	0	X	X	X
PM10A	2.50 to 6.00	4.25	0.295	0		X	X
PM10B	6.0 to 10.0	8.00	0.705	0		X	X
TSPA	10.0 to 20.0	15.0	0.641	0			X
TSPB	20.0 to 30.0	25.0	0.369	0			X

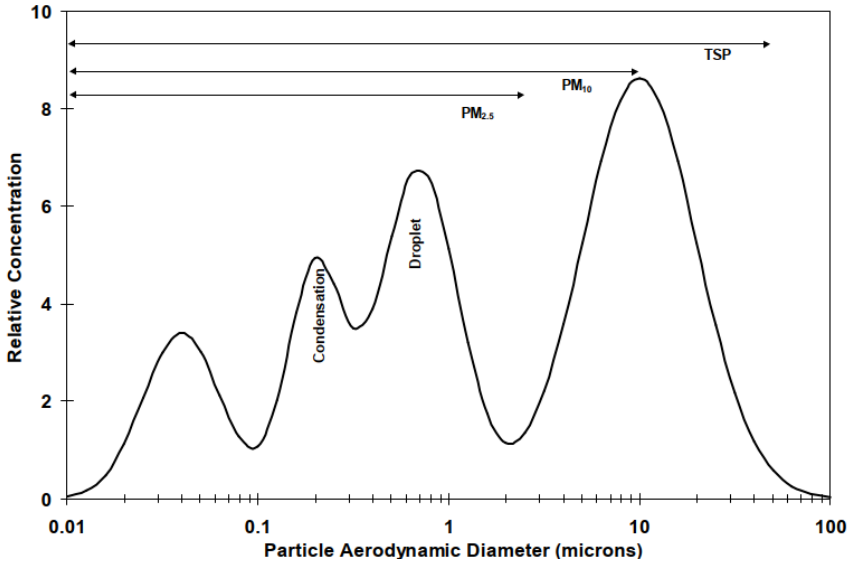

Figure A2: Typical Size Distribution of Particles in Ambient Air (Figure 2-1 from Chow and Watson 1998)

A2.5 Emission Escape Fractions for Sources Below Ground Level

The ISCST3 model includes a particulate emission escape fraction (EEF) algorithm to model open-pit sources (US EPA 1995), which is a modelling option not available to CALPUFF. As the mining blocks may be as deep as 50 m and have a surrounding noise berm approximately 6 to 7 m high (average 6.5 m), it is anticipated that some large-diameter particulate will deposit onto the pit wall, the noise berm, and mine surface. For this reason, an EEF approach was used to account for the partial retention of particulate emissions in sources which are below ground, as it will more accurately reflect physical reality.

Derivation of the escape fraction from open pit sources is referenced in Reed (2005). According to Cole and Fabrick (1984), the EEF from an open pit can be calculated by the following formula:

$$EEF = \frac{1}{1 + \frac{V_d * H}{Dp}}$$

Where:

- V_d is the gravitational settling velocity (m/s)
- *Dp* is the diffusivity (0.5 m^2/s)
- *H* is depth of the pit

The settling velocity is calculated by:

$$V_d = \frac{(\rho - \rho_{air}) * g * {d_p}^2 * c_2 * S_{CF}}{18\mu}$$

Where:

- ρ is the particle density (estimated to be 2.0 g/cm^3)
- ρ_{air} is the air density (1.2 x 10^{-3} g/cm^3)
- d_p is the particle diameter
- μ is the absolute viscosity of air (1.81 x 10^{-4} g/cm/s)
- c_2 conversion constant (1 x 10^{-8} $cm^2/\mu m^2$)
- S_{CF} is the slip correction factor (equation 1-85 in US EPA 1995)

Table A4 summarizes the average depths at which modelled sources operate. **Table A5** presents calculated settling velocities and slip factors for the nine particle fractions listed in **Table A3**.

Table A4: Average Depth of Modelled Project Sources

Source	Range of Depths (m)	Average (Modelled) Depth (m)
Aggregate Pit – Full Production	12.5 – 50.0	25.0
Haul Road in Reclaimed Areas	37.5	37.5
Average Depth of Crusher	15 – 25	20.0
Aggregate Pit – Stripping of Overburden and Soil	0 – 12.5	6.3
Overburden Dumping at Reclamation Area	37.5 – 50.0	43.8
In-pit Conveyor in Western and Central Part of Pit	36.0	36.0
In-pit Conveyor at the East Side of the Scott Property	0.0 – 20.0	10.0
Average Depth of Off-site Conveyor	0	0

Note: Depth is inclusive of the averaged 6.5 m height of the noise berm.

Table A5: Calculated Settling Velocities and Slip Factors

PM Fraction	Mean Diameter d_p (µm)	Settling Velocity V_d (m/s)	Slip Factor S_{CF} (m/s)
PM2.5A	0.25	6.31E-06	1.6787
PM2.5B	0.625	2.97E-05	1.2619
PM2.5C	0.875	5.47E-05	1.1868
PM2.5D	1.125	8.72E-05	1.1453
PM2.5E	1.875	2.30E-04	1.0872
PM10A	4.25	1.13E-03	1.0384
PM10B	8	3.93E-03	1.0204
TSPA	15	1.37E-02	1.0109
TSPB	25	3.79E-02	1.0065

Figure A3 presents the location of emission sources used for modelling operations for the Summer Mechanical Breaker and Blasting Cases; whereas, **Figure A4** presents location of emission sources used for modelling the Truck Case, and **Figure A5** presents sources for the Winter Case.

Examples of depth calculations are as follows:

- Maximum depth of the aggregate pit (50.0 m) is the sum of soil depth (0.5 m) and overburden layer (12.0 m) and the average depth of aggregate layer (37.5 m).
- Reclaimed area depth is the average pit depth (37.5 m). It was assumed that a 12.5 m layer (i.e., sum of overburden and soil depths) was moved to the bottom of the aggregate pit (50.0 m -12.5 m = 37.5 m). As such, 37.5 m is the depth at which the haul road is located.
- As the in-pit and off-site conveyors are 1.5 m above the ground, the average depth of the in-pit conveyor in the western and central location of the pit is raised by 1.5 m, to 36 m below grade.
- The in-pit conveyor in the eastern location of the pit ramps upward and reaches ground surface outside the property boundary – south of 144 Avenue NW and east of Rocky Ridge Rd. NW. This section was modelled at an average depth of 10 m below surface. The length of this section was modelled as 405 m for the Summer Mechanical Breaker and Blasting Cases, and as 511 m for the Summer Truck Case.

For the EEF calculation, the average height of the noise berm (6.5 m) was added to the depth of the pit and reclaimed area to obtain a more accurate H value. The remainder of the off-site conveyor (approximately 5 km) to the Spy Hill Property is bermed on the northern side when transporting aggregate eastward, and on the eastern side when transporting material southward, and no EEF was applied. **Table A6** summarizes the EEF used in the modelling for the Project based on inputs from **Table A3** and **Table A5**.

Table A6: Escape Emission Fractions for Particle Sizes and Depths in Modelling

PM Fraction	Aggregate Pit (& Temporary Crusher) Full Production H = 31.5 m	Haul Road Reclamation Area H = 44 m	In-pit Conveyor at Reclamation Area H = 42.5 m	Permanent Crusher H = 26.5 m	Aggregate Pit Stripping H = 12.8 m	Dumping at Reclamation Area H = 50.3 m	In-pit Conveyor at East Side of Scott Property H = 16.5 m
PM2.5A	0.9996	0.9994	0.9995	0.9997	0.9998	0.9994	0.9998
PM2.5B	0.9981	0.9974	0.9975	0.9984	0.9992	0.9970	0.9991
PM2.5C	0.9966	0.9952	0.9954	0.9971	0.9986	0.9945	0.9983
PM2.5D	0.9945	0.9924	0.9926	0.9954	0.9978	0.9913	0.9973
PM2.5E	0.9857	0.9802	0.9808	0.9880	0.9942	0.9774	0.9928
PM10A	0.9336	0.9096	0.9124	0.9435	0.9720	0.8981	0.9657
PM10B	0.8015	0.7430	0.7496	0.8276	0.9089	0.7168	0.8898
TSPA	0.5369	0.4536	0.4622	0.5795	0.7413	0.4209	0.6987
TSPB	0.2954	0.2309	0.2371	0.3326	0.5088	0.2081	0.4561

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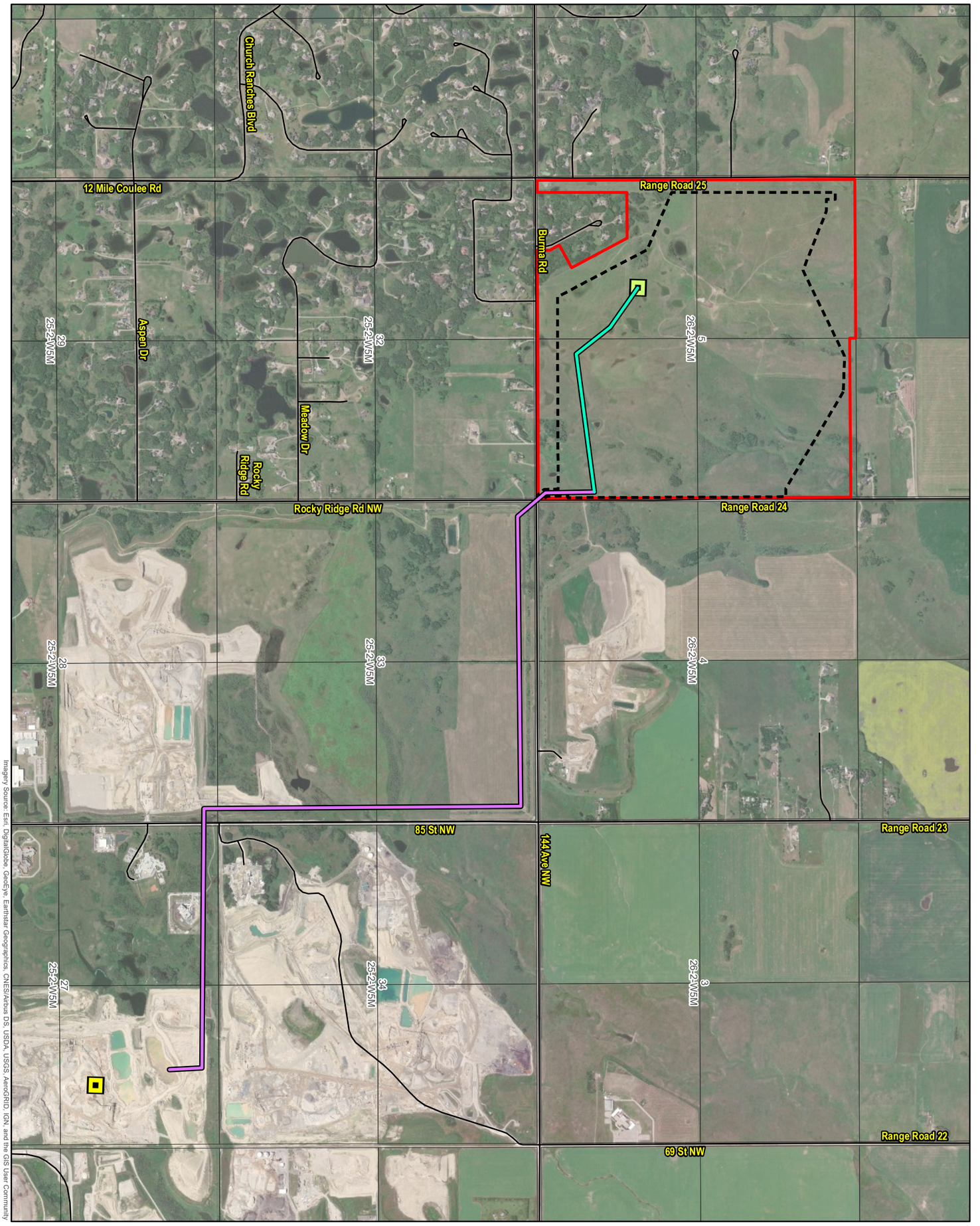
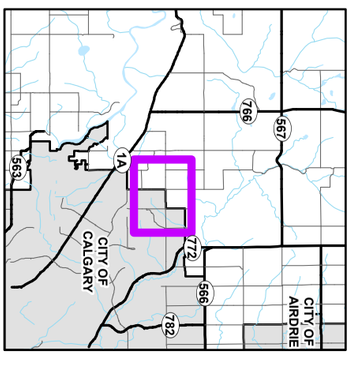


Legend

- Mining Block
- Spy Hill Pile
- Property Boundary
- Project Footprint
- Off-Site Conveyor
- In-Pit Conveyor
- Road

Key Map



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LOCATION OF EMISSION SOURCES USED FOR SUMMER MECHANICAL BREAKER OR BLASTING CASES

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Figure: A3

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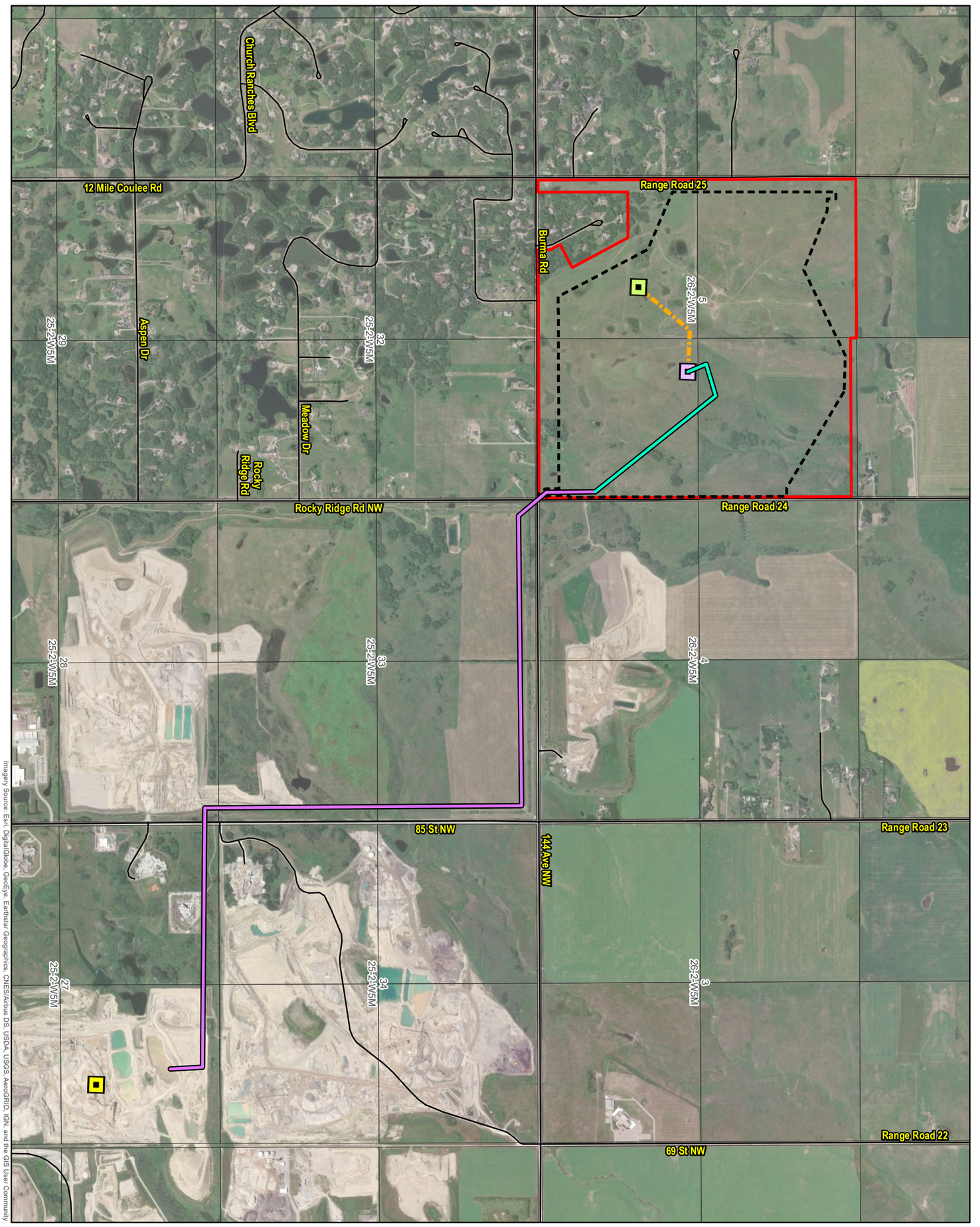

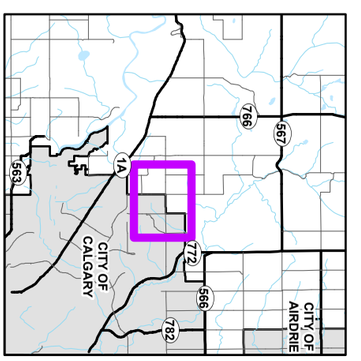

Legend

- Mining Block
- Permanent Breaker
- Spy Hill Pile
- Property Boundary
- Project Footprint
- Haul Road
- Off-Site Conveyor
- In-Pit Conveyor
- Road

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LOCATION OF EMISSION SOURCES USED FOR TRUCK CASE

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Figure: A4

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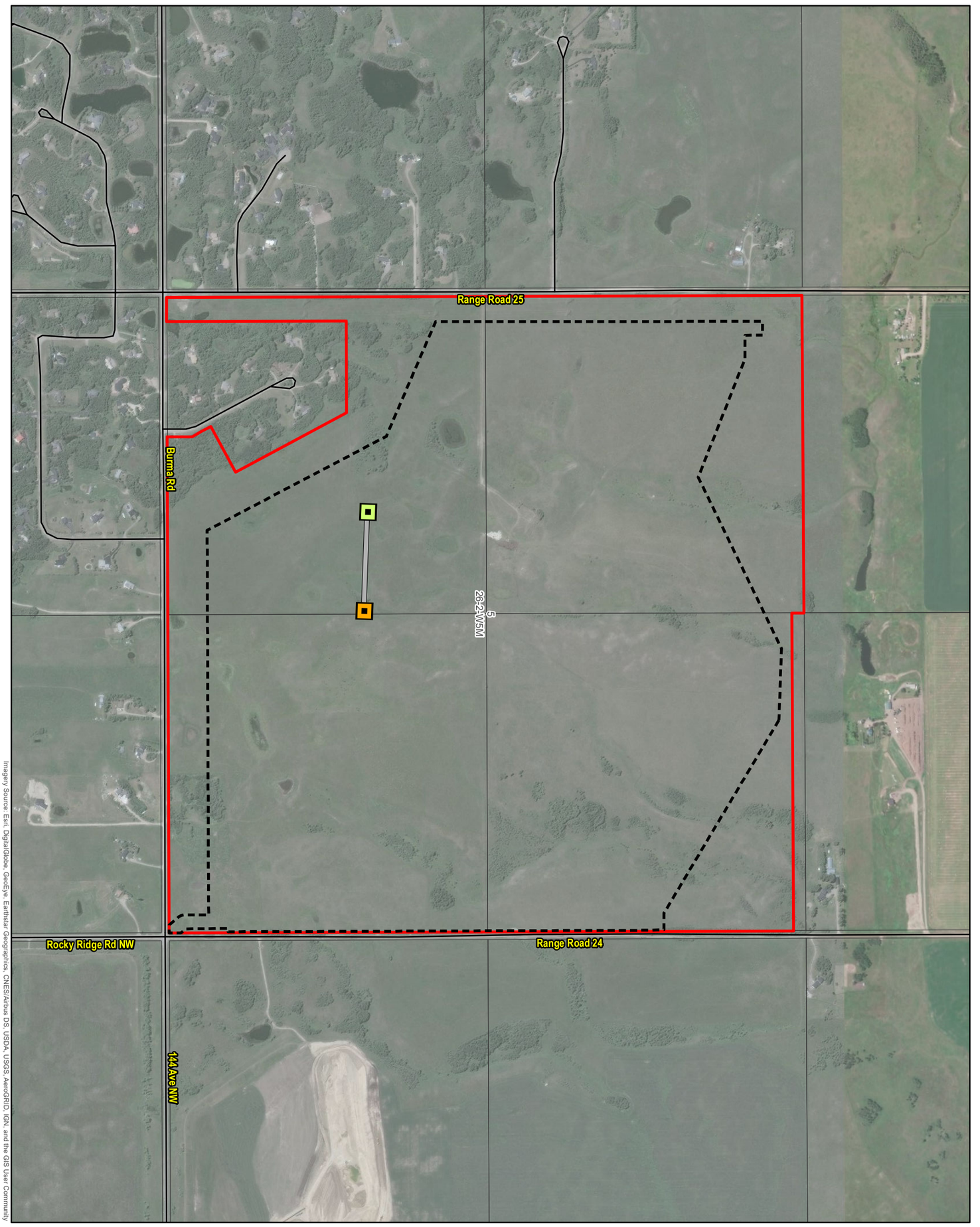

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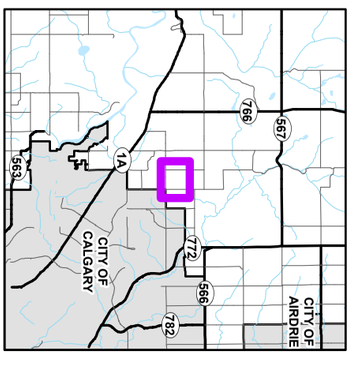
Legend

- Reclamation Area
- Mining Block
- Scraper's Road
- Property Boundary
- Project Footprint
- Road

Key Map



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LEHIGH HANSON MATERIALS LIMITED
Project No.: 60610856 Date: 2020-06-19

LOCATION OF EMISSION SOURCES USED FOR WINTER CASE

AECOM

Figure: A5

A2.6 Reduction of Dust Emissions due to Watering or Chemical Suppression

Heavy equipment and vehicle traffic along haul roads during aggregate mining operations is the primary source of dust emissions. To mitigate the impact of road dust, facility operators often implement operational procedures aimed at suppressing emissions, such as the application of chemical suppressants (e.g., $CaCl_2$) or watering. Operation during frozen or snow-covered road conditions also minimizes road dust emissions.

This reduction was studied by comparing two years of summer and winter data from a network of static dust fall stations located near the Grande Cache Coal processing plant and the H.R. Milner generating plant areas, and near a haul road (GCCoal 2004; CVR 2013). The average readings from November to April were approximately 43% lower than for the rest of the monitoring period (May to October), with even lower proportions observed in December and January (approximately 50% reduction). Per climatological data obtained from the City of Calgary and Springbank airports, periods of snow cover extend from November to April; however, can be as early as October (Government of Canada 2020).

Table A7 summarizes emission reduction data presented by the Emission Factor Documentation for US EPA AP 42 Section 13.2.2 (Unpaved Roads) (US EPA 1998a) from many observations, with mean reductions for $PM_{2.5}$, PM_{10}, and TSP measurements from 79 to 91%. The average annual precipitation in the City of Calgary area is above 400 mm (Springbank – 470 mm/year; Calgary International Airport – 419 mm). This impacts the fugitive dust calculation presented in this assessment, as dust emissions would be lower than those used to obtain the emission factors in US EPA (AP42). For example, in US EPA (1998b) (which is an example applicable to Western Surface Coal Mining), emission factors were developed for mines based on annual precipitation levels of 280 mm to 403 mm; which is less than precipitation levels recorded at stations near the Project.

Table A7: Reduction of Dust Emissions due to Naturally Occurring or Anthropogenic Dust Control Measures

Place/Industry	Equipment/ Control Method	Emission Reduction of $PM_{2.5}$ (%)	Emission Reduction of PM_{10} (%)	Emission Reduction of TSP (%)
California[(a)] /Road Construction	Scraper / Watering	-	79	-
Wyoming[(b)] / Coal Mines	Haul Trucks / Watering	-	54	41
North Caroline[(c)] / Stoney Quarry	Haul Trucks / Watering	-	94	-
Michigan[(d)] / Coal Yard at Power Plant	Scraper / Watering	79	80	80
Ohio[(e)] / Iron & Steel Plant	Haul Trucks / Watering	87	-	78
Ohio[(e)] / Iron & Steel Plant	Haul Trucks / Coherex	91	-	95
Indiana[(f)] / Iron & Steel Plant	Haul Trucks / Petro-Tac	79	91	81
Missouri[(f)] / Iron & Steel Plant	Haul Trucks / Watering	72	92	89
Missouri[(f)] / Iron & Steel Plant	Haul Trucks / Coherex	89	92	83
Wyoming, New Mexico, North Dakota[(g)] / Coal Mines	Haul Trucks / Watering	61	-	73
Wyoming, New Mexico, North Dakota[(g)] / Coal Mines	Haul Trucks / $CaCl_2$	24	-	88
Median		79	91	81

Notes: (a) AQMD (1996)
(b) US EPA (1994)
(c) National Stone Association (1994)
(d) MRI (1985)
(e) US EPA (1983a)
(f) US EPA (1983b)
(g) US EPA (1981) (poor quality data: average of controlled emissions measured at Wyoming and New Mexico over average of uncontrolled emissions measured at Wyoming, New Mexico, and North Dakota)

For the purpose of this assessment, it was assumed that haul road emissions would be reduced by 80% by watering or natural precipitation. It was also assumed there would be a 90% reduction when operations are conducted during frozen or snow-covered (or very moist) conditions.

A3. Fugitive Dust Emissions

A3.1 Loading/Unloading Emissions

The emission factor formula for loading and unloading aggregate and overburden was sourced from AP 42 Section 13.2.4 (Aggregate Handling and Storage Piles) US EPA (2006b):

$$TSP\left(\frac{kg}{t}\right) = \frac{0.0016 * 0.74 * \left[\frac{U}{2.2}\right]^{1.3}}{\left[\frac{M}{2}\right]^{1.4}}$$

$$PM_{10}\left(\frac{kg}{t}\right) = \frac{0.35}{0.74} * TSP\left(\frac{kg}{t}\right)$$

$$PM_{2.5}\left(\frac{kg}{t}\right) = \frac{0.053}{0.74} * TSP\left(\frac{kg}{t}\right)$$

Where:

- U is mean wind speed (m/s)
- M is moisture content (%) (**Table A1**)

Loading / unloading emissions are wind speed dependent and modelled using wind speed dependent emission factors. The equations have an “A” rating (excellent) for aggregate handling. The meteorological conditions at the Project were obtained from CALMET files. The hourly wind speed was used to calculate emissions for every modelled hour.

Example 1: Following is an example emission calculation of TSP emissions from aggregate loading into trucks, using a wind speed dependent emission factor with a wind speed of 5.0 m/s:

$$TSP\left(\frac{kg}{tonne}\right) = \frac{0.0016 * 0.74 * \left[\frac{5.0\ m/s}{2.2}\right]^{1.3}}{\left[\frac{4.0}{2}\right]^{1.4}} = 0.001305$$

Example 2: An example TSP emission factor calculation for overburden loading during pit stripping at the new mining block and unloading overburden at the reclamation area with a wind speed 5.0 m/s is:

$$TSP\left(\frac{kg}{tonne}\right) = \frac{0.0016 * 0.74 * \left[\frac{5.0\ m/s}{2.2}\right]^{1.3}}{\left[\frac{8.0}{2}\right]^{1.4}} = 0.000494$$

Table A8 presents the maximum 1-hour wind speed dependent emissions calculated for overburden and aggregate loading and unloading. **Table A9** lists maximum 24-hour wind speed dependent emissions calculated for overburden and aggregate loading and unloading. **Table A10** lists total annual emissions from five years of wind speed data (total emissions divided by 5 years) calculated for overburden and aggregate loading and unloading.

Table A8: Loading and Unloading of Overburden and Aggregate - Wind Speed Dependent Maximum 1-Hour Average Emissions (EEF Applied)

Operation	TSP 1-Hour Maximum (kg/hr)	PM_{10} 1-Hour Maximum (kg/hr)	$PM_{2.5}$ 1- Hour Maximum (kg/hr)
Overburden Load (Winter Case)	2.43	1.36	0.220
Overburden Unload (Winter Case)	1.73	1.17	0.218
Aggregate Load in Pit on Mobile Crusher and In-pit Conveyor (Mechanical Breaker and Blasting Cases)	6.67	4.22	0.736
Aggregate Load onto Trucks at Pit (Truck Case)	3.36	2.11	0.368
Aggregate Unload at Permanent Crusher and In-pit Conveyor (Truck Case)	4.54	2.80	0.479

Table A9: Loading and Unloading of Overburden and Aggregate - Wind Speed Dependent Maximum 24-Hour Average Emissions (EEF Applied)

Operation	TSP 24-Hour Maximum (kg/day)	PM_{10} 24-Hour Maximum (kg/day)	$PM_{2.5}$ 24- Hour Maximum (kg/day)
Overburden Load (Winter Case)	14.8	8.29	1.33
Overburden Unload (Winter Case)	10.5	7.10	1.33
Aggregate Load at Pit on Mobile Crusher and Conveyor (Mechanical Breaker and Blasting Cases)	40.0	25.3	4.41
Aggregate Load on Trucks at Pit (Truck Case)	20.0	12.7	2.21
Aggregate Unload at Permanent Crusher and Conveyor (Truck Case)	27.2	16.8	2.87

Table A10: Loading and Unloading of Overburden and Aggregate - Wind Speed Dependent Total Annual Emissions (EEF Applied)

Operation	TSP Annual Total (t/year)	PM_{10} Annual Total (t/year)	$PM_{2.5}$ 24- Hour Total (t/year)
Overburden Load (Winter Case)	0.365	0.205	0.0330
Overburden Unload (Winter Case)	0.259	0.175	0.0328
Aggregate Load at Pit on Mobile Crusher and In-pit Conveyor (Mechanical Breaker and Blasting Cases)	2.612	1.652	0.2880
Aggregate Load on Trucks at Pit (Truck Case)	1.306	0.826	0.1440
Aggregate Unload at Permanent Crusher and In-pit Conveyor (Truck Case)	1.777	1.097	0.1874

Unmitigated emissions for the Project include the following: loading of aggregate onto the mobile crusher and in-pit/off-site conveyor; loading and dumping of overburden at the reclamation area; and loading of conglomerate (i.e., 35% of the aggregate) into the permanent crusher. Emissions for loading crushed conglomerate from the bottom of the permanent crusher onto the in-pit conveyor are reduced by 70% because the crusher is enclosed (Table 4 in NPI 2012).

Emissions of the remaining 65% of aggregate transferred directly into the in-pit conveyor hopper will be unmitigated, but emissions for aggregate transferred directly onto the in-pit conveyor at the permanent crusher site will be covered and mitigated (70% reduction).

Since these operations occur below ground level, the EEF was applied (as explained in Section A2.5).

A3.2 Bulldozing Operations

Overburden bulldozing emissions are based on AP 42 Table 11.9-2 (US EPA 1998b):

$$TSP\left(\frac{kg}{hr}\right) = \frac{2.6 * (s)^{1.2}}{(M)^{1.3}}$$

$$PM_{10}\left(\frac{kg}{hr}\right) = \frac{0.45 * 0.75 * (s)^{1.5}}{(M)^{1.4}}$$

$$PM_{2.5}\left(\frac{kg}{hr}\right) = 0.105 * TSP\left(\frac{kg}{hr}\right)$$

where:

- *s* is the silt content of the material (%)
- *M* is the moisture content of the material (%) (**Table A1**)

One bulldozer was modelled working 11 hours/day at the reclamation area. During normal aggregate pit operations in Mechanical Breaker and Blasting Cases (with mobile crusher and off-site conveyor from pit to Spy Hill), one bulldozer will work at the pit. In the Truck Case, no bulldozers are needed at the mining block.

The TSP emission factor for overburden bulldozing is:

$$TSP\left(\frac{kg}{hr}\right) = \frac{2.6 * (3.3)^{1.2}}{(8)^{1.3}} = 0.730$$

Emissions of one bulldozer working 11 hours at the reclamation area:

$$TSP\ \left(\frac{kg}{day}\right) = 1\ bulldozer * 0.730\left(\frac{kg}{hr}\right) * 11\left(\frac{hr}{day}\right) = 8.03$$

Table A11 summarizes bulldozer emission factors and total emissions for one bulldozer working at reclamation area for 11 hours/day.

Table A11: Overburden and Aggregate Bulldozing Emission Factors (kg/hour) and Emissions with EEF (kg/11-hour day)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor for Overburden at Reclamation Area	kg/hr	0.73	0.110	0.077
Emissions Factor for Aggregate at Mining block	kg/hr	1.80	0.291	0.189
Emissions from Reclamation Area with EEF (50.3 m Deep)	kg/day	8.03	1.21	0.84
Emissions from Mining block with EEF (31.5 m Deep)	kg/day	19.8	3.20	2.08

A3.3 Mobile and Permanent Crushers

Table A12 summarizes mobile crusher emission factors and total emissions for maximum daily aggregate production during 11-hour days of operations for two conveyor cases (Mechanical Breaker and Blasting) and the permanent crusher (Truck Case). Emission factors for TSP and PM_{10} from uncontrolled tertiary crushing were taken from AP 42 Table 11.19.2-1 (Crushed Stone Processing and Pulverized Mineral Processing) (US EPA 2004). The

$PM_{2.5}$ emission factor was obtained using the controlled emission factors ratio: $PM_{2.5}/PM_{10}$ = 0.00005/0.00027 = 0.185 (US EPA 2004). Since the permanent crusher will be covered, emissions from crushing were reduced by 70% as suggested by NPI (2012). Aggregate is broken but not screened – larger rocks are simply broken into smaller pieces and moved by off-site conveyor to Spy Hills for further processing. Since the average depth of crusher operations was 26.5 m below surface, the EEF was used.

Table A12: Aggregate Crushing Emission Factors (kg/t) and Emissions with EEF (kg/11-hour day)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor	kg/t	0.0027	0.0012	0.00222
Mobile Crusher Emissions (Unmitigated)	kg/day	6.91	4.20	0.889
Mechanical Breaker Emissions (Unmitigated)	kg/day	6.91	4.20	0.889
Permanent Crusher Emissions (Reduced by 70%)	kg/day	2.17	1.28	0.267

For the Blasting Case there are mobile crusher emissions only at the mining block; for the Mechanical Breaker Case there are mobile crusher and Mechanical Breaker emissions at the mining block; and for the Truck Case there are permanent crusher emissions at the crusher site and Mechanical Breaker emissions at the mining block.

A3.4 Vehicle Parameters (Wheel Entrainment Emissions)

Table A13 summarizes parameters of vehicles (scrapers, haul trucks) travelling on haul roads. Emissions depend on total vehicle kilometres travelled (VKT).

Table A13: Parameters of Vehicles Transporting Material on Haul Roads (during 11-hour day)

Vehicle / Material	Total VKT/Day	Trips/Day/ Vehicle	No. of Vehicles Needed	Vehicle Load (tonnes)	Average Vehicle Weight (tonnes)
Quarry Truck CAT773D	238	72	3	53	66.0
Water Truck (CAT773D)	12.0	11	1	53	66.0
Scraper CAT627K	351	165	4	26	55.2

Vehicles on-site travel between 15 km/hr and 20 km/hr (average 18 km/hr). The terrain is uneven with changes of elevation between active and reclamation areas, and there will likely be a steep approach to the upper part of the crusher. Heavy, loaded trucks will operate at lower speeds than lighter, empty trucks returning from the crusher. The average speed (18 km/hr) is reasonable given the number of trucks (e.g., 4 for aggregate) and the number of trips needed to move material. For example:

11,494 t/day / 53 t/truck = 217 trips/day = 72 trips/day/truck/11 hours = 6.6 trips/hr/truck

The total daily distance travelled by all modelled vehicles was:

217 trips/day* 2* 0.55 km = 237.6 km/day.

The average distance from the mining block to the top of the permanent crusher is approximately 550 m (one way). Within each hour, one truck will travel approximately 24 minutes on the haul road and idle approximately 36 minutes either at the crusher site (unloading aggregate) or at the mining block (loaded with aggregate by excavators or wheel loader). The total return distance multiplied by 6.6 trips per hour and per truck and divided by 24 minutes results in the following estimation of average speed:

Average haul truck speed = 2 * 0.55 km * 6.6 trips/hour/truck / (24 minutes/60 minutes) = 18 km/hr

Similarly, for the scraper, there will be 17,188 t/day / 26 t/truck = 661 trips/day = 165 trips/day/vehicle = 15 trips/hour/scraper. It was estimated that one scraper travels approximately 250 m between stripped aggregate block and the reclamation area. The total daily distance was estimated as:

661 trips/day * 2 ways * 0.25 km = 331 km/day

Four scrapers will move overburden from the stripped area to the reclamation area.

A3.5 Scraper Travel Emissions

Emission factors for TSP and PM_{10} emissions from scrapers in travel mode were taken from Table 2 in NPI (2012):

$$TSP\left(\frac{kg}{VKT}\right) = 9.6 * 10^{-6} * s^{1.3} * W^{2.4}$$
$$PM_{10}\left(\frac{kg}{VKT}\right) = 1.32 * 10^{-6} * s^{1.3} * W^{2.4}$$
$$PM_{2.5}\left(\frac{kg}{VKT}\right) = 0.10 * PM_{10}\left(\frac{kg}{VKT}\right)$$

where:

- *s* is the silt content of the material (%)
- *W* is the scraper weight in tonnes
- The multiplier for the $PM_{2.5}$ emissions was modified according to changes for $PM_{2.5}$ emission factors made in 2006 (US EPA 2006b): $PM_{2.5}/PM_{10}$ = 0.15/1.5 = 0.10.

Table A14 summarizes scraper travel emission factors and total emissions for four scrapers moving overburden from the mining block to the reclamation area for 11 hours/day (331 km/day). Since the scraper travels between the stripped mining block (depth 12.8 m) and the bottom of the reclamation area (depth 50.3 m), a 42.5 m depth was assumed and the EEF was applied at that depth.

Table A14: Scraper Travel Emission Factors (kg/VKT) and Emissions with EEF (kg/11-hour day)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor	kg/VKT	0.686	0.0943	0.0094
Emissions - Unmitigated	kg/day	10.0	2.55	0.310

Since the new mining block will be stripped in January, February, and March, an emission reduction of 90% was applied for scraper travel in winter haul road conditions.

The emission calculation is as follows (for silt content 3.3% and weight 55.2 t):

$$TSP\left(\frac{kg}{VKT}\right) = 9.6 * 10^{-6} * 3.3^{1.3} * 55.2^{2.4} = 0.686$$

331 km/day * 0.686 kg/VKT= 226.8 kg/day

Mitigated: 226.8 kg/day * (1-90/100) = 22.7 kg/day.

Using EEF at a depth of 42.5 m, TSP emissions are reduced to 10.0 kg/day. Scraper travel emissions were modelled as a ROAD source in CALPUFF.

A3.6 Haul Truck Fugitive Dust Emissions

Transportation emissions, from vehicles hauling aggregate from the mining block to the permanent crusher on unpaved roads, can be calculated using equations taken from US AP 42, Table 13.2.2-2 (Unpaved Roads) (US EPA 2006a):

$$TSP\left(\frac{kg}{VKT}\right) = 4.9 * 0.2819 * \left(\frac{s}{12}\right)^{0.7} * \left(\frac{W}{2.7}\right)^{0.45}$$
$$PM_{10}\left(\frac{kg}{VKT}\right) = 1.5 * 0.2819 * \left(\frac{s}{12}\right)^{0.9} * \left(\frac{W}{2.7}\right)^{0.45}$$
$$PM_{2.5}\left(\frac{kg}{VKT}\right) = 0.10 * PM_{10}\left(\frac{kg}{VKT}\right)$$

where:

- *s* - is the silt content of the road surface (3.3% - **Table A1**)
- *W* – is average weight of vehicle fleet

The total kilometres travelled by the vehicle fleet (water truck and quarry trucks) is around 587 km/day.

The emission factor for the haul road is (silt content 4.8%; and weight 66.0 t):

$$TSP\left(\frac{kg}{VKT}\right) = 6.0 * 0.2819 * \left(\frac{3.3}{12}\right)^{0.7} * \left(\frac{66}{2.7}\right)^{0.45} = 2.348$$

Using VKT = 250 km/day:

2.348 (kg/VKT) * 250 km/day = 586 kg/day

Mitigated by Watering: 586 * (1-80/100) = 117 kg TSP/day

Table A15 summarizes haul truck emissions for 4 trucks hauling aggregate from the mining block to the permanent crusher. Since hauling occurs approximately 44 m below the ground, EEFs were applied.

Table A15: Quarry Truck Travel Emission Factors (kg/VKT) and Emissions with EEF (kg/11-hour day)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor	kg/VKT	2.348	0.556	0.0556
Emissions – Mitigated & with EEF	kg/day	56.0	22.5	2.75

A3.7 Conveyor Fugitive Dust Emissions

Conveyor emissions are usually estimated using emission factors for controlled conveyor transfer points from AP 42 Table 11.19.2-1 (Crushed Stone Processing and Pulverized Mineral Processing) (US EPA 2004). Ten transfer points were modelled for the Truck Case (where the off-site conveyor starts at the permanent crusher site) and nine for the cases when in-pit conveyor starts at the mining block (at the mobile crusher site). The off-site conveyor will be covered outside the Scott Pit property and will be not covered inside. However, all transfer point emissions will be controlled. **Table A16** summarizes transfer points emission factors and emissions assuming the EEF for the conveyors are calculated per the information in Section A2.5.

Table A16: Transfer Point Emission Factors (kg/t) and Emissions (kg/11-hour day)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor (for one Transfer Point)	kg/t	7.00E-05	2.30E-05	6.50E-06
Transfer Point Emissions for Centre of Pit – Mechanical Breaker and Blasting Cases	kg/day	1.29	0.676	0.223
Transfer Point Emissions for Centre of Pit – Truck Case	kg/day	1.73	0.902	0.297
Transfer Point Emissions East of Pit	kg/day	1.16	0.495	0.149
Transfer Point Emissions for Off-site Conveyor	kg/day	3.22	1.057	0.299

Conveyors are subject to wind driven emissions, even if covered. Both conveyors are anticipated to be 48” wide (1.22 m). The exposed conveyor width was made larger (by 20% or 1.46 m) because the aggregate surface on the conveyor belt is not completely smooth. With a width of 1.46 m and an off-site length of 4.98 km, the effective area for emissions was 7,284 m^2 (0.73 ha). **Table A17** summarizes lengths and areas of the conveyor sections for all emission cases.

Table A17: Lengths and Areas of Modelled Conveyor Sections

Cases	Length (m)	Area (ha)
Off-site Conveyor - Outside Scott Property	4,979	0.728
In-pit Conveyor in Centre and West of Pit - Mechanical Breaker and Blasting Cases	1,040	0.152
In-pit Conveyor in Eastern Part of the Pit - Mechanical Breaker and Blasting Cases	405	0.059
TOTAL - Mechanical Breaker and Blasting Cases	**6,424**	**0.940**
In-pit Conveyor in Centre and West of Pit - Truck Case	1,030	0.151
In-pit Conveyor in Eastern Part of the Pit - Truck Case	511	0.075
TOTAL - Truck Case	**6,520**	**0.954**

Wind speed dependent emissions for conveyors were adopted from AP 42 Table 11.9-2 (US EPA 1998b). The emission factor for TSP is 1.9*U kg/hectare/hr (0.5 g/s/ha), where U is wind speed in m/s. It was assumed the threshold velocity, below which there are no wind driven emissions, is 5.14 m/s. This velocity is similar to the threshold velocity (5.43 m/s) listed in A&WMA (1992) and NPI (2012). Conveyor wind speed dependent emissions are generally low and for simplicity were modelled using the average wind ranges in CALPUFF. For example, for wind speed between 10.8 m/s and 22 m/s the emissions were calculated for an average speed of 16.4 m/s. For an active conveyor area of 0.73 ha, TSP hourly emissions, for the wind speed range 10.8 m/s to 22.0 m/s, are:

$$TSP\left(\frac{kg}{hr}\right) = 0.5 * 16.4\left(\frac{g}{s * ha}\right) * 0.73\,ha * 3600\frac{s}{hr} * \frac{kg}{1000g} = 5.97$$

The off-site conveyor will be fully enclosed and a 70% reduction in emissions was applied as suggested by NPI (2012), reducing TSP emissions in the example to 1.79 kg/hr. An EEF was applied per Section A2.5.

Table A18 summarizes maximum 1-hour emissions, **Table A19** summarizes maximum 24-hour emissions, and **Table A20** summarizes total annual wind speed dependent emissions from the conveyor surfaces.

Table A18: Maximum 1-hour Conveyor Wind Speed Dependent Emissions

Conveyor	TSP 1-Hour Maximum (kg/hr)	PM_{10} 1-Hour Maximum (kg/hr)	$PM_{2.5}$ 1- Hour Maximum (kg/hr)
Centre of Pit - Mechanical Breaker & Blasting Cases (in-pit)	2.66	1.76	0.319
Centre of Pit - Truck Case (in-pit)	2.63	1.74	0.316
East of Pit - Mechanical Breaker & Blasting Cases (in-pit)	1.33	0.77	0.125
East of Pit - Truck Case (in-pit)	1.68	0.97	0.158
Outside Scott Pit (off-site)	6.45	3.05	0.462

Table A19: Maximum 24-hour Conveyor Wind Speed Dependent Emissions

Conveyor	TSP 24-Hour Maximum (kg/day)	PM_{10} 24-Hour Maximum (kg/day)	$PM_{2.5}$ 24- Hour Maximum (kg/day)
Centre of Pit - Mechanical Breaker & Blasting Cases (in-pit)	16.5	10.9	1.98
Centre of Pit - Truck Case (in-pit)	16.4	10.8	1.96
East of Pit - Mechanical Breaker & Blasting Cases (in-pit)	8.3	4.8	0.78
East of Pit - Truck Case (in-pit)	10.4	6.0	0.98
Outside Scott Pit (off-site)	40.1	19.0	2.87

Table A20: Average Annual Total Conveyor Wind Speed Dependent Emissions

Conveyor	TSP Total Annual (t/year)	PM_{10} Total Annual (t/year)	$PM_{2.5}$ Total Annual (t/year)
Centre of Pit - Mechanical Breaker & Blasting Cases (in-pit)	0.352	0.233	0.0423
Centre of Pit - Truck Case (in-pit)	0.349	0.230	0.0418
East of Pit - Mechanical Breaker & Blasting Cases (in-pit)	0.176	0.101	0.0165
East of Pit - Truck Case (in-pit)	0.222	0.128	0.0209
Outside Scott Pit (off-site)	0.854	0.404	0.0612

A3.8 Fugitive Dust Emissions from Mined and Scraped Surfaces

The fugitive dust emissions from exposed surfaces at the mining block, scraped area, and the reclamation area can be calculated using equations for conveyor emissions presented in the previous section. As in conveyor cases, wind-generated emissions were calculated using hourly wind speeds.

The active area of the surface was estimated using the Phase 2 plan. Total area for Phase 2 operations was estimated to be 207,000 m^2. Assuming five years of operations for Phase 2, the area of the active mine in one year is 207,000 / 5 = 41,400 m^2. This area is stripped in 3 months and assuming that the active area is 50% of the total area stripped in a given month: 0.5 * 41,400 / 3 = 3,451 m^2 = 0.345 ha. This is a conservative assumption since that area will be smaller on a given workday and the ground in winter will be wet and/or frozen. However, to account for occasional drier, snow-free periods, 0.345 ha used for active scraping and for the reclamation area. The mining block area during aggregate removal operations was estimated as 50% of the active area for each month: 0.5 * 41,400 / 8 = 2,588 m^2 = 0.26 ha.

Table A21 summarizes maximum 1-hour emissions, **Table A22** summarizes maximum 24-hour emissions, and **Table A23** summarizes total annual wind generated emissions from the aggregate, freshly scraped pit block, and reclamation area.

Table A21: Wind Generated Overburden and Aggregate Maximum 1-Hour Wind Speed Dependent Emissions (EEF Applied)

Activity	TSP 1-Hour Maximum (kg/hr)	PM_{10} 1-Hour Maximum (kg/hr)	$PM_{2.5}$ 1- Hour Maximum (kg/hr)
Freshly Scraped Pit Area (Active Area 0.345 ha)	7.12	4.00	0.643
Reclamation Area (Active Area 0.345 ha)	5.06	3.42	0.639
Aggregate Mining Area (Active Area 0.26 ha)	4.19	2.65	0.462

Table A22: Wind Generated Overburden and Aggregate Maximum 24-hour Wind Speed Dependent Emissions (EEF Applied)

Activity	TSP 24-Hour Maximum (kg/day)	PM_{10} 24-Hour Maximum (kg/day)	$PM_{2.5}$ 24- Hour Maximum (kg/day)
Freshly Scraped Pit Area (Active Area 0.345 ha)	97.4	54.7	8.81
Reclamation Area (Active Area 0.345 ha)	69.2	46.9	8.75
Aggregate Mining Area (Active Area 0.26 ha)	57.8	36.6	6.37

Table A23: Wind Generated Overburden and Aggregate Average Annual Total Wind Speed Dependent Emissions (EEF Applied)

Activity	TSP Total Annual (t/year)	PM_{10} Total Annual (t/year)	$PM_{2.5}$ Total Annual (t/year)
Freshly Scraped Pit Area (Active Area 0.345 ha)	1.055	0.592	0.0954
Reclamation Area (Active Area 0.345 ha)	0.750	0.507	0.0948
Aggregate Mining Area (Active Area 0.26 ha)	1.125	0.712	0.1241

A4. Emissions from Diesel Combustion

The following section outlines the approach taken to estimate emissions generated by diesel combustion from the aggregate pit equipment such as excavators, loader, bulldozers, scrapers, and idling trucks. Subsequent sections list emission factors, parameters, and maximum hourly emissions of SO_2, NOx, CO, THC (VOC), $PM_{2.5}$, PM_{10}, TSP, benzene and Benzo(a)Pyrene (BaP).

A4.1 Diesel Combustion, Gaseous Emissions of NO_X, CO, SO_2 and Particulates

Table A24 lists Project diesel-powered equipment based on Source Classification Code (SCC) with age (tier), power, and fuel consumption to calculate emissions from combustion. The list of equipment was provided by Lehigh. Fuel consumption was taken from Caterpillar (2016a) for medium load application and from Caterpillar (2016b) for the D9R Track Dozer.

Table A24: Source Classification Code (SCC) Parameters, Power, Age, and Fuel Consumption of Diesel-Powered Equipment

SCC	Equipment	Fleet Size	Tier	Engine Net Power (hp)	Fuel Consumption (l/hr)
2270002051	Quarry Truck CAT773D[1]	3	1	650	48.1
2270002036	Excavator CAT374D with breaker attachment[1,2,3]	1	2	476	44.6
2270002060	Cat 990H Wheel Loader[1,2,3]	2	3	627	66.7
2270002051	Water Truck CAT773 Modified[1]	1	1	650	48.1
2270002018	Scraper CAT627K[4]	4	3	290	71.6
2270002069	Bulldozer CATD9R (Track)[4]	1	1	405	52.8
2270002069	Bulldozer CATD10R (Track)[2,3]	1	1	575	56.0
2270002033	Atlas Copco D65 Drill[3]	1	3	540	52.6

Notes: 1 Truck Case
2 Mechanical Breaker & Conveyor Case
3 Blasting & Conveyor Case
4 Winter Case

For haul trucks, it was assumed that within each operating hour, four CAT 773D trucks will idle for 18 minutes during loading with aggregate and for another 18 minutes when unloading into the crusher. During the remainder of the hour, trucks are hauling aggregate between the mining block and the crusher. Each truck makes six to seven round trips each hour. In addition, it was assumed that one water truck travels the road continuously, 11 hours/day.

The equipment production year indicates the engine efficiency (tier), based on equipment specifications. Usually, newer engines have lower emissions. **Table A25** summarizes Brake Specific Fuel Consumption (BSFC) values and engine Load Factors (LF). BSFC is a measure of the fuel efficiency of a combustion engine which burns fuel and produces rotational power. The methodology for the calculation of emission factors in NONROAD model was taken from US EPA (2010; 2008). Steady state, zero-hour emission factors (EF_{raw}) and BSFC, listed in the emission database on the NONROAD model website (part of the archive for the MOVES model), are already adjusted by the Transient Adjustment Factor (TAF). Transient mode of engine operation better reflects engine load, speed of vehicle and other parameter changes (e.g., during loader transit, lifting material, unloading and moving). The transient mode emission factors (EF_{raw}) are obtained by multiplying steady state emission factors (E_{ss}) by TAF.

The engine Load Factor (LF) is defined as the portion of the rated engine power that is utilized during engine operation. This factor is specific to the equipment type and independent of engine size and rated engine power.

Table A25: Load Factors (LF) and Brake Specific Fuel Consumption (BSFC) of Diesel-Powered Equipment

Equipment	LF	BSFC (lb/hp-h)
Quarry Truck CAT773D	0.59	0.367
Excavator CAT374D with breaker attachment	0.59	0.371
Cat 990H Wheel Loader	0.59	0.371
Water Truck CAT773 Modified	0.59	0.367
Scraper CAT627K,	0.59	0.371
Bulldozer CATD9R (Track)	0.59	0.433
Bulldozer CATD10R (Track)	0.59	0.433
Atlas Copco D65 Drill	0.59	0.367

In US EPA (2010), Equation 1 and Equation 2 (Page 6) were used to calculate emission factors for CO, NO_X, and HC (which was assumed as equivalent to THC in this document). Diesel combustion emission factors adjusted for deterioration are calculated by the following equation (Page 6; Equation 1, US EPA 2010):

$$EF_{adjusted}\ (g/hp\text{-}h) = EF_{raw} * DF$$

Where:

- EF_{raw} – Emission Factor NO_X, CO, or THC (g/hp-h from data in US EPA 2008)
- DF –Deterioration Factor (unitless) (function of the technology type and age of the engine) for NO_X, CO, and THC.

$$DF = 1 + A * \frac{(cumulative\ hours * LF)}{median\ life\ at\ full\ load\ in\ hours}$$

Where *A* is relative deterioration factor (% of emission increase / % of useful life). The maximum deterioration factors (*DF*) were used in the calculation assuming all Project equipment has worked more hours than their median life. **Table A26** lists relative deterioration factors for nonroad diesel engines (Table A6, page A16, US EPA 2010).

Table A26: Relative Deterioration Factor (*A*) of Nonroad Diesel Powered Equipment

Compound	Tier 1	Tier 2	Tier 3
THC	0.036	0.034	0.027
CO	0.101	0.101	0.151
NO_X	0.024	0.009	0.008
PM_{10}	0.473	0.473	0.473

An example of calculations for adjusted emission factor for NO_X emitted by CAT 773D haul truck (Tier 1, net power 650 hp) is:

$$EF_{adjusted}\ (g/hp\text{-}h) = 5.52 * 1.024 = 5.65$$

The adjusted emission factors for PM_{10} emissions were slightly modified to account for variation in diesel fuel sulphur content – S_{PMadj} (Equation 5 at Page 23 of the US EPA 2010):

$$S_{PMadj} = BSFC * 453.6 * 7 * 0.02247 * (0.33 – 0.0015)$$

Where:

- S_{PMadj} – adjustment to PM_{10} emissions to account for variations in fuel sulphur content
- BSFC – Brake Specific Fuel Consumption (lb/hp-h)
- 453.6 is the conversion factor from pounds to grams
- 7 – grams PM_{10} sulphate / grams of PM_{10} sulphur
- 0.02247 is default value for grams of PM_{10} sulphur / grams of fuel sulphur consumed (for Tiers 1 to 3)
- 0.33 – default certification fuel sulphur weight percent (33,000 ppm sulphur content)
- 0.0015 – fuel sulphur weight percent used in Canada since 2010 (15 ppm)

The S_{PMadj} values were calculated as:

- S_{PMadj} = 0.0860 g/hp-h for BSFC0.367 lb/hp-h,
- S_{PMadj} = 0.0870 g/hp-h for BSFC; = 0.371 lb/hp-h, and
- S_{PMadj} = 0.1015 g/hp-h for BSFC = 0.433 lb/hp-h.

Following is an example calculation for Tier 1 and BSFC = 0.367 lb/hp-h:

$$S_{PMadj} = 0.367 * 453.6 * 7 * 0.02247 * (0.33 – 0.0015) = 0.086 \text{ g/hp-h}$$

The adjusted PM_{10} emission factor is calculated using Equation 2, Page 6; US EPA (2008):

$$EF_{adjusted} \text{ (g/hp-h)} = EF_{raw} * DF - S_{PMadj}$$

Where:

- EF_{raw} – Emission Factor for PM_{10} (g/hp-h from raw data in NONROAD, 2008)
- DF – Maximum Deterioration Factor (unitless) (1+A: function of the technology type and age of the engine) for PM_{10} listed in **Table A21** above
- S_{PMadj} – adjustment to PM emissions presented above (BSFC - **Table A25**).

An example calculation for adjusted emission factor of PM_{10} emitted by CAT 773D haul truck (Tier 1, net power 650 hp) is:

$$EF_{adjusted} \text{ (g/hp-h)} = 0.27 * 1.473 – 0.086 = 0.312$$

The emission factors of $PM_{2.5}$ was calculated as 0.97*PM_{10} and TSP = PM_{10} (pages 23 and 24 of US EPA 2010).

The diesel combustion emission factor for SO_2 were obtained by the following equation (Equation 7 at Page 24 of US EPA 2010):

$$SO_2 = \{[BSFC * 453.6 * (1- 0.02247) – THC] * 0.01 * 2 * 0.0015\}$$

Where:

- BSFC – Brake Specific Fuel Consumption (lb/hp-h)
- 453.6 – Conversion factor from pounds to grams

- 0.02247 – Fraction of fuel sulphur converted to direct PM
- THC – Total Hydrocarbon
- 0.01 – Conversion factor from weight percent to weight fraction
- 2 – Grams of SO_2 formed from a gram of sulphur
- 0.0015 – Weight percent of sulphur in ultra-low sulphur diesel (15 ppm)

An example calculation for adjusted emission factor for SO_2 emitted by CAT 773D haul truck (Tier 1, net power 650 hp) is:

$$SO_2 = \{[0.367 * 453.6 * (1- 0.02247) – 0.155] * 0.01 * 2 * 0.0015\} = 0.0049 \text{ g/hp-h}$$

S_{PMadj} and SO_2 adjusted emission factors are calculated using ultra low sulphur diesel - ULSD (15 ppm sulphur). **Table A27** summarizes deterioration-adjusted emission factors used to calculate combustion emissions from diesel burning equipment.

Table A27: Deterioration-Adjusted Emission Factors

Equipment	S_{PMAdj} (g/hp-h)	THC (g/hp-h)	SO_2 (g/hp-h)	NO_x (g/hp-h)	CO (g/hp-h)	TSP (g/hp-h)	PM_{10} (g/hp-h)	$PM_{2.5}$ (g/hp-h)
Quarry Truck CAT773D	0.086	0.155	0.0049	5.65	2.24	0.312	0.312	0.302
Excavator CAT374D with breaker attachment	0.087	0.176	0.0049	4.15	1.42	0.149	0.149	0.144
Cat 990H Wheel Loader	0.087	0.175	0.0049	2.63	2.34	0.237	0.237	0.230
Water Truck CAT773 Modified	0.086	0.155	0.0049	5.65	2.24	0.312	0.312	0.302
Scraper CAT627K,	0.087	0.195	0.0049	2.63	1.31	0.237	0.237	0.230
Bulldozer CATD9R (Track)	0.102	0.218	0.0058	5.84	2.24	0.267	0.267	0.259
Bulldozer CATD10R (Track)	0.102	0.218	0.0058	5.84	2.24	0.267	0.267	0.259
Atlas Copco D65 Drill	0.086	0.175	0.0049	2.52	0.97	0.135	0.135	0.131

Table A28 summarizes diesel combustion emissions calculated for equipment used in the Truck Case, **Table A29** summarizes diesel combustion emissions for equipment used in Mechanical Breaker Case, **Table A30** summarizes diesel combustion emissions for Blasting Case, and **Table A31** summarizes diesel combustion emissions for Winter Case.

The maximum hourly emissions (g/s) presented in **Table A28**, **Table A29**, **Table A30** and **Table A31** were calculated for particulates, NO_X, CO, and THC using following equation:

$$\text{Emission (g/s)} = LF^* EF_{adjusted} * PR * EN / 3600 \text{ s/h}$$

Where:

- LF – Load Factor from **Table A25**
- $EF_{adjusted}$ – Adjusted Emission Factor (g/hp-h) from **Table A27**
- PR – Engine Power Rating (hp) (**Table A24**)
- EN – Number of Engines (**Table A24**)

An example calculation for emissions of NO_X emitted by three CAT 773D haul trucks idling within one hour (Tier 1, net power 650 hp) is:

$$\text{Emission (g/s)} = 0.59^* 5.652 \text{ g/hp-h} * 650 \text{ hp} * 3 \text{ trucks} *18 \text{ min} /60 \text{ min} / 3600 \text{ s/h} = 0.542$$

The maximum hourly emissions (g/s) presented in **Table A28**, **Table A29**, **Table A30** and **Table A31** were calculated for SO_2 using following equation:

$$\text{Emission (g/s)} = EF_{adjusted} * PR * EN / 3600 \text{ s/h}$$

Where:

- $EF_{adjusted}$ – Adjusted SO_2 Emission Factor (g/hp-h) from **Table A27**
- PR – Engine Power Rating (hp) (**Table A24**)
- EN – Number of Engines (**Table A24**)

An example calculation for adjusted emission factor for SO_2 emitted by three CAT 773D haul trucks idling at aggregate pit site for 18 minutes in one hour (Tier 1, net power 650 hp) is:

$$\text{Emission (g/s)} = 0.0049 \text{ g/hp-h} * 650 \text{ hp} * 18 \text{ min}/60 \text{ min} / 3600 \text{ s/h} = 0.00079$$

Table A28: Emissions from Diesel Combustion – Truck Case

Equipment	THC (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)
Permanent Crusher Area							
Trucks CAT773D Idling	0.0149	0.00079	0.542	0.214	0.0299	0.0299	0.0290
Haul Road							
Trucks CAT773D Hauling	0.0199	0.00106	0.7226	0.2857	0.0398	0.0398	0.0386
Water Truck CAT773	0.0010	0.00005	0.0366	0.0145	0.0020	0.0020	0.0020
TOTAL for Haul Road	**0.0209**	**0.0011**	**0.759**	**0.300**	**0.0418**	**0.0418**	**0.0406**
Aggregate Pit Operations							
Trucks CAT773D Idling	0.0149	0.00079	0.542	0.214	0.0299	0.0299	0.0290
Excavators CAT374D with breaker attachment	0.0137	0.00065	0.3235	0.1108	0.0116	0.0116	0.0113
Cat 990H Wheel Loader	0.0359	0.00172	0.5407	0.4802	0.0487	0.0487	0.0473
TOTAL for Aggregate Pit	**0.0645**	**0.0032**	**1.406**	**0.805**	**0.0902**	**0.0902**	**0.0875**
TOTAL							
Hourly Maximum TOTAL for Truck Case (g/s)	**0.100**	**0.005**	**2.707**	**1.319**	**0.162**	**0.162**	**0.157**
Daily Maximum TOTAL for Truck Case (kg/11 hrs day)	**3.97**	**0.202**	**107**	**52.2**	**6.41**	**6.41**	**6.22**

Table A29: Emissions from Diesel Combustion – Mechanical Breaker Case

Equipment	THC (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)
Aggregate Pit Operations							
Excavators CAT374D with breaker attachment	0.0137	0.00065	0.3235	0.1108	0.0116	0.0116	0.0113
Cat 990H Wheel Loader	0.0359	0.00172	0.5407	0.4802	0.0487	0.0487	0.0473
Bulldozer CAT D10R (Track)	0.0205	0.0009	0.5500	0.2106	0.0251	0.0251	0.0244
TOTAL for Aggregate Pit (g/s)	**0.070**	**0.003**	**1.414**	**0.8016**	**0.0855**	**0.0855**	**0.0829**
Daily Maximum TOTAL for Mechanical Breaker Case (kg/11 hrs day)	**2.78**	**0.130**	**56.0**	**31.7**	**3.38**	**3.38**	**3.28**

Table A30: Emissions from Diesel Combustion – Blasting Case

Equipment	THC (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)
Aggregate Pit Operations							
Excavators CAT374D	0.0137	0.00065	0.3235	0.1108	0.0116	0.0116	0.0113
Cat 990H Wheel Loader	0.0359	0.00172	0.5407	0.4802	0.0487	0.0487	0.0473
Bulldozer CAT D10R (Track)	0.0205	0.0009	0.5500	0.2106	0.0251	0.0251	0.0244
Drill Atlas COPCO D65	0.0113	0.0007	0.1625	0.0624	0.0087	0.0087	0.0084
TOTAL for Aggregate Pit:	**0.081**	**0.004**	**1.577**	**0.8640**	**0.0942**	**0.0942**	**0.0913**
Daily Maximum TOTAL for Blasting Case (kg/11 hrs day)	**3.22**	**0.159**	**62.4**	**34.2**	**3.73**	**3.73**	**3.62**

Table A31: Emissions from Diesel Combustion – Winter Case

Equipment	THC (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)
Four Scrapers Stripping Overburden and Travelling to Reclamation Area							
Scrapers CAT627K	0.0371	0.00159	0.5002	0.2495	0.0451	0.0451	0.0437
Reclamation Area Bulldozing							
Bulldozer CAT D9R (Track)	0.0144	0.0006	0.3874	0.1484	0.0177	0.0177	0.0172
TOTAL for Reclamation and Scrapers (g/s)	**0.0515**	**0.0022**	**0.8876**	**0.3978**	**0.0628**	**0.0628**	**0.0609**
Daily Maximum TOTAL for Winter Case (kg/11 hrs day)	**2.04**	**0.089**	**35.1**	**15.8**	**2.49**	**2.49**	**2.41**

A4.2 Diesel Combustion Emissions of Benzene and BaP

Emissions of speciated hydrocarbons and PAHs from diesel (and gasoline) combustion can be calculated using emission factors in AP 42 Table 3.4-1 (Large Stationary Diesel) (US EPA 1996a) and Tables 3.3-1 and 3.3-2 (Gasoline and Diesel Industrial Engines) (US EPA 1996b). Emission factors in AP 42 are in units of lb/MMBtu. According to US EPA (1996c) suggested values for diesel properties are:

1. Diesel Higher Heating Value (HHV) 19,300 Btu/lb
2. Diesel fuel density 7.1 lb/US Gallon (or 0.85 kg/Litre of diesel fuel)

Using the above values, the conversion factor can be calculated as: 1lb/MMBtu = 16.42 gram/litre of diesel fuel. Emission factors for small and large engines were determined by the approximate horsepower for each individual operation (small engines are smaller or equal to 600 hp).

Alternatively, there are more recent emission factors obtained from heavy truck emissions measured in situ at Syncrude Oil Sands mines. Twenty-two measurements in 2009 and 2010 on two truck types yielded an average emission factor (DRI & WBEA, 2014a,b).

The benzene emissions in DRI & WBEA (2014a,b) were slightly lower (1.02E-02 g/l) than those in US EPA (1996a, and b) and were not used in this air quality assessment. Both emission factors for BaP listed in US EPA (1996a,b) are below detection limits (BDL - <4.22E-06 g/l and <3.09E-06 g/l), so BaP emissions were calculated using the emission factor (5.78E-06 g/l) from DRI & WBEA (2014a,b).

Table A32 summarizes benzene and BaP emission factors used to calculate combustion emissions from Project diesel burning equipment. Using emission factors from **Table A32** and fuel consumption from **Table A24**, benzene and BaP emissions were calculated and summarized in **Table A33** for the Truck Case, in **Table A34** for the Mechanical Breaker Case, in **Table A35** for the Blasting Case and in **Table A36** for the Winter Case:

Table A32: Benzene and BaP Emission Factors Used for Emission Calculations

Compound	Emission Factors for Large Engines ≥ 600 hp (g/l)[1]	Emission Factors for Small Diesel & Gasoline Engines < 600 hp (gram/litre)[2]	DRI & WBEA (2014a,b)
Benzene	1.27E-02	1.53E-02	-
BaP	-	-	5.78E-06

Notes: 1 US EPA (1996a) / 2 US EPA (1996b)

Table A33: Benzene and BaP Emissions from Diesel Combustion - Truck Case

Equipment	Benzene (g/s)	BaP (g/s)
Permanent Crusher Area		
Trucks CAT 773D Idling	1.53E-04	6.94E-08
Haul Road		
Trucks CAT773D Hauling	2.03E-04	9.26E-08
Water Truck CAT773	1.70E-04	7.71E-08
TOTAL for Haul Road	**3.73E-04**	**1.70E-07**
Aggregate Pit Operations		
Trucks CAT773D Idling	1.53E-04	6.94E-08
Excavators CAT374D with breaker attachment	1.89E-04	7.15E-08
Cat 990H Wheel Loader	4.70E-04	2.14E-07
TOTAL for Aggregate Pit	**8.12E-04**	**3.55E-07**
TOTAL		
Hourly Maximum TOTAL for Truck Case (g/s)	**1.34E-03**	**5.94E-07**
Daily Maximum TOTAL for Truck Case (kg/11 hrs day)	**5.30E-02**	**2.35E-05**

Table A34: Benzene and BaP Emissions from Diesel Combustion - Mechanical Breaker Case

Equipment	Benzene (g/s)	BaP (g/s)
Aggregate Pit Operations		
Excavators CAT374D with breaker attachment	1.89E-04	7.15E-08
Cat 990H Wheel Loader	4.70E-04	2.14E-07
Bulldozer CAT D10R (Track)	2.38E-04	8.99E-08
TOTAL for Aggregate Pit	**8.98E-04**	**3.75E-07**
Daily Maximum TOTAL for Aggregate Pit (kg/11 hrs day)	**3.55E-02**	**1.49E-05**

Table A35: Benzene and BaP Emissions from Diesel Combustion - Blasting Case

Equipment	Benzene (g/s)	BaP (g/s)
Aggregate Pit Operations		
Excavators CAT374D	1.89E-04	7.15E-08
Cat 990H Wheel Loader	4.70E-04	2.14E-07
Bulldozer CAT D10R (Track)	2.38E-04	8.99E-08
Drill Atlas COPCO D65	2.24E-04	8.44E-08
TOTAL for Aggregate Pit (g/s)	1.12E-03	4.60E-07
Daily Maximum TOTAL for Blasting Case (kg/11 hrs day)	**4.44E-02**	**1.82E-05**

Table A36: Benzene and BaP Emissions from Diesel Combustion - Winter Case

Equipment	Benzene (g/s)	BaP (g/s)
Four Scrapers Stripping Overburden and Travelling to Reclamation Area		
Scrapers CAT627K	1.22E-03	4.60E-07
Reclamation area Bulldozing		
Bulldozer CAT D9R (Track)	7.60E-04	2.87E-07
TOTAL for Reclamation and Scrapers (g/s)	4.48E-04	1.69E-07
Daily Maximum TOTAL for Winter Case (kg/11 hrs day)	**1.21E-03**	**4.57E-07**

A5. Summary of Emissions

Table A37, **Table A38**, **Table A39 and Table A40** summarize the total maximum daily emissions from the Project, for Truck, Mechanical Breaker, Blasting, and Winter Cases, respectively.

Normal pit operations occur from April 1 to November 30 (Truck, or Mechanical Breaker, or Blasting Case), and stripping for the new mining block and dumping of overburden and soil into the reclamation area in January, February, and March of each year.

The highest maximum daily combustion emissions are expected from the mining block operations and the highest maximum daily particulate emissions will be from hauling aggregate from pit to crusher. Wind driven emissions can be very high but typically for a very short time. When winds are higher, dispersion conditions are more favourable, and concentrations observed near the ground can be lower.

Table A37: Summary of Maximum Daily Emissions - Truck Case

Emissions	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Permanent Crusher Area (Loading, Idling Trucks)									
Diesel Combustion	0.590	0.0314	21.5	8.49	1.18	1.18	1.15	6.04E-03	2.75E-06
Loading	0	0	0	0	27.2	16.8	2.87	0	0
Crushing	0	0	0	0	2.17	1.28	0.27	0	0
Crusher-area Emissions with EEF Applied	**0.59**	**0.0314**	**21.5**	**8.49**	**30.6**	**19.3**	**4.29**	**0.0060**	**2.75E-06**
Haul Road									
Diesel Combustion	0.83	0.0440	30.1	11.9	1.66	1.66	1.61	1.48E-02	6.72E-06
Wheel Entrainment	0	0	0	0	56.0	22.5	2.75	0	0
Road Emissions with EEF Applied	**0.83**	**0.044**	**30.1**	**11.9**	**57.7**	**24.2**	**4.36**	**0.0148**	**6.72E-06**
Mining Block (Mechanical Breaker, Truck Loading)									
Diesel Combustion	2.55	0.125	55.7	31.9	3.57	3.57	3.47	0.032	1.41E-05
Loading	0	0	0	0	20.0	12.7	2.21	0	0
Wind Generated	0	0	0	0	57.8	36.6	6.37	0	0
Mechanical Breaker	0	0	0	0	6.9	4.20	0.89	0	0
Pit Emissions with EEF Applied	**2.55**	**0.13**	**55.7**	**31.9**	**88.3**	**57.1**	**12.9**	**0.032**	**1.41E-05**
Conveyor									
Transfer Points	0	0	0	0	6.10	2.45	0.74	0	0
Unload at Spy Hill	0	0	0	0	10.5	5.86	0.40	0	0
Wind Generated	0	0	0	0	66.9	35.8	5.81	0	0
Conveyor Emissions with EEF Applied	**0**	**0**	**0**	**0**	**83.5**	**44.1**	**7.0**	**0**	**0**
TOTAL									
TOTAL Truck Case	**3.97**	**0.20**	**107**	**52**	**260**	**145**	**28.5**	**0.053**	**2.35E-05**

Note: EEF = pit emission escape fraction

Table A38: Summary of Maximum Daily Emissions - Mechanical Breaker Case

Emissions	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Mining Block (Mechanical Breaker, Bulldozer, Loading onto Mobile Crusher and In-pit Conveyor)									
Diesel Combustion	2.78	0.130	56.0	31.7	3.38	3.38	3.28	0.036	1.49E-05
Loading	0	0	0	0	40.0	25.3	4.41	0	0
Wind Generated	0	0	0	0	57.8	36.6	6.37	0	0
Mechanical Breaker, Bulldozer & Mobile Crusher	0	0	0	0	24.3	11.4	3.84	0	0
Pit Emissions with EEF Applied	**2.78**	**0.13**	**56.0**	**31.7**	**125.5**	**76.7**	**17.9**	**0.036**	**1.49E-05**

Emissions	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Conveyor									
Transfer Points	0	0	0	0	5.67	2.23	0.67	0	0
Unload at Spy Hill	0	0	0	0	10.5	5.86	0.40	0	0
Wind Generated	0	0	0	0	64.9	34.7	5.63	0	0
Conveyor Emissions with EEF Applied	**0**	**0**	**0**	**0**	**81.1**	**42.8**	**6.7**	**0**	**0**
TOTAL									
TOTAL Mechanical Breaker Case	**2.78**	**0.13**	**56.0**	**31.7**	**207**	**119**	**24.6**	**0.036**	**1.49E-05**

Note: EEF = pit emission escape fraction

Table A39: Summary of Maximum Daily Emissions - Blasting Case

Emissions	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Mining Block (Drill, Bulldozer, Loading on Mobile Crusher and In-pit Conveyor)									
Diesel Combustion	3.22	0.159	62.4	34.2	3.73	3.73	3.62	0.044	1.82E-05
Loading	0	0	0	0	40.0	25.3	4.41	0	0
Wind Generated	0	0	0	0	57.8	36.6	6.37	0	0
Drill, Bulldozer & Mobile Crusher	0	0	0	0	25.2	12.5	3.55	0	0
Pit Emissions with EEF Applied	**3.22**	**0.159**	**62.4**	**34.2**	**126.7**	**78.1**	**17.9**	**0.044**	**1.82E-05**
Conveyor									
Transfer Points	0	0	0	0	5.67	2.23	0.67	0	0
Unload at Spy Hill	0	0	0	0	10.5	5.86	0.40	0	0
Wind Generated	0	0	0	0	64.9	34.7	5.63	0	0
Conveyor Emissions with EEF Applied	**0**	**0**	**0**	**0**	**81.1**	**42.8**	**6.7**	**0**	**0**
Blasting									
Blasting (1hr/day)	**0**	**0.54**	**71.4**	**303.5**	**5.94**	**3.99**	**0.27**	**0**	**0**
TOTAL									
TOTAL Blasting Case (kg/Day)	**3.22**	**0.69**	**134**	**338**	**214**	**125**	**24.9**	**0.044**	**1.82E-05**

Note: EEF = pit emission escape fraction

Table A40: Summary of Maximum Daily Emissions - Winter Case

Emissions	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Stripping Overburden at new Mining Block									
Loading	0	0	0	0	14.8	8.29	1.33	0	0
Wind Generated	0	0	0	0	97.4	54.7	8.81	0	0
Stripping Emissions with EEF Applied	**0**	**0**	**0**	**0**	**112.2**	**63.0**	**10.14**	**0**	**0**
Scraper Travel									
Diesel Combustion	1.47	0.06	19.8	9.88	1.79	1.79	1.73	0.048	1.82E-05
Wheel Entrainment	0	0	0	0	10.0	2.55	0.31	0	0
Scraper Emissions with EEF Applied	**1.47**	**0.063**	**19.8**	**9.88**	**11.8**	**4.34**	**2.04**	**0.048**	**1.82E-05**
Reclamation Area									
Diesel Combustion (Bulldozer)	0.57	0.026	15.3	5.87	0.70	0.70	0.68	0.009	3.35E-06
Bulldozing	0	0	0	0	3.47	1.12	0.84	0	0
Dumping of Overburden	0	0	0	0	10.5	7.10	1.33	0	0
Wind Generated	0	0	0	0	69.2	46.9	8.75	0	0
Reclamation Emissions with EEF Applied	**0.57**	**0.026**	**15.3**	**5.87**	**83.9**	**55.8**	**11.6**	**0.009**	**3.35E-06**
TOTAL									
TOTAL Winter Case	**2.04**	**0.089**	**35.1**	**15.8**	**208**	**123**	**23.8**	**0.057**	**2.16E-05**

Note: EEF = pit emission escape fraction

From **Table A37**, **Table A38**, **Table A39** and **Table A40** it is clear that maximum daily emissions of THC, benzene and BaP are highest for the Truck Case. Modelled maximum daily emissions of CO, NO_2, and SO_2 are significantly higher for the Blasting Case from using ANFO.

The highest particulate daily maximum emissions are from wind generated emissions at very high wind speeds. However, these emissions are infrequent. For continuous operations, truck daily maximum emissions are the highest, following by bulldozers, crusher and mechanical breaker.

Table A41 summarizes the maximum 24-hour emissions from the four emission cases. The Mechanical Breaker Case has the lowest maximum daily total emissions. Particulate emissions are the highest for the Truck Case while SO_2, NO_2, and CO emissions are significantly higher for the Blasting Case.

Table A41: Summary of 24-hour Emissions for All Cases

Emissions/ Cases	THC (kg/day)	SO_2 (kg/day)	NO_x (kg/day)	CO (kg/day)	TSP (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	Benzene (kg/day)	BaP (kg/day)
Winter	2.04	0.09	35.1	15.8	208	123	23.8	0.057	2.16E-05
Truck	3.97	0.20	107	52	260	145	28.5	0.053	2.35E-05
Mechanical Breaker	2.78	0.13	56.0	31.7	207	119	24.6	0.036	1.49E-05
Blasting	3.22	0.69	134	338	214	125	24.9	0.044	1.82E-05

Table A42, **Table A43** and **Table A44** summarize total modelled annual emissions for Truck, Mechanical Breaker and Blasting Cases combined with the Winter Case to illustrate total annual emissions. The highest total annual emissions are from hauling aggregate in the Truck Case, followed by mining block emissions and the permanent crusher. SO_2, NO_2, and CO emissions are significantly higher for the Blasting Case. Wind generated particulate emissions from wind-exposed areas (and loading / unloading wind dependent emissions) are much less significant for total annual emissions than for daily maximum emissions as high wind speeds occur infrequently

Table A42: Summary of Total Annual Emissions - Combined Truck and Winter Cases

Emissions	THC (t/year)	SO_2 (t/year)	NO_x (t/year)	CO (t/year)	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	Benzene (t/year)	BaP (t/year)
Truck Case									
Permanent Crusher	0.144	0.008	5.24	2.07	0.82	0.60	0.35	1.47E-03	6.71E-07
Mining block Block Total Emissions	0.623	0.031	13.6	7.8	2.56	1.90	1.06	7.85E-03	3.43E-06
Haul Road Total Emissions	0.202	0.011	7.34	2.90	14.1	5.89	1.06	3.60E-03	1.64E-06
Loading / Unloading	0	0	0	0	3.08	1.92	0.33	0	0
Wind Generated from Mining block Block Surface	0	0	0	0	1.13	0.71	0.12	0	0
Conveyor Transfer Points and Unload	0	0	0	0	4.05	2.03	0.28	0	0
Conveyor Wind Generated	0	0	0	0	1.43	0.76	0.12	0	0
TOTAL for Truck Case	**0.97**	**0.049**	**26.2**	**12.8**	**27.1**	**13.8**	**3.33**	**0.013**	**5.74E-06**
Winter Case									
Travelling Scrapers	0.132	0.0057	1.783	0.889	1.061	0.390	0.184	4.34E-03	1.64E-06
Bulldozer at Reclamation Area	0.051	0.0023	1.381	0.529	0.375	0.164	0.137	7.99E-04	3.02E-07
Loading / Unloading	0	0	0	0	0.624	0.380	0.066	0	0
Wind Generated from Pit and Reclamation Area	0	0	0	0	1.805	1.099	0.190	0	0
TOTAL for Winter	**0.184**	**0.0080**	**3.16**	**1.42**	**3.87**	**2.03**	**0.58**	**0.0051**	**1.94E-06**
TOTAL									
TOTAL for Hauling and Winter Case	**1.15**	**0.057**	**29.3**	**14.2**	**31.0**	**15.8**	**3.91**	**0.018**	**7.68E-06**

Table A43: Summary of Total Modelled Annual Emissions – Combined Mechanical Breaker and Winter Cases

Emissions	THC (t/year)	SO_2 (t/year)	NO_x (t/year)	CO (t/year)	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	Benzene (t/year)	BaP (t/year)
Mechanical Breaker Case									
Mining block Block Total Emissions	0.68	0.032	13.7	7.75	6.75	3.61	1.74	8.67E-03	3.63E-06
Loading / Unloading	0	0	0	0	2.61	1.65	0.29	0	0
Wind Generated from Mining block Block Surface	0	0	0	0	1.13	0.71	0.12	0	0
Conveyor Transfer Points and Unload	0	0	0	0	3.95	1.97	0.26	0	0
Conveyor Wind Generated	0	0	0	0	1.38	0.74	0.12	0	0
TOTAL for Mechanical Breaker Case	**0.68**	**0.032**	**13.7**	**7.75**	**15.8**	**8.68**	**2.53**	**8.67E-03**	**3.63E-06**
Winter Case									
TOTAL for Winter	**0.184**	**0.0080**	**3.16**	**1.42**	**3.87**	**2.03**	**0.58**	**0.0051**	**1.94E-06**
TOTAL									
TOTAL for Mechanical Breaker and Winter Case	**0.86**	**0.040**	**16.8**	**9.16**	**19.7**	**10.7**	**3.11**	**0.014**	**5.57E-06**

Table A44: Summary of Total Annual Emissions - Combined Blasting and Winter Cases

Emissions	THC (t/year)	SO_2 (t/year)	NO_x (t/year)	CO (t/year)	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	Benzene (t/year)	BaP (t/year)
Blasting Case									
Mining block Block	0.79	0.039	15.2	8.34	7.05	3.95	1.75	0.011	4.44E-06
Loading / Unloading	0	0	0	0	2.61	1.65	0.29	0	0
Wind Generated from Mining block Block Surface	0	0	0	0	1.13	0.71	0.12	0	0
Conveyor Transfer Points and Unload	0	0	0	0	3.95	1.97	0.26	0	0
Conveyor Wind Generated	0	0	0	0	1.38	0.74	0.12	0	0
Blasting	0	0.131	17.4	74.0	1.45	0.97	0.07	0	0
TOTAL for Blasting Case	**0.79**	**0.170**	**32.7**	**82.4**	**17.6**	**10.0**	**2.61**	**0.011**	**4.44E-06**
Winter Case									
TOTAL for Winter	**0.184**	**0.0080**	**3.16**	**1.42**	**3.87**	**2.03**	**0.58**	**0.0051**	**1.94E-06**
TOTAL									
TOTAL for Blasting and Winter Case	**0.97**	**0.177**	**35.8**	**83.8**	**21.4**	**12.0**	**3.18**	**0.016**	**6.38E-06**

Table A45 summarizes total annual emissions for the three cases. The lowest annual total emissions are from the combined Mechanical Breaker and Winter Cases. The highest particulate emissions (also THC, benzene and BaP) are from the combined Truck and Winter Cases, while the highest SO_2, NO_2, and especially CO emissions are caused by blasting in the combined Blasting and Winter Cases.

Dispersion modelling results are dependent on total emissions and source configurations. For example, in the Truck Case, particulate emissions are higher but spread over the haul road length and are internal to the Scott Footprint; whereas, Mechanical Breaker emissions are lower but concentrated at the mining block nearer the Scott Property boundary.

Table A45: Summary of Total Annual Emissions for All Cases

Emissions/ Cases	THC (t/year)	SO_2 (t/year)	NO_x (t/year)	CO (t/year)	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	Benzene (t/year)	BaP (t/year)
Winter + Truck	1.15	0.057	29.3	14.2	31.0	15.8	3.91	0.018	7.68E-06
Winter + Mechanical Breaker	0.86	0.040	16.8	9.16	19.7	10.7	3.11	0.014	5.57E-06
Winter + Blasting	0.97	0.177	35.8	83.8	21.4	12.0	3.18	0.016	6.38E-06

A6. Modelled Source Parameters

Previous sections identified emissions for all emission Cases as well as the basis for the emissions. This section documents the forms of those emissions in the dispersion model.

Table A46 summarizes parameters associated with volume sources in the mining block, including the location and the dimensions of the volume sources. In the mining block, four volume sources may be present depending on the emission Case and all four are listed. **Table A47** lists the volume sources associated with the permanent crusher in the Truck Case. **Table A48** lists the sources associated with the Winter Case. **Table A49** lists the parameters associated with line sources for conveyors, scraper travel and haul roads. **Table A50** and **Table A51** list the start and end points for modelled conveyors. **Table A52** identifies the haul road location.

Table A46: Modelled Volume Source Parameters – Mining Block

Parameter / Source	Mining Block - Mechanical Breaker or Drill, Idling Trucks or Bulldozer & Portable Crusher	Mining Block - Loading	Mining Block – Wind Generated	Blasting
Volume Source Location of Centre				
UTM11 (km E)	692.202			
UTM11 (km N)	5,674.308			
Elevation (m ASL)	1,248			
Volume Source Parameters				
Effective Height – E_h (m)	5.0	5.1	0.5	25
Initial Lateral Volume Source Dimension: σ_{xy} (m)	1.9	1.8	11.8	25
Initial Vertical Volume Source Dimension: σ_z (m)	2.3	2.4	0.5	12.5
Number of Days Modelled	244			

Table A47: Modelled Volume Source Parameters for Permanent Crusher – Truck Case

Parameter / Source	Permanent Crusher and Idling Trucks	Mining Block - Loading
Volume Source Location of Centre		
UTM11 (km E)	692.620	
UTM11 (km N)	5,674.571	
Elevation (m ASL)	1,255	
Volume Source Parameters		
Effective Height – E_h (m)	4.1	4.1
Initial Lateral Volume Source Dimension: σ_{xy} (m)	1.5	1.5
Initial Vertical Volume Source Dimension: σ_z (m)	1.9	1.9
Number of Days Modelled	244	

Table A48: Modelled Volume Sources Parameters – Winter Case

Parameter / Source	Scraping Area - Loading	Scraping Area – Wind Generated	Reclamation Area - Unloading	Reclamation Area – Wind Generated
Volume Source Location of Centre				
UTM11 (km E)	692.202		692.452	
UTM11 (km N)	5,674.308		5,674.308	
Elevation (m ASL)	1,270		1,233	
Volume Source Parameters				
Effective Height – E_h (m)	4.4	0.5	4.4	0.5
Initial Lateral Volume Source Dimension: σ_{xy} (m)	1.7	16.7	1.5	16.7
Initial Vertical Volume Source Dimension: σ_z (m)	2.3	0.5	2.1	0.5
Number of Days Modelled	90			

Table A49: Modelled Line Source Parameters

Parameter / Source	Conveyor - Mechanical Breaker and Blasting Cases	Conveyor - Truck Case	Scraper Travel	Haul Road
Start / End Location UTM 11 (km E)	692.202 696.319	692.620 696.319	692.202 696.452	692.202
Start / End Location UTM 11 (km N)	5,674.308 5,671.708	5,674.571 5,671.708	5,674.308 5,671.308	5,674.308
Effective Height – E_h (m)	1.5	1.5	4.4	4.6
Initial Lateral Volume Source Dimension: σ_{xy} (m)	1.4	1.4	1.7	4.1
Initial Vertical Volume Source Dimension: σ_z (m)	1.0	1.0	2.0	2.2
Total Length (km)	6.42	6.52	0.25	0.55
Number of Days Modelled	244	244	90	244

Table A50: Location of Conveyor - Mechanical Breaker and Blasting Cases

Description	UTM11 (km E)	UTM11 (km N)	Elevation (m ASL)	Length of Segment (m)
Beginning: Loading at Mobile Crusher (in-pit)	692.202	5,674.308	1,251	-
Centre and West Part of Pit Transfer Point 1 (in-pit)	692.406	5,674.175	1,243	0.244
Centre and West Part of Pit Transfer Point 2 (in-pit)	692.546	5674.009	1242	0.217
Centre and West Part of Pit Transfer Point 3 (in-pit)	693.125	5674.021	1238	0.579
East Part of Pit Transfer Point 4 (in-pit)	693.190	5673.908	1265	0.130
East Part of Pit Transfer Point 5 (in-pit)	693.438	5673.790	1270	0.275
Outside of the Pit Transfer Point 6 (off-site)	694.862	5673.834	1254	1.425
Outside of the Pit Transfer Point 7 (off-site)	694.917	5672.234	1270	1.601
Outside of the Pit Transfer Point 8 (off-site)	695.825	5672.266	1263	0.909
Outside of the Pit Transfer Point 9 (off-site)	695.844	5671.696	1264	0.570
End: Spy Hill Unloading (off-site)	696.319	5671.708	1260	0.475

Table A51: Location of Conveyor - Truck Case

Description	UTM11 (km E)	UTM11 (km N)	Elevation (m ASL)	Length of Segment (m)
Beginning: Loading at Permanent Crusher (in-pit)	692.620	5674.571	1250	-
Centre and West Part of Pit Transfer Point 1 (in-pit)	692.578	5674.662	1232	0.100
Centre and West Part of Pit Transfer Point 2 (in-pit)	692.582	5674.710	1231	0.048
Centre and West Part of Pit Transfer Point 3 (in-pit)	692.735	5674.716	1231	0.153
Centre and West Part of Pit Transfer Point 4 (in-pit)	693.186	5674.144	1251	0.728
East Part of Pit Transfer Point 5 (in-pit)	693.190	5673.908	1265	0.236
East Part of Pit Transfer Point 6 (in-pit)	693.438	5673.790	1265	0.275
Outside of the Pit Transfer Point 7 (off-site)	694.862	5673.834	1254	1.425
Outside of the Pit Transfer Point 8 (off-site)	694.917	5672.234	1270	1.601
Outside of the Pit Transfer Point 9 (off-site)	695.825	5672.266	1263	0.909
Outside of the Pit Transfer Point 10 (off-site)	695.844	5671.696	1264	0.570
End: Spy Hill Unloading (off-site)	696.319	5671.708	1260	0.475

Table A52: Location of Haul Road - Truck Case

Description	UTM11 (km E)	UTM11 (km N)	Elevation (m ASL)	Length of Segment (m)
Beginning: Loading at Mining Block	692.202	5674.308	1251	-
Bend	692.410	5674.574	1228	0.337
End: Permanent Crusher	692.620	5674.571	1250	0.210

A7. Effect of Vegetation on Dust Concentrations

A7.1 Introduction

Several studies have surveyed the effects of vegetation on dust reduction. For example, studies of the dust reduction due to vegetation around poultry farms identified a two-year study (Malone and Donnelly, 2001; Malone, 2004) in which a 9-m wide belt of three rows of dense evergreen trees less than 5 m high located 15 m from a barn fan reduced total dust concentrations across the belt by 50%. The reduction was due to a substantial reduction in wind speed through the belt which apparently enhanced deposition of material from the plume.

Measurements from towers placed at progressively farther distances from a haul road proved that long grass substantially removed PM_{10} (Zhu et al., 2012). At 84 m from the road, concentrations decreased to 13% of near-road concentrations which were measured 8 m from the road; at 160 m concentrations decreased to 7.5%. In desert conditions (bare land), concentrations 136 m from the road decreased to 67% of near-road (12 m) concentrations (Zhu et al., 2012). This decrease was attributed to enhanced deposition due to surface roughness. Particle deposition velocities increased with increased surface roughness.

Dust plume profiling tests conducted by Midwest Research Institute (MRI) showed that tall vegetation (oak and cedar trees) bordering an emission source captures fugitive dust (PM_{10} and $PM_{2.5}$) in the range of 50% over a transport distance of 25 m from an unpaved road (Cowherd et al., 2006). These rates significantly exceed the levels represented in standard air plume dispersion models used for regulatory compliance purposes, where in the current work, near-source effects were modelled with standard grid sizes in the range of 50 m or more.

Desert Research Institute (DRI) measured the removal of PM_{10} dust emitted from an unpaved road at 50 m and 100 m downwind (Gillies et al., 2002). The results, for unstable conditions over sparsely vegetated terrain, indicated that there was no measurable removal of PM_{10} 100 m downwind of the source. That is, nearly all PM_{10} emitted from the unpaved road was available for transport beyond that distance, which was in good agreement with the predictions from a Gaussian model.

In contrast, similar measurements during night-time stable conditions over very rough terrain measured an 85% removal (15% remaining) of PM_{10} within the first 95 m downwind of an unpaved road (Veranth et al., 2003). The Gaussian model (ISC3) appeared to substantially over predict the transportable fraction of PM_{10} under those conditions.

According to Cowherd et al. (2006), the vegetation capture factor is independent of particulate size (factors were very similar for PM_{10} and $PM_{2.5}$). The same paper also showed vegetation reduced the mass in plumes by 41-67% within a few tens of metres from a road source.

A7.2 Treatment in Models

Numerous studies conducted by MRI and DRI (Cowherd et al., 2006; Etyemezian et al., 2003; Cowherd et al., 2003) in the southwestern US have assessed dust plume dispersion perpendicular to haul roads; specifically, the capacity of surrounding vegetation or terrain features to abate dust emissions. The results of these studies are summarized by the United States Environmental Protection Agency (US EPA – Pace, 2005) using composite

fugitive dust capture fractions (CF) for five basic land cover types as in **Table A53**. The CF are similar for PM_{10} and $PM_{2.5}$ (Cowherd, 2006; Etyemezian et al., 2003).

Table A54 compares composite CF by land use category recommended by US EPA to CF values originally proposed by the Western Regional Modelling and Analysis Platform (WRAP) and then updated based on the WRAP emission inventory (Cowherd, 2007). For example, the roughness created by forests essentially traps dust emissions and restricts transport outside this area according to US EPA and the newest WRAP recommendations.

Table A53: Recommended Capture Fractions (CF, %) for Five Land Cover Types (Pace, 2005)

Land Cover Type	Average Height (m)	Recommended CF (%)	Estimated CF Range (%)	Comment
Forest	18-20	100%	80 to 100%	Forested areas will capture dust effectively
Urban	5 – 50+	50%	25 to 75%	Structures are interspersed with open areas
Scrub, Sparsely Wooded & Grasses	1 – 2	25%	10 to 40%	Portion of plume is below sparse vegetation
Agricultural (seasonal)	1 - 2	25%	10 to 40%	Portion of plume is below crop (seasonally)
Barren / Water	0	0%	0 to 10%	Impediment-free surfaces are unable to capture dust

Table A54: Comparison of Capture Fractions (CF, %) Recommended by US EPA (Pace, 2015) to Values Recommended by WRAP (Cowherd, 2007)

Land Cover Type	Original CF (%) (Recommended)	Original Used by WRAP - CF (%)	Updated in WRAP - CF (%)
Forest	100%	70%	100%
Urban	50%	70%	100%
Shrubland	25%	40%	25%
Grassland	25%	30%	25%
Agriculture	25%	15%	25%
Barren / Water	0%	3%	0%

Capture fractions were originally developed to apply to grid modelling of regional impacts; however, the modelling deficiencies (Cowherd, 2007) apply to plume models as well as grid models when used to estimate the impact of haul roads in open pit mines. These deficiencies include source representation, treatment of near-source plume loss, and treatment of pit trapping.

Although CALPUFF includes a particulate removal mechanism (deposition), Staniaszek and Rudolph (2020) compared CALPUFF dust modelling with and without deposition and showed the model does not sufficiently account for deposition in dense vegetation areas compared to measurements reported in the literature.

A CF value of 25% (for shrubs and tall grasses) was applied to emissions from Project sources.

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Appendix B

Emission Case Options – Summary of Modelling Predictions

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B1. Overview of Emission Cases

This attachment summarizes CALPUFF dispersion model results for the emission cases considered by Lehigh. The model results were one criterion by which Lehigh chose the scenario for more detailed assessment, as presented in the main report.

Section 4.1 of the Air Dispersion Modelling Assessment provides detailed information about four emission cases, for which emission sources were identified, estimated, and modelled. Details of emission estimations for all cases are provided in Attachment A.

For all emission cases, the Phase 2 mining block was positioned in the SW corner of the Scott Property. This location is expected to be the worst-case for residential predictions.

B2. Model Predictions

For this overview of model prediction for the four emission cases, the following comments apply:

- Background concentrations are “natural” background based on air quality measurements at the Calgary Northwest (Varsity) or Calgary Southeast station operated by CRAZ, or from the Scotford station for compounds not measured at the CRAZ stations. Other industrial background relevant to the Scott property were not included for this assessment of options as the industrial background would be the same for all options.
- The predictions include the effects of mitigation (e.g., enclosed crusher, watered haul roads) as appropriate for each option.
- The tables of predictions include a column including the additional effects of mitigation by vegetation on particulate concentrations in non-winter conditions.
- The tables include the relevant Alberta Ambient Air Quality Objectives (AAAQO) unless otherwise noted.
- Predictions are presented only at the maximum point of impingement at or outside the property boundary.
- All modelling followed the methodology described in the main report, including the use of protocols mandated by Alberta Environment and Parks and the use of 5 years of meteorology provided by them to be used in CALMET model.

Model results are presented in **Table B1** to **Table B7** below. Model predictions for both Conveyor cases (in summer) predict TSP, PM_{10} and $PM_{2.5}$ exceedances at the property boundary while the Winter case is not predicted to generate any exceedances. Incorporating a 25% reduction in particulate concentration from Project activities due to vegetation at and around Project activities will improve particulate predictions but does not eliminate the exceedances in all cases.

Exceedances of AAQOs for particulate matter occurred on only one day in five years of modelled, obtained by CALMET model meteorology, and all on the same day: November 29, 2005. On that day, it rained from 07:00 until 21:00 with total accumulation over 2.29 mm. According to U. S. EPA and Environment Canada guidance documented in the main report, dust emissions from unpaved haul roads should be zero on days with precipitation over 0.25 mm. The dispersion model, following the requirements of AEP, does not account for emission reduction due to precipitation, although we expect on this wet day all fugitive dust emissions would be significantly reduced.

Maximum 24-hour particulate predictions for all cases are at the property boundary, southwest of the modelled monitoring block (Figure B1). The mining block location modelled is expected to be the worst case for these residences. The mining block moves frequently, and it is unlikely that the worst-case meteorology leading to the highest predictions will occur with this location.

All predictions for of BaP, Benzene, CO, SO_2, and NO_2 are less than AaAQO’s for all compounds and modelling periods.

Appendix B. Emission Case Options – Summary of Modelling Predictions

Table B1: Maximum Predicted Concentrations of TSP

Case	Maximum Prediction (µg/m³)	25% Reduction Due to Vegetation (µg/m³)	AAQO (µg/m³)
TSP 24-Hour			
Natural Background	41	41	**100**
Winter Case Maximum	62	57	**100**
Summer Mechanical Breaker	**113**[1]	95	**100**
Summer Blasting	**122**[1]	**102**[1]	**100**
Summer Truck	**123**[1]	**103**[1]	**100**
TSP Annual			
Natural Background	36	36	**60**
Winter and Summer Mechanical Breaker	39	38	**60**
Winter and Summer Blasting	39	38	**60**
Winter and Summer Truck	39	38	**60**

Note: 1. Ambient Air Quality Objective exceeded for one day in five years (0.05% of the time)

Table B2: Maximum Predicted Concentrations of PM_{10}

Case	Maximum Prediction (µg/m³)	25% Reduction Due to Vegetation (µg/m³)	AAQO1 (µg/m³)
PM_{10} 24-Hour			
Natural Background	20	20	**50**
Winter Case Maximum	30	28	**50**
Summer Mechanical Breaker	**64**[2]	**53**[2]	**50**
Summer Blasting	**71**[2]	**58**[2]	**50**
Summer Truck	**70**[2]	**57**[2]	**50**

Notes: 1. BC objective
2. Ambient Air Quality Objective exceeded for one day in five years (0.05% of the time)

Table B3: Maximum Predicted Concentrations of $PM_{2.5}$

Case	Maximum Prediction (µg/m³)	25% Reduction Due to Vegetation (µg/m³)	AAQO (µg/m³)
$PM_{2.5}$ 1-Hour			
Natural Background	12	12	**80**
Winter Case Maximum	40	33	**80**
Summer Mechanical Breaker	**108**	**84**	**80**
Summer Blasting	**108**	**84**	**80**
Summer Truck	**83**	65	**80**
$PM_{2.5}$ 24-Hour			
Natural Background	**12**	12	**29**
Winter Case Maximum	17	16	**29**
Summer Mechanical Breaker	**31**[1]	27	**29**
Summer Blasting	**32**[1]	27	**29**
Summer Truck	**29**[1]	25	**29**
$PM_{2.5}$ 24-Hour CAAQS			
Natural Background	12	12	**27**
Winter Case Maximum	17	16	**27**
Summer Mechanical Breaker	17	16	**27**
Summer Blasting	16	15	**27**
$PM_{2.5}$ Annual			
Natural Background	7.0	7.0	**8.8**
Winter and Summer Mechanical Breaker	7.4	7.3	**8.8**
Winter and Summer Blasting	7.4	7.3	**8.8**
Winter and Summer Truck	7.4	7.3	**8.8**

Note; 1. Ambient Air Quality Objective exceeded for one day in five years (0.05% of the time)

Figure B1: Location of Maximum Predicted Particulate Concentrations

Appendix B. Emission Case Options – Summary of Modelling Predictions

Table B4: Maximum Predicted Concentrations of NO_2

Case	NO_X (µg/m^3)	NO_2 (µg/m^3)	AAQO (µg/m^3)
1-Hour			
Natural Background	54	54	**300**
Winter Case Maximum	268	83	**300**
Summer Mechanical Breaker	**730**	129	**300**
Summer Blasting	**734**	130	**300**
Summer Truck	**815**	138	**300**
Annual			
Natural Background	16	16	**45**
Winter and Summer Mechanical Breaker	19	19	**45**
Winter and Summer Blasting	21	21	**45**
Winter and Summer Truck	20	20	**45**

Table B5: Maximum Predicted Concentrations of CO

Case	CO (µg/m^3)	AAQO (µg/m^3)
1-Hour Maximum		
Natural Background	458	**15,000**
Winter Case Maximum	582	**15,000**
Summer Mechanical Breaker	872	**15,000**
Summer Blasting	3,224	**15,000**
Summer Truck	909	**15,000**
8-Hour Maximum		
Natural Background	458	**6,000**
Winter Case Maximum	506	**6,000**
Summer Mechanical Breaker	629	**6,000**
Summer Blasting	2,365	**6,000**
Summer Truck	667	**6,000**

Table B6: Maximum Predicted Concentrations of Benzene

Case	Benzene (µg/m^3)	AAQO (µg/m^3)
1-Hour Maximum		
Natural Background	0.0[1]	**30**
Winter Case Maximum	0.50	**30**
Summer Mechanical Breaker	0.46	**30**
Summer Blasting	0.58	**30**
Summer Truck	0.46	**30**
Annual		
Natural Background	0.05[2]	**0.3**
Winter and Summer Mechanical Breaker	0.053	**0.3**
Winter and Summer Blasting	0.053	**0.3**
Winter and Summer Truck	0.053	**0.3**

Notes: 1. 90th Percentile from hourly Scotford AQ Station observations – October 1st, 2018 to September 30th, 2019.
2. Average value from hourly Scotford AQ Station observations – October 1st, 2018 to September 30th, 2019.

Appendix B. Emission Case Options – Summary of Modelling Predictions

Table B7: Maximum Predicted Concentrations of Benzo-a-pyrene

Case	Benzo-a-pyrene (ng/m^3)	AAQO (ng/m^3)
Annual		
Natural Background	0.052	**0.3**
Winter and Summer Mechanical Breaker	0.053	**0.3**
Winter and Summer Blasting	0.053	**0.3**
Winter and Summer Truck	0.053	**0.3**

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Appendix C

Isopleths of Modelling Results

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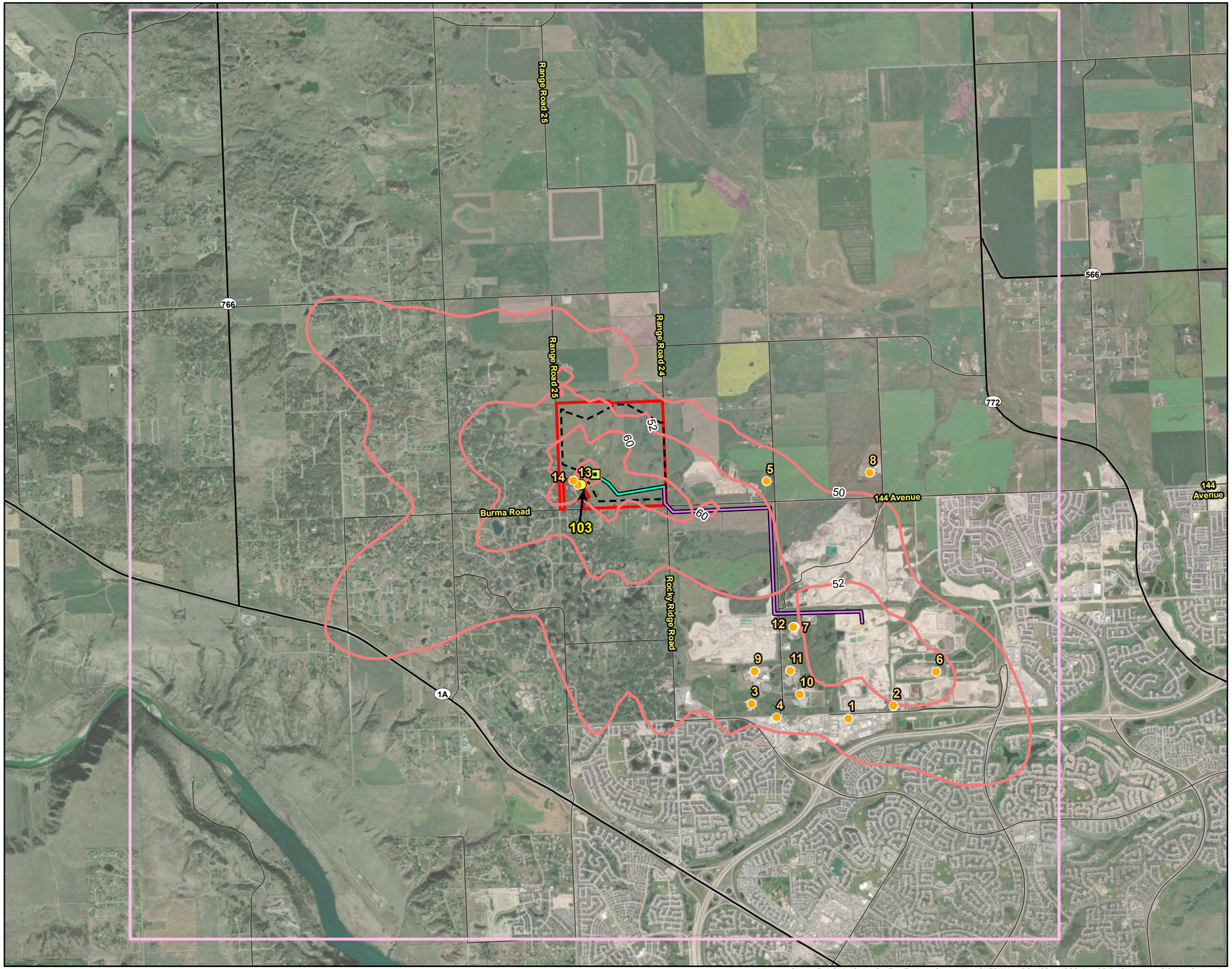

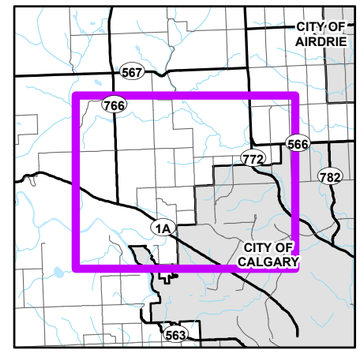

Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 100 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

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1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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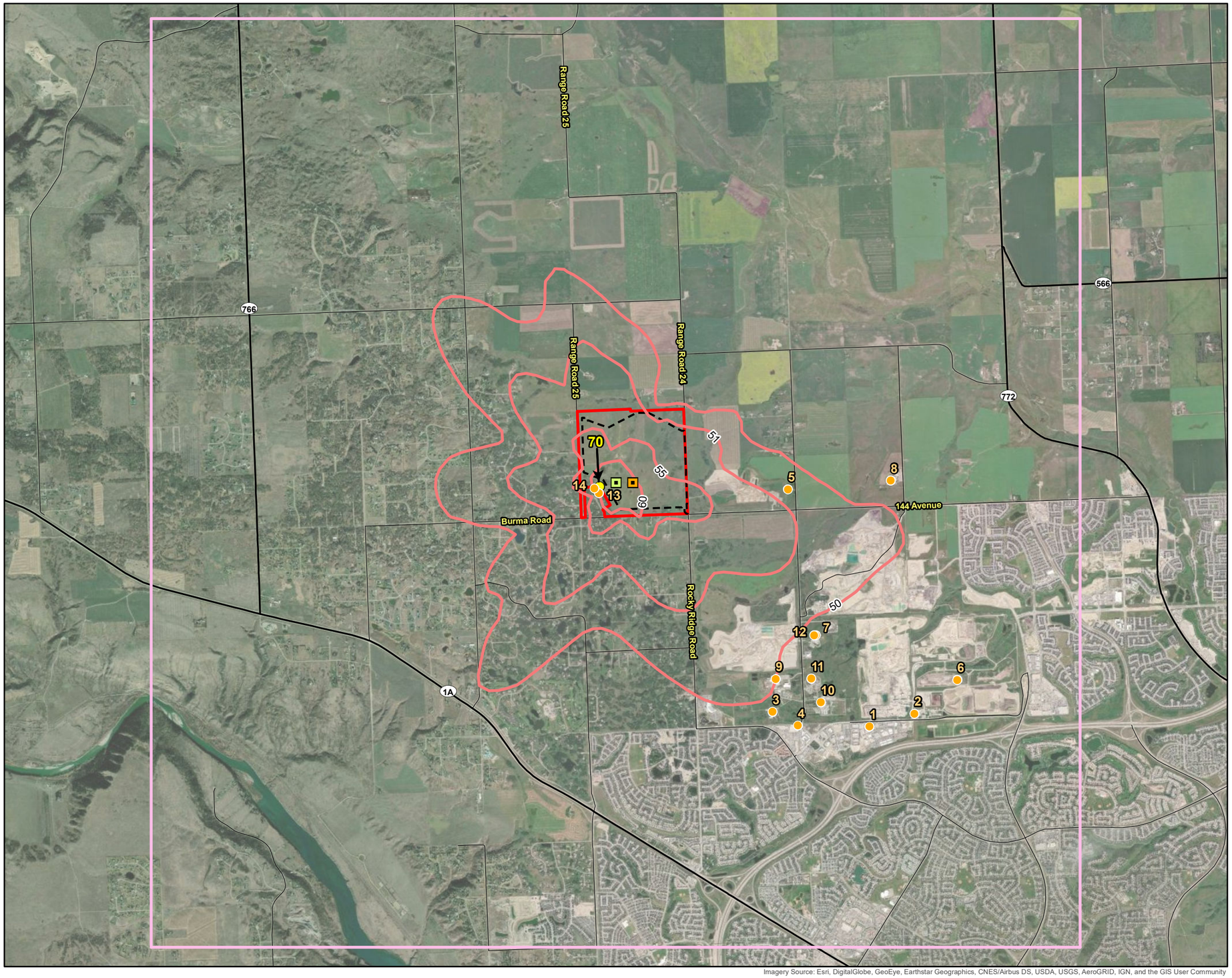
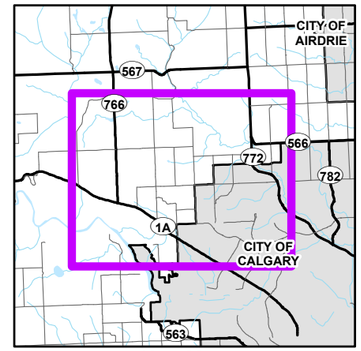
Figure: C1

PREDICTED MAXIMUM 24-HOUR AVERAGE TSP CONCENTRATIONS (µg/m^3) APPLICATION SUMMER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19





Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Highway
- Road

AAAQO = 100 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Figure: C2

PREDICTED MAXIMUM 24-HOUR AVERAGE TSP CONCENTRATIONS (µg/m^3) APPLICATION WINTER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
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Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

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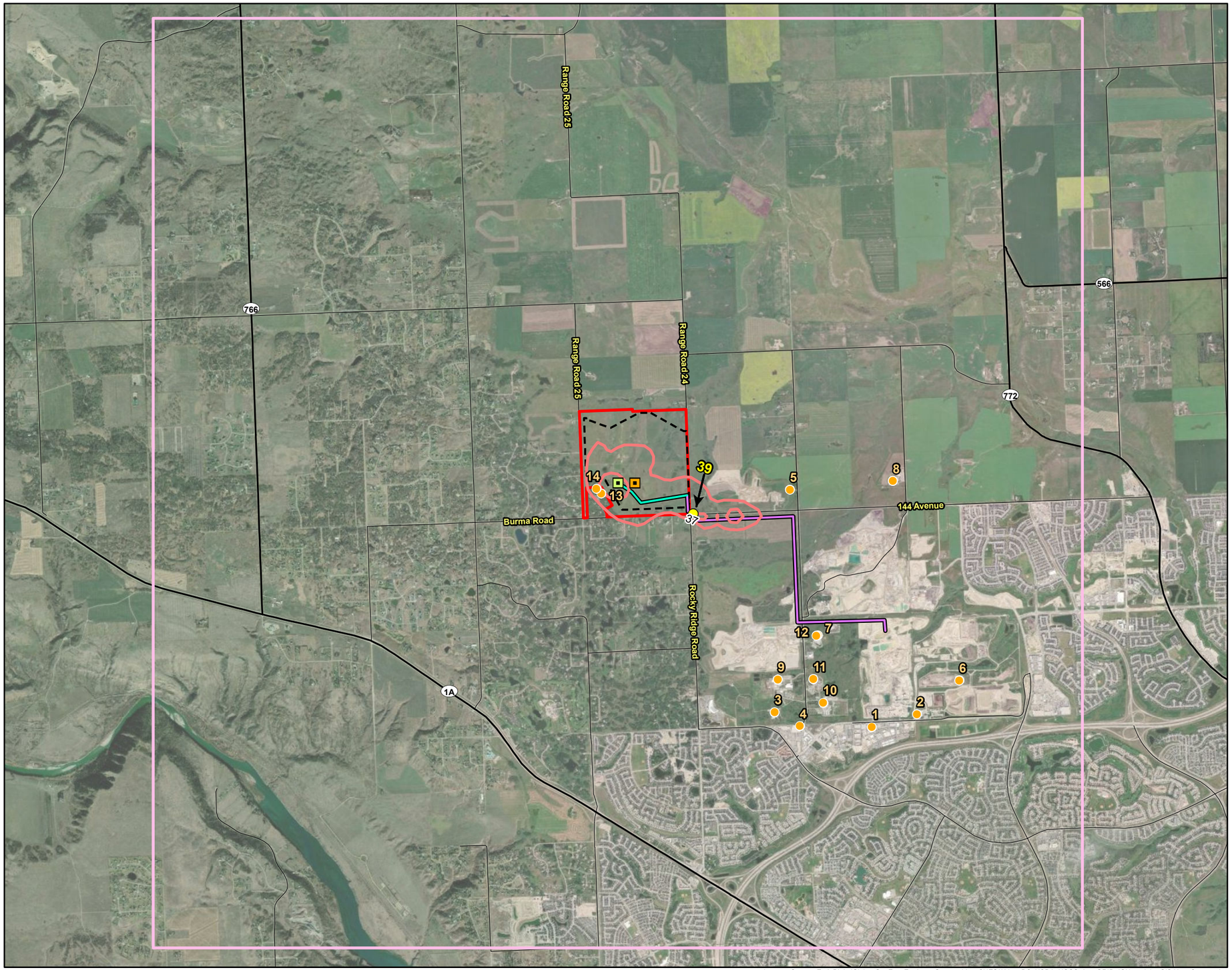
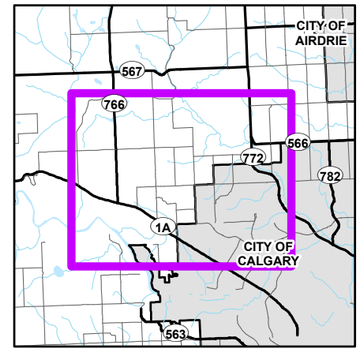


Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 60 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
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14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800 m

Sources: AltaLIS; NRCan

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AECOM

Figure: C3

PREDICTED MAXIMUM ANNUAL AVERAGE TSP CONCENTRATIONS (µg/m^3) APPLICATION SUMMER AND WINTER CASES

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C3_60610856_LEHIGH_ANNUALTSP.MXD

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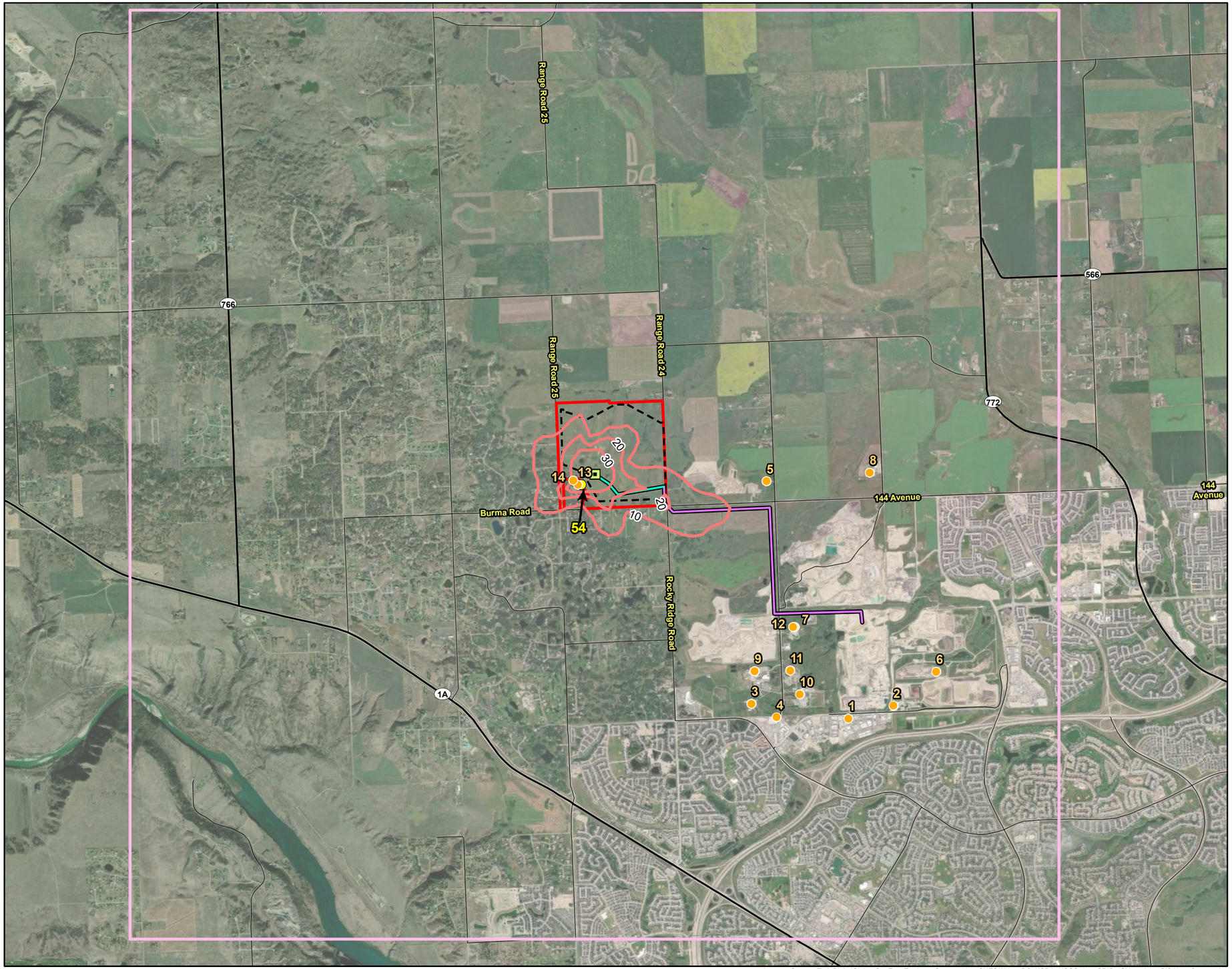
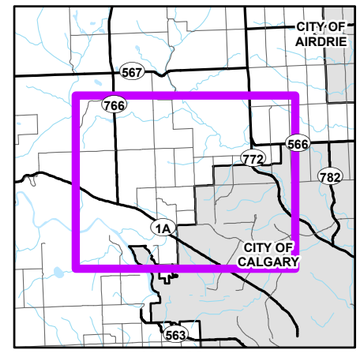
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C4_60610856_LEHIGH_24-HOURTSP_PROJECTONLY.MXD
Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm





Key Map

Legend

Model Features
- Maximum Modelled Concentration (µg/m^3)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 100 µg/m^3
- Concentration Contour

Sensitive Receptor
1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

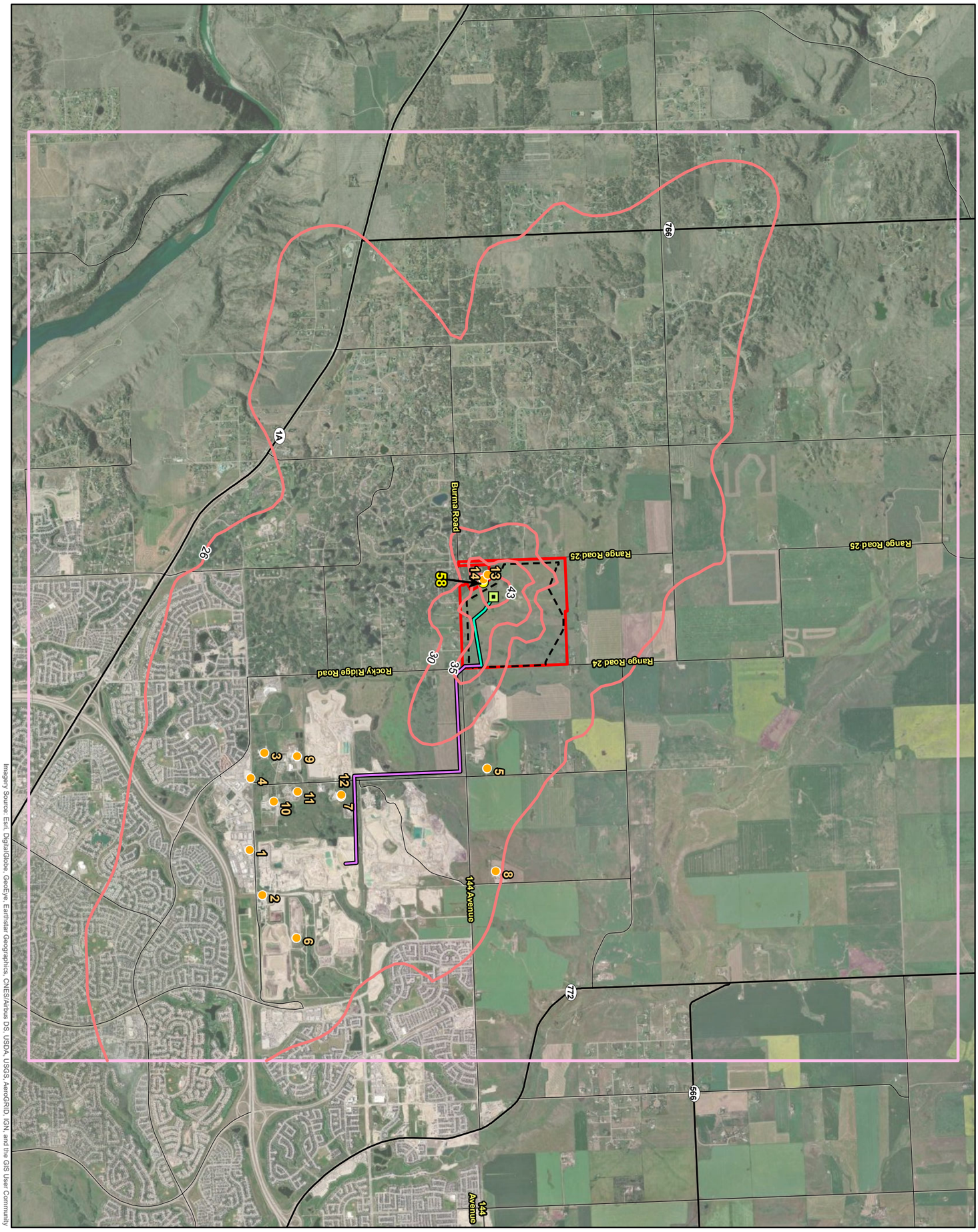
Figure: C4

PREDICTED MAXIMUM 24-HOUR AVERAGE TSP CONCENTRATIONS (µg/m^3)
PROJECT ONLY SUMMER CASE

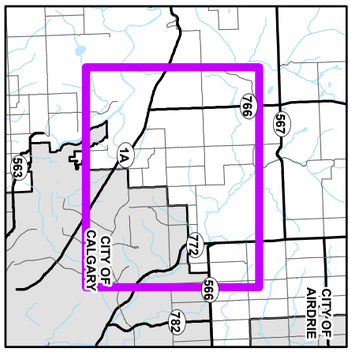
LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C5_60610856_LEHIGH_24-HOURPM.MXD

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm



Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

Model Features

- Maximum Modelled Concentration (µg/m³)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAQO = 50 µg/m³

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No. 1 Crestview Estates
14. No. 2 Crestview Estates

N W E S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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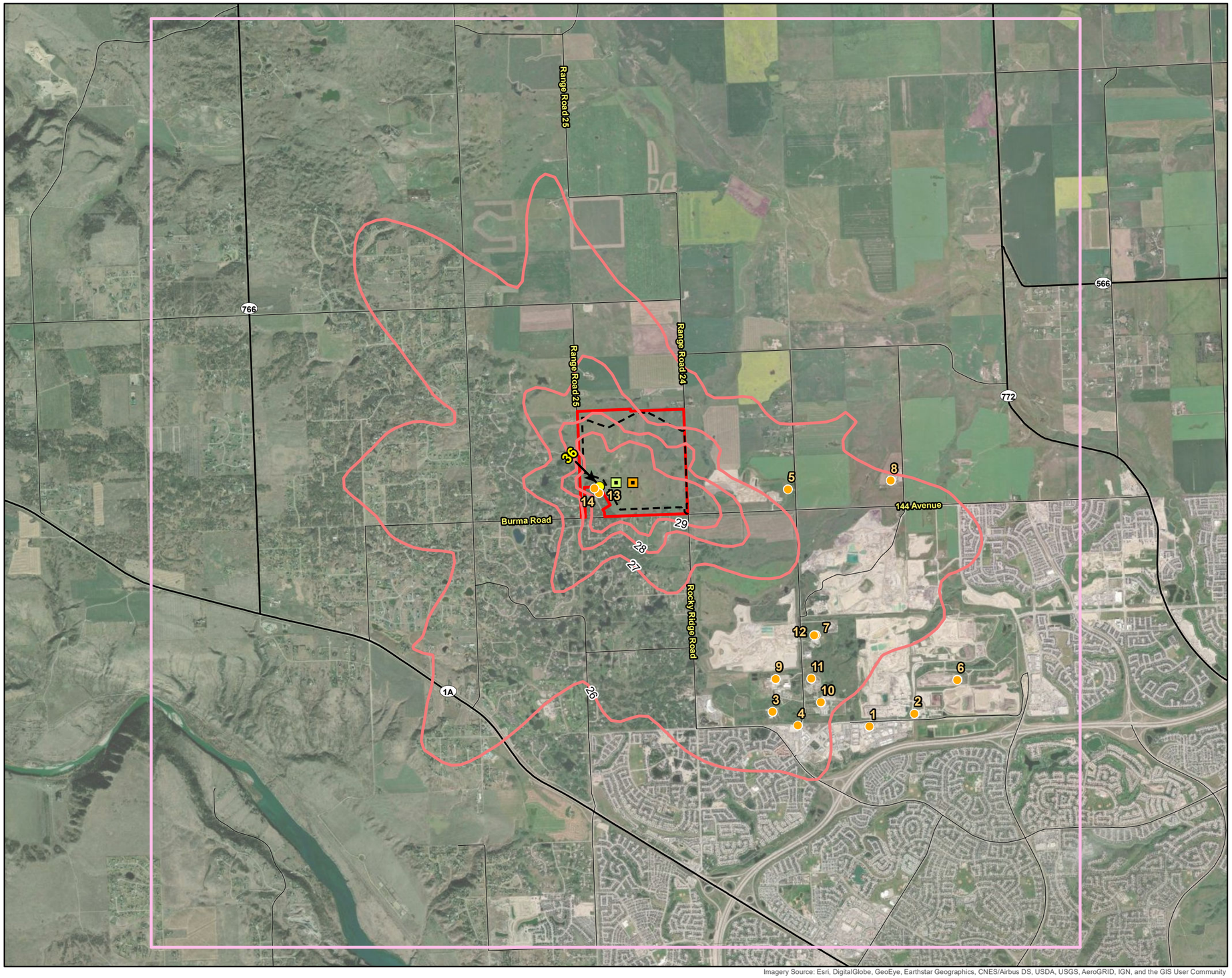
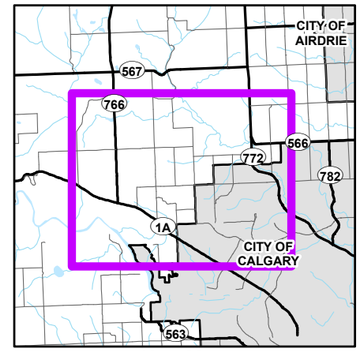
LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

PREDICTED MAXIMUM 24-HOUR AVERAGE
PM_{10} CONCENTRATIONS (µg/m³)
APPLICATION SUMMER CASE

AECOM

Figure: C5





Key Map

Legend

Model Features
- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Highway
- Road

AAQO = 50 µg/m^3
- Concentration Contour

Sensitive Receptor
1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AECOM

Figure: C6

PREDICTED MAXIMUM 24-HOUR AVERAGE PM_{10} CONCENTRATIONS (µg/m^3)
APPLICATION WINTER CASE

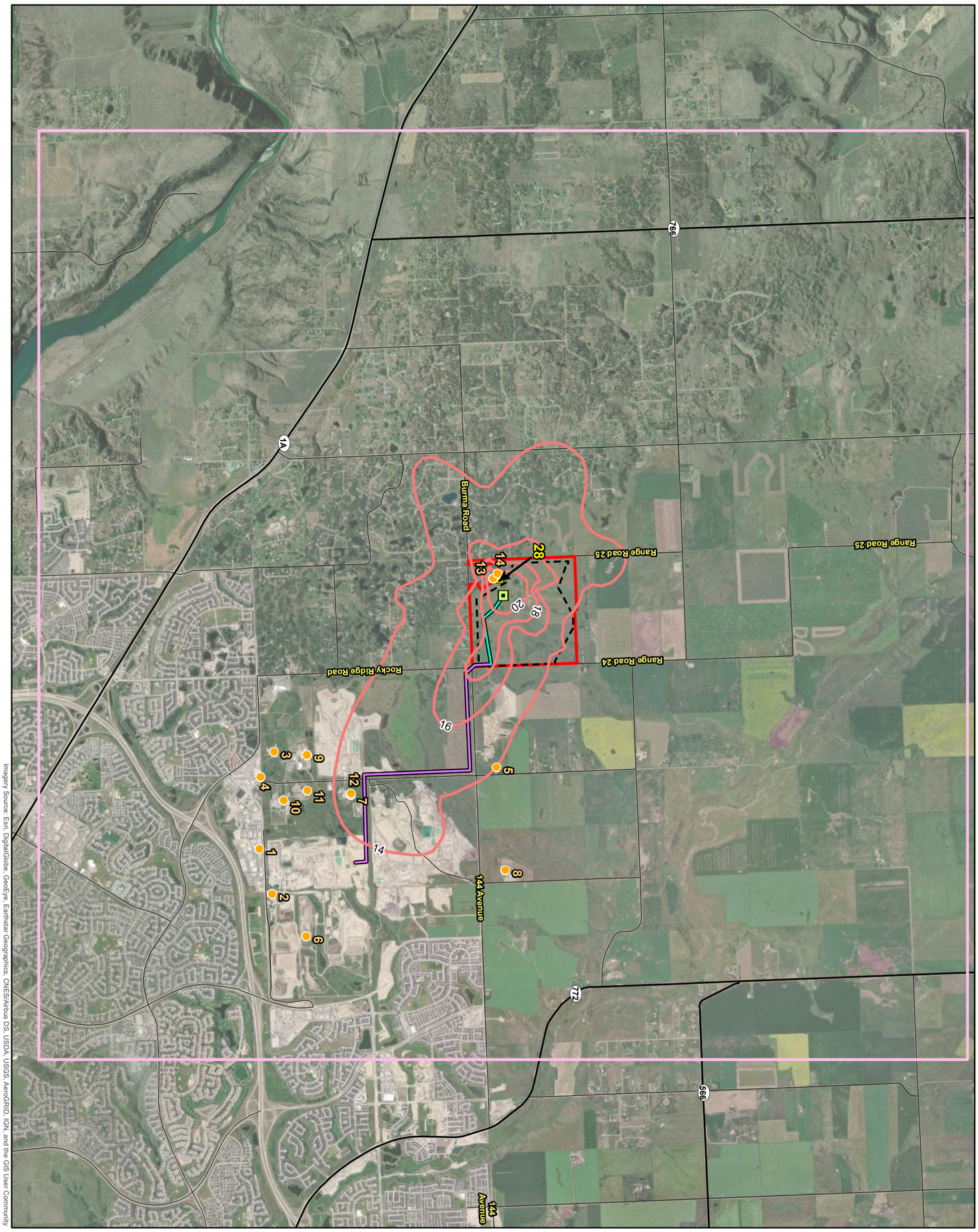
LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

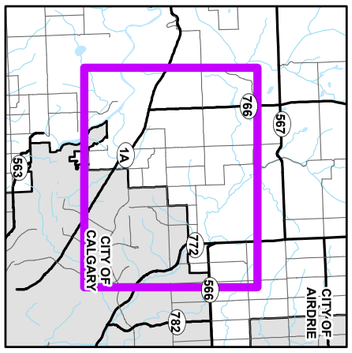
Last saved by: STEPHANIE.CLARK (2020-06-18) Last Plotted: Thu Jun 18, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C6_60610856_LEHIGH_24-HOURAVERAGEPM.MXD

Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C7_60610856_LEHIGH_24-HOUR25.MXD

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm



Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m³)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 29 µg/m³

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No. 1 Crestview Estates
14. No. 2 Crestview Estates

N E S W

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

PREDICTED MAXIMUM 24-HOUR AVERAGE $PM_{2.5}$ CONCENTRATIONS (µg/m³) APPLICATION SUMMER CASE

AECOM

Figure: C7

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

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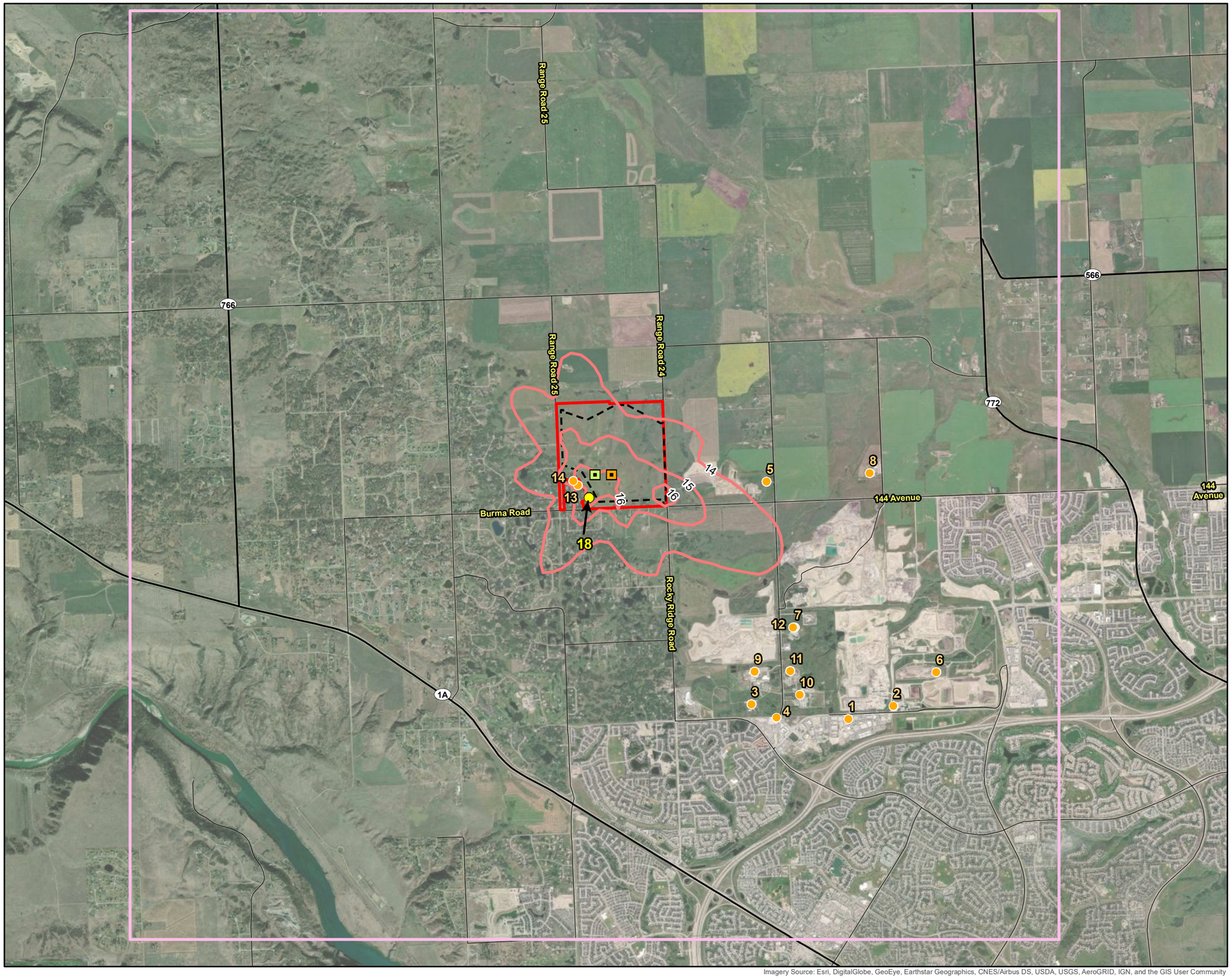
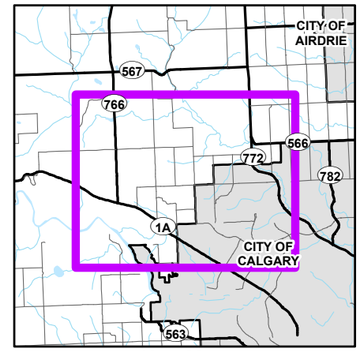


Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Highway
- Road

AAAQO = 29 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
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1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Figure: C8

PREDICTED MAXIMUM 24-HOUR AVERAGE $PM_{2.5}$ CONCENTRATIONS (µg/m^3) APPLICATION WINTER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm
Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
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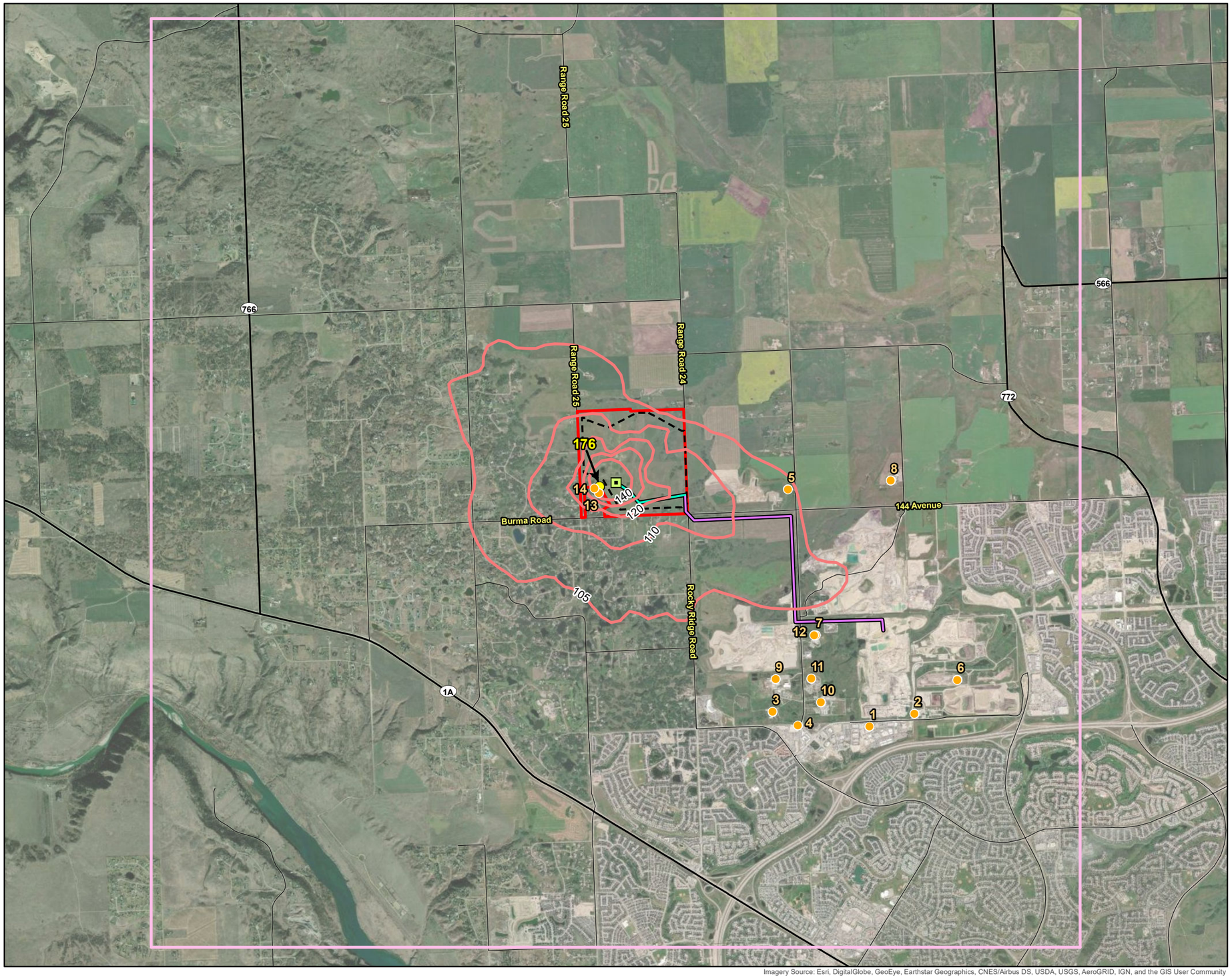

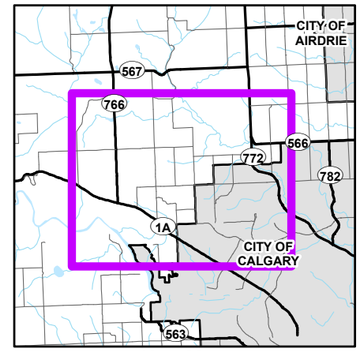

Key Map

Legend

Model Features
- Maximum Modelled Concentration (µg/m^3)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 300 µg/m^3
- Concentration Contour

Sensitive Receptor
1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N W E S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800 m

Sources: AltaLIS; NRCan

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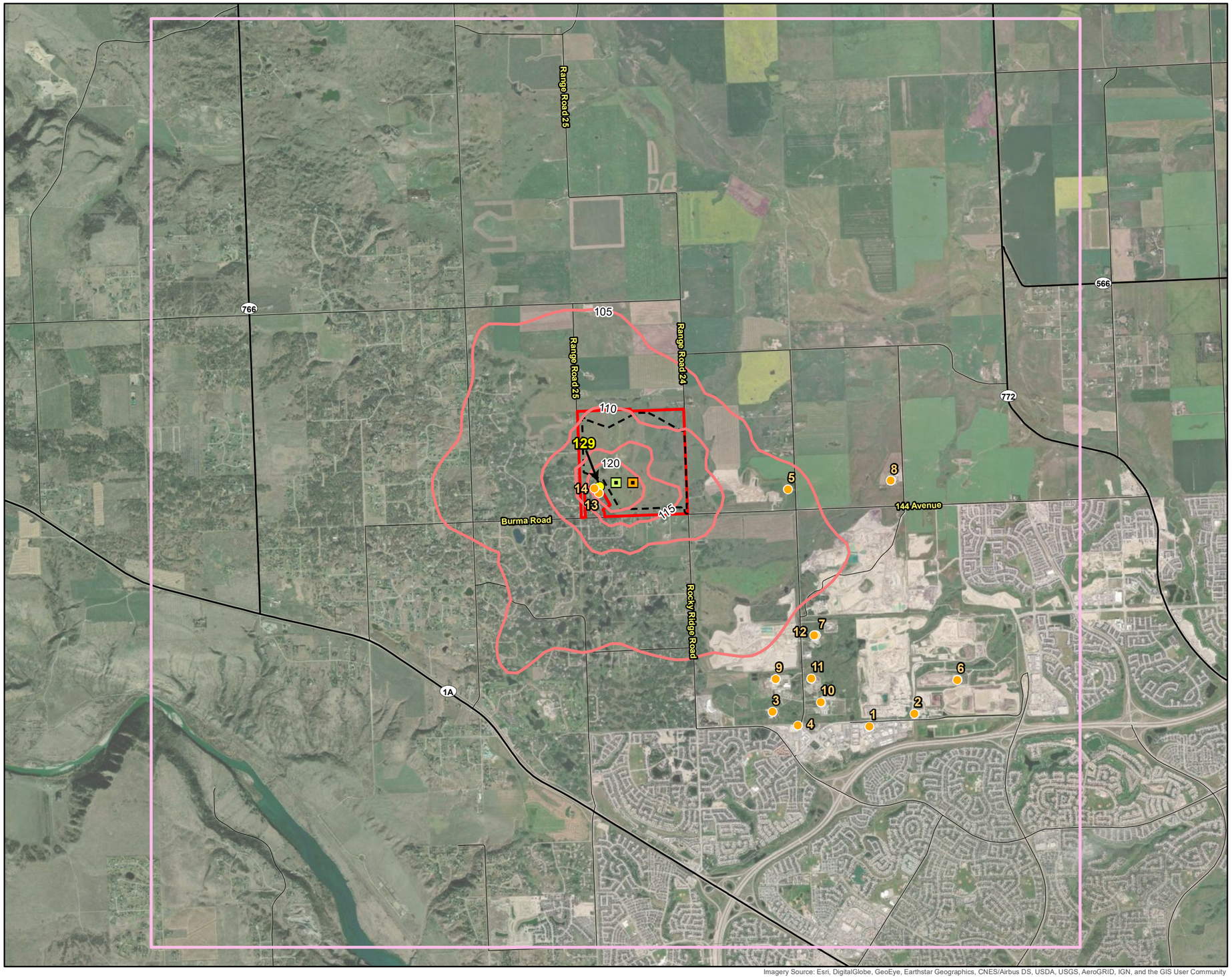
Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

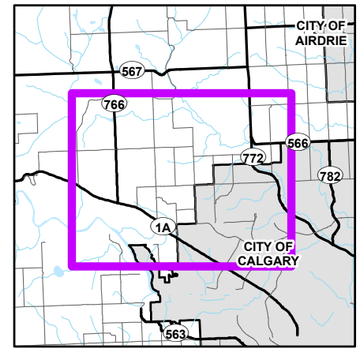
AECOM

Figure: C9

PREDICTED MAXIMUM 1-HOUR AVERAGE NO_2 CONCENTRATIONS (µg/m$_3$)
APPLICATION SUMMER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19





Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Highway
- Road

AAAQO = 300 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

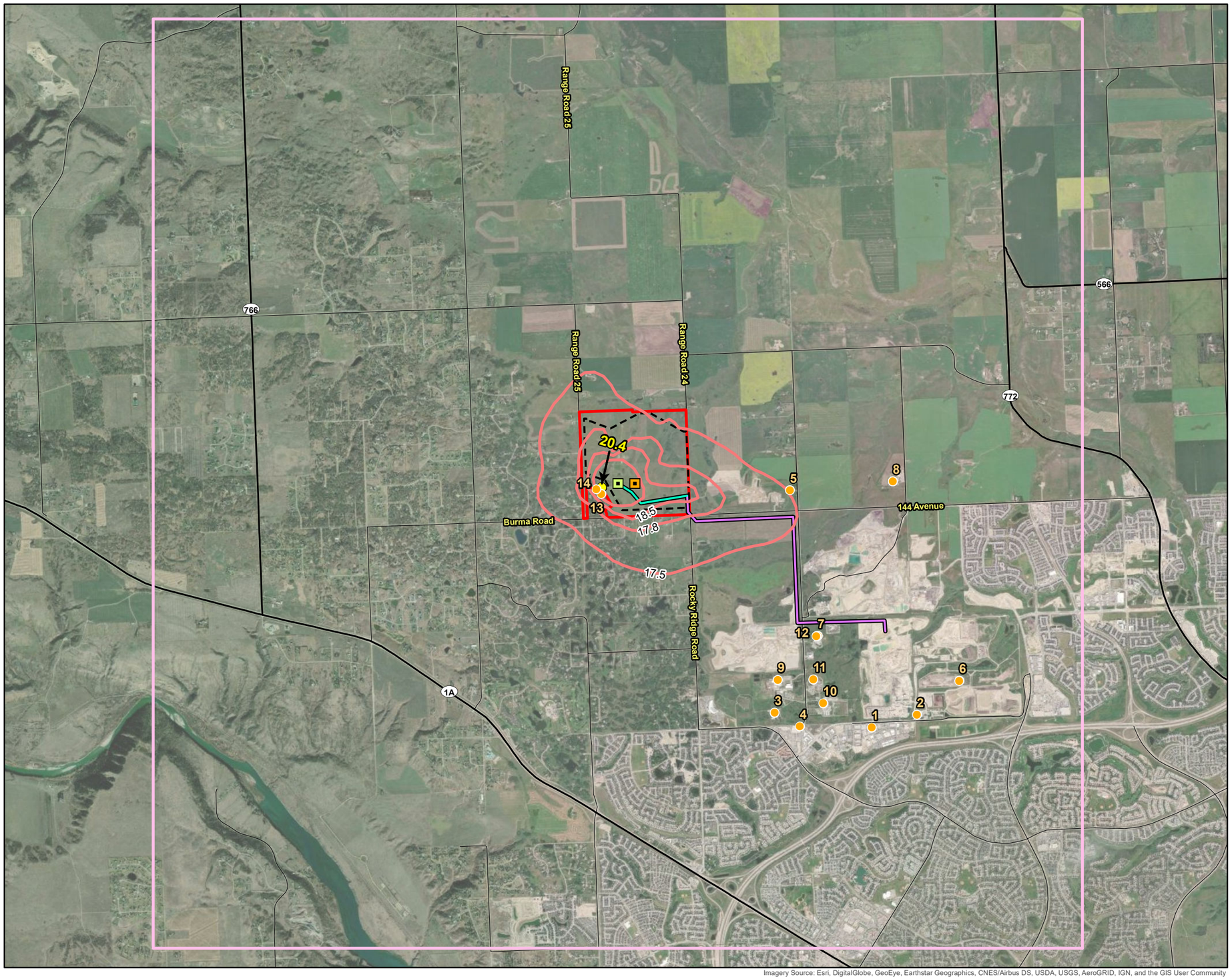
AECOM

Figure: C10

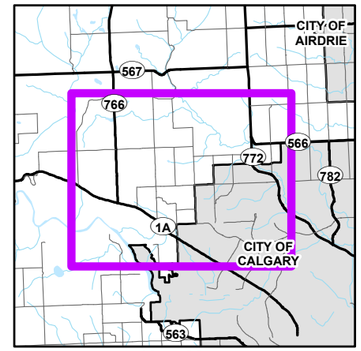
PREDICTED MAXIMUM 1-HOUR AVERAGE NO_2 CONCENTRATIONS (µg/m$_3$) APPLICATION WINTER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm
Last saved by: STEPHANIE.CLARK (2020-06-18) Last Plotted: Thu Jun 18, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C10_60610856_LEHIGH_1-HOURAVERAGENO.MXD



Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 45 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
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1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Figure: C11

PREDICTED MAXIMUM ANNUAL AVERAGE NO_2 CONCENTRATIONS (µg/m^3) APPLICATION SUMMER AND WINTER CASES

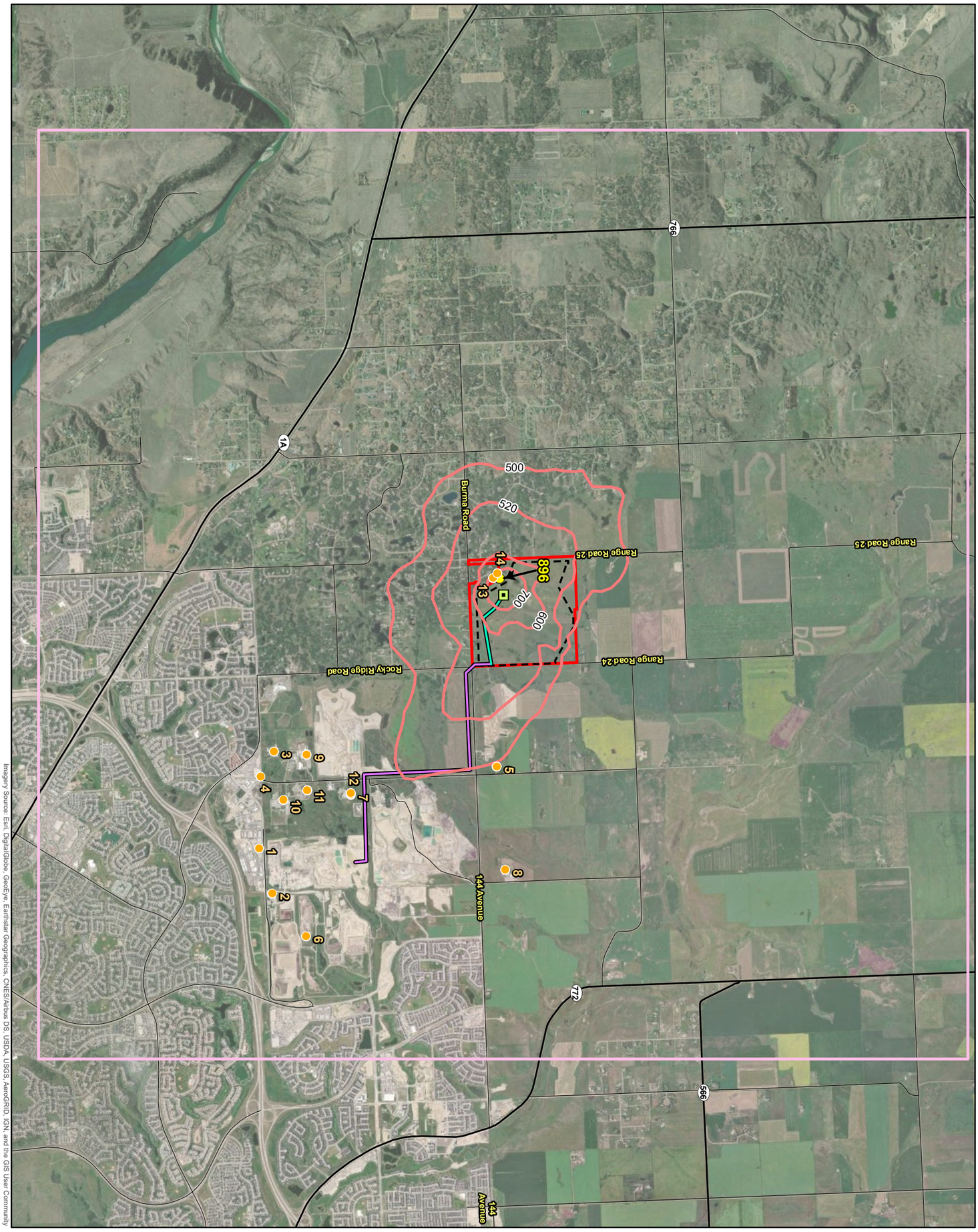
LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C11_60610856_LEHIGH_ANNUALNO.MXD

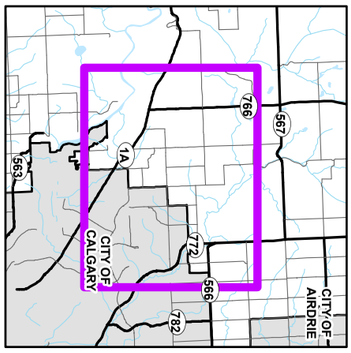
Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

Last saved by: STEPHANIE.CLARK (2020-06-19) Last Plotted: Fri Jun 19, 2020
Filename: P:\60610856\900-CAD_GIS\920-929 (GIS-GRAPHICS)\02_MXDS\AIR\APPENDIX C\C12_60610856_LEHIGH_1-HOURCO.MXD

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm



Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

Model Features

- Maximum Modelled Concentration (µg/m³)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 15,000 µg/m³

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No. 1 Crestview Estates
14. No. 2 Crestview Estates

N W E S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19

PREDICTED MAXIMUM 1-HOUR AVERAGE CO CONCENTRATIONS (µg/m³) APPLICATION SUMMER CASE

AECOM

Figure: C12

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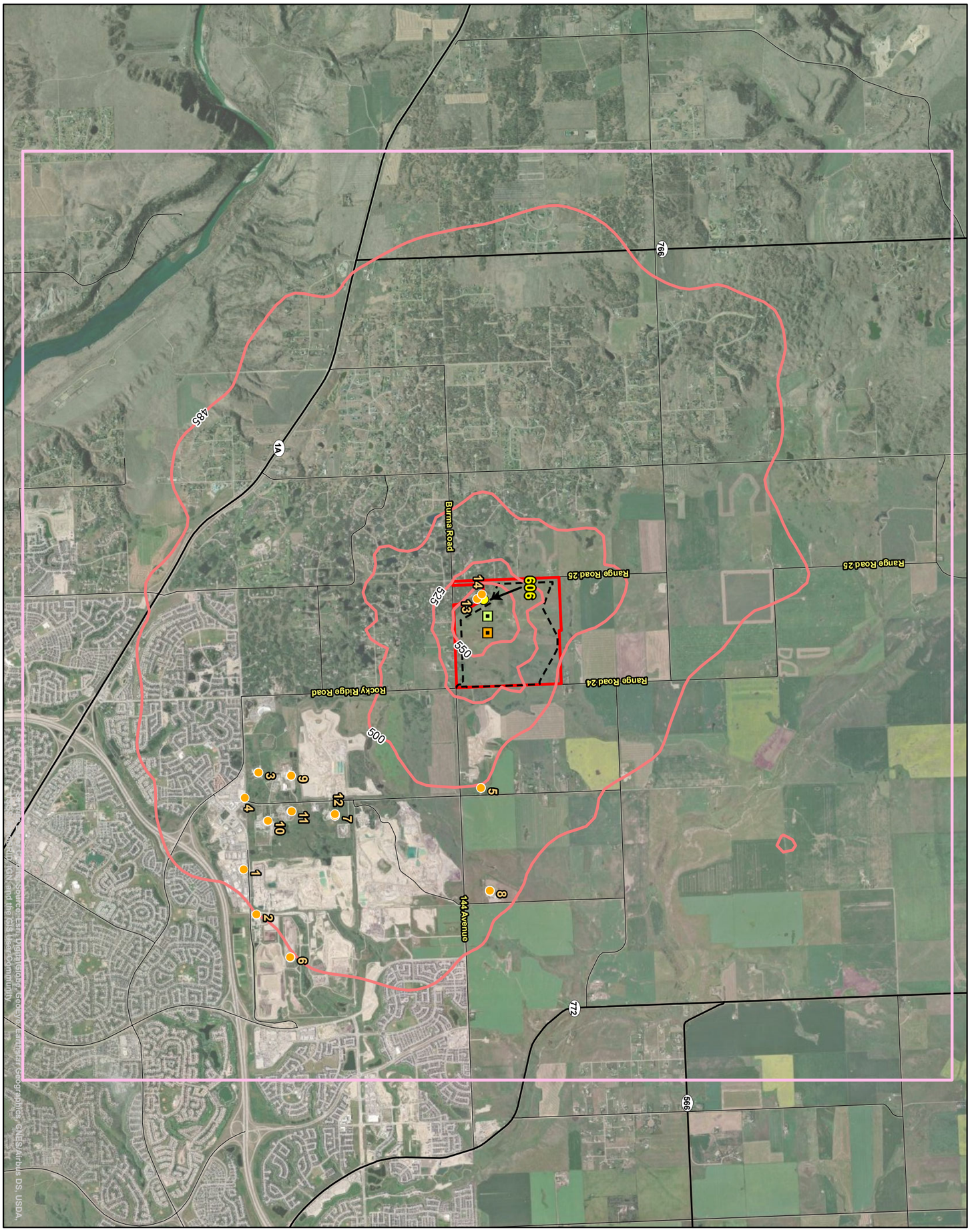
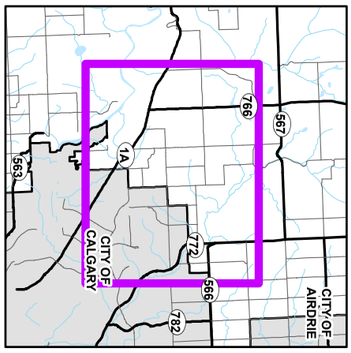
Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm





Legend

Model Features

- Maximum Modelled Concentration (µg/m³)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Highway
- Road

AAAQO = 15,000 µg/m³

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No. 1 Crestview Estates
14. No. 2 Crestview Estates

N
W E
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1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Source: GeoGratis

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LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

PREDICTED MAXIMUM 1-HOUR
AVERAGE CO CONCENTRATIONS (µg/m³)
APPLICATION WINTER CASE

AECOM

Figure: C13

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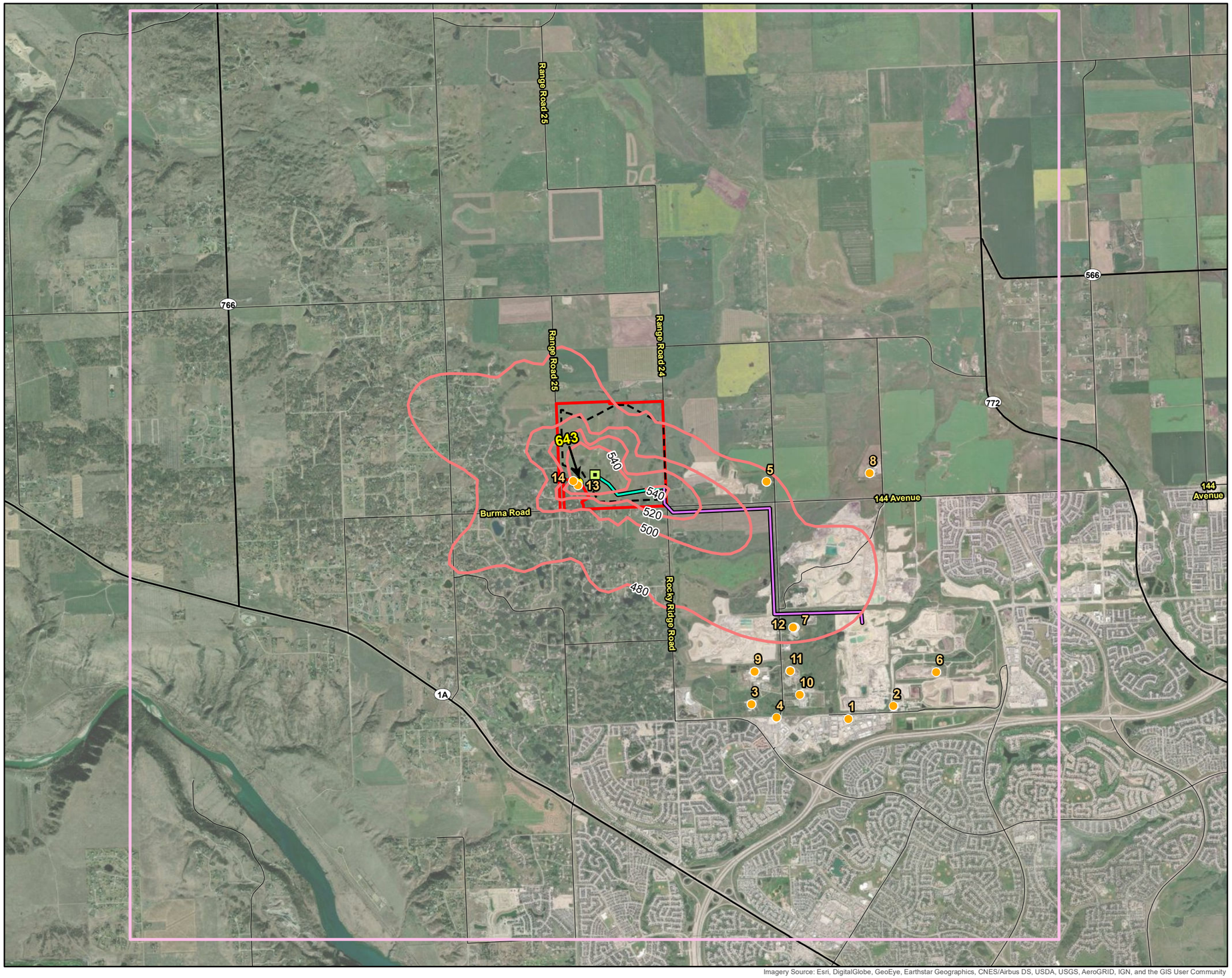
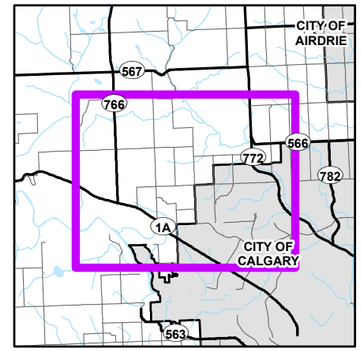


Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Mining Block
- Property Boundary
- Project Footprint
- CALPUFF Domain (14x14 km)
- Off-Site Conveyor
- In-Pit Conveyor
- Highway
- Road

AAAQO = 6,000 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
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S

1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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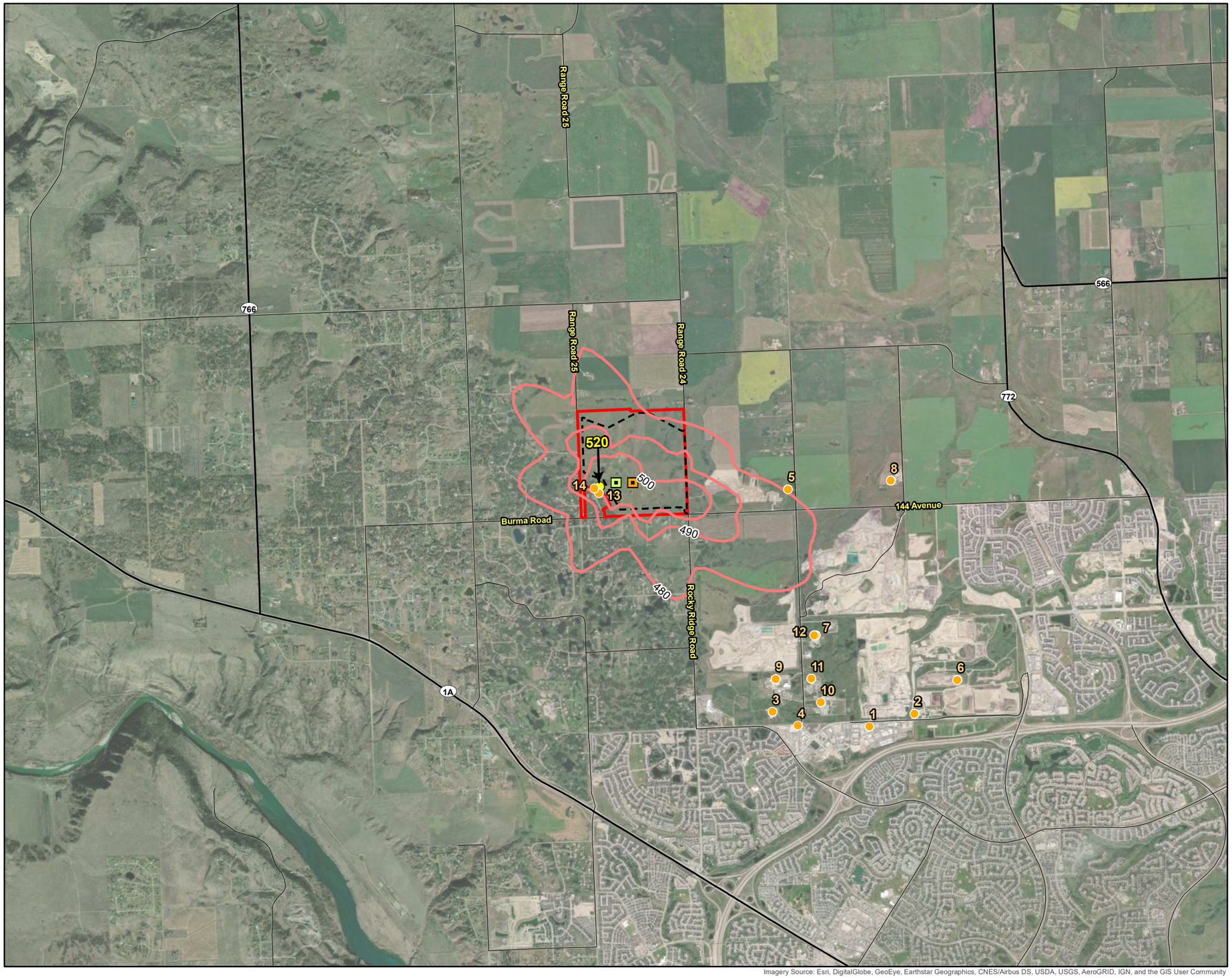
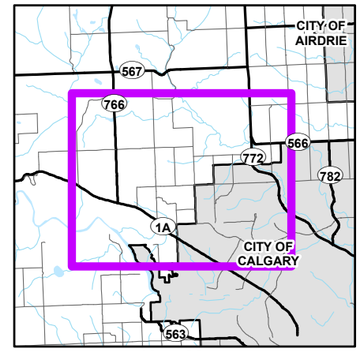
Figure: C14

PREDICTED MAXIMUM 8-HOUR AVERAGE CO CONCENTRATIONS (µg/m^3) APPLICATION SUMMER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-19



Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Key Map

Legend

Model Features

- Maximum Modelled Concentration (µg/m^3)
- Reclamation Area
- Mining Block
- Property Boundary
- Project Footprint
- Highway
- Road

AAAQO = 6,000 µg/m^3

- Concentration Contour

Sensitive Receptor

1. Spy Hill Bottle Depot (76 Street NW)
2. Inland Pit (69 Street NW)
3. Medical Facility
4. Walmart (85 Street NW)
5. Farm (144 Ave NW & RR23)
6. Spy Hill Gravel Pit
7. 85 Street NW Facility
8. Bearspaw Christian School (144 Avenue NW)
9. U of C Facility
10. Calgary Correctional Facility
11. Calgary Remand Centre
12. Youth Detention Centre
13. No.1 Crestview Estates
14. No. 2 Crestview Estates

N
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1:60,000
NAD 1983 UTM Zone 11N

600 300 0 600 1,200 1,800
m

Sources: AltaLIS; NRCan

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Figure: C15

PREDICTED MAXIMUM 8-HOUR AVERAGE CO CONCENTRATIONS (µg/m^3) APPLICATION WINTER CASE

LEHIGH SCOTT PROPERTY
AIR MODELLING ASSESSMENT REPORT
LEHIGH HANSON
Project No.: 60610856 Date: 2020-06-18

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Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm