Air Quality Assessment Report
Violet Hill Pit
Town of Mono, ON

Greenwood Aggregates Company Limited

Prepared for:
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Executive Summary

Trinity Consultants Ontario Inc. was retained by Greenwood Aggregates Company Limited to conduct an Air Quality Assessment (AQA) in support of applications to amend the Official Plan and Zoning By-law to obtain a licence under the Aggregate Resources Act (ARA) for proposed gravel pit operations on lands owned in the Town of Mono. The application will be for a Class 'A' Licence to Operate a Pit above the known water table.

This AQA report was prepared to assess compliance of the activities at the site with the Ontario Ministry of Environment and Climate Change's standards and guidelines for air quality. Where applicable, the study followed the guidelines in the MOECC`s "Procedure for Preparing an Emission Summary and Dispersion Modelling Report", Version 3.0, dated March 2009 and "Air Dispersion Modelling Guideline for Ontario", Version 2.0, dated March 2009.

The Ministry of Environment and Climate Change (MOECC) recently adopted new updated versions of several regulatory air dispersion models. The mandatory use of the new versions of AERMOD and AERMET models became effective as of the date the MOECC posted an Information Notice on the EBR (November 2, 2015). The new versions of AERMOD and AERMET are 14134 (dated May 14, 2014) and it is these versions that have been used to show compliance.

The results show that all point of impingement concentrations are below current MOECC criteria.

Greenwood Aggregates has further identified the following dust minimization measures and best management practices to be implemented at the site:

1. Travel speeds for trucks, scrapers, loaders, and any other equipment at the site will remain below 35 km/hr on paved roads and 20 km/hr on unpaved roads.

2. All truck loads will be tarped/covered before leaving the site.

3. The site entrance and exit will be swept as necessary to minimize tracking of dust off-site.

4. In the event of dust complaints, the complaint will be directed to the Site Supervisor, who will follow the protocols outlined in the Greenwood Complaints Procedures document which is kept on-site.

5. A water truck will be employed to moisten ground surfaces to minimize dust. Additional watering will occur when significant dust plumes are observed trailing from trucks or otherwise migrating off-site.

6. Other commercial dust suppressants may be employed at the discretion of the Site Supervisor should dust issues persist.

7. Extraction shall be suspended at the discretion of the Site Supervisor if the condition of the pit is dry and dusty and the wind is sufficient to cause wide-spread visible erosion of the open face with plumes directed off-site.

8. The site will maintain all water truck and water spray equipment in good working order to ensure reliability of operation.

9. Weather reports will be checked daily to plan for next-day operations and watering needs.

10. The dust control measures listed here serve as a standard operating procedure and should be kept on site in a conspicuous location and used for staff training and guidance.

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1.0 INTRODUCTION AND SITE DESCRIPTION

Trinity Consultants Ontario Inc. was retained by Greenwood Aggregates Company Limited (‘Greenwood’) to conduct an Air Quality Assessment (AQA) in support of applications to amend the Official Plan and Zoning By-law to obtain a licence under the Aggregate Resources Act (ARA) for proposed gravel pit operations on lands owned in the Town of Mono. The application will be for a Class A Licence to Operate a Pit above the known water table.

1.1 Purpose and Scope of Report

This report has been prepared to address the potential air quality impact from the site, focusing on the potential impacts from dust particles (total suspended particulate matter (PM) and fine particulate matter, both <10 um (PM_{10}) and <2.5 um ($PM_{2.5}$)), respirable crystalline silica, and combustion gases (nitrogen oxides (NOx), carbon monoxide (CO) and sulphur dioxide (SO_2)).

In order to meet the project objectives, the following tasks were completed:

1. Reviewed documentation provided by Greenwood including process operation descriptions, production rates and site drawings**.**

2. Identified air emission sources.

3. Identified potential substances released from the site and prepared emission rate estimates using accepted emission factors.

4. Performed air dispersion modelling using the AERMOD model to assess the maximum ground level concentrations for the substances emitted from the site emission sources.

5. Evaluated the results of the air dispersion modelling against the Point of Impingement (POI) concentration limits set by the Ministry of the Environment and Climate Change (MOECC).

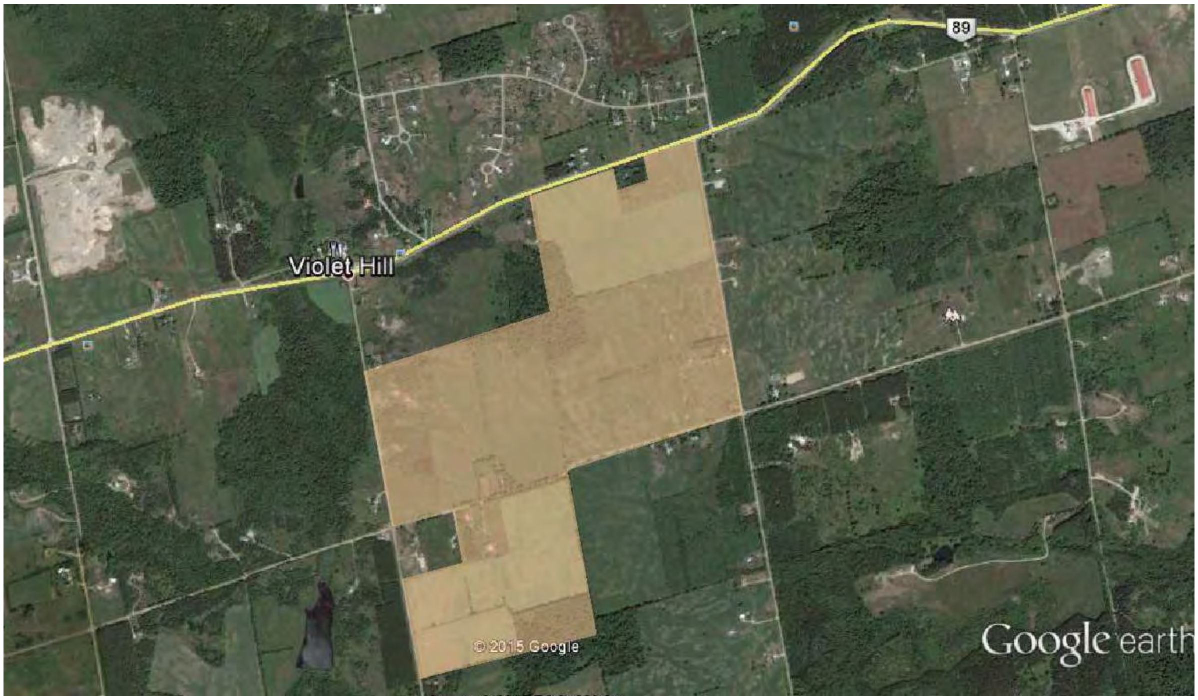
6. Provided Trinity’s opinion regarding the results from the air dispersion modelling and the potential impact of the site emissions at the gravel pit property line and nearby residences.

1.2 Site Description

The legal description of the site is Part Lots 30, 31, and 32, Concession 4 in the Town of Mono, County of Dufferin, Ontario. The site plan (entitled ‘Operational Concept’ dated 04

May 2015) is provided in Appendix A. An aerial view of the approximate location of the proposed pit is shown below:

Figure 1. Aerial View of Proposed Pit (Approximate Location)



The Site is currently zoned as A (Rural). Surrounding lands are zoned A (Rural, to the east), NEC (Niagara Escarpment Development Control Area, to the west and south), and CL (Local Commercial) and Residential to the north. The zoning plans (for both the Town of Mono and Mulmur Township) are provided in Appendix B.

1.2.1 Proposed Operations

Three (3) operating scenarios for the pit were evaluated.

Scenario 1 - Operation in North Area (A, B, and C) only;
Scenario 2 - Operations in both North (A, B, and C) and South Area (D and E);
Scenario 3 - Operations in North Area (crushing/screening/transport of material off-site only) and South Area (excavation).

The estimated max production will be 1,000,000 tonnes per annum. The top layer of the deposit will require full time use of a crusher. The deposit itself is fairly sandy and a full-time crusher on the site is not anticipated, however, there could be some crushing from time to time. The site will have a full-time screening plant in operation with some potential for washing of material as well. Normal aggregate pit equipment will be on site, including bulldozers for stripping, one or two loaders, conveyor systems and stackers. Sources of emissions on site that are evaluated in the assessment include; excavation, crushing, screening, stock piles, truck loading and truck traffic.

2.0 OPERATING CONDITIONS, EMISSION ESTIMATING, and DATA QUALITY

The proposed gravel pit site will include the following major operations:

- Aggregate extraction and processing plants (crushing/screening/washing)
- Traffic on-site on gravel pit roads and activity on storage piles

Each of these major operations is described in the following report sections. The procedures and assumptions used for calculating emissions rates are provided in Appendix C.

2.1 Operating Conditions

The estimated maximum production will be 1,000,000 tonnes per annum. The maximum throughput of the stationary crushing/screening/washing plant is expected to be 600 tonnes per hour, operating a maximum of twelve hours per day. The portable crushing and screening plant has an expected capacity of 500 tonnes per hour.

2.1.1 Aggregate Extraction and Crushing

Aggregate extraction and crushing in the gravel pit includes the following processes which potentially release air emissions:

- Excavation by stripping of the deposit (with bulldozer and scrapers or high hoe and trucks); there will be no blasting or drilling on the site. The stripped topsoil will initially be moved to create the berms surrounding the site to be stored until final rehabilitation or be used in progressive rehabilitation when the required berm construction is complete. The use of berms is considered to be an appropriate and practical mitigation for quarries.
- Crushing aggregate material (includes primary and secondary crushing, primary and secondary screening and diesel generators (which were conservatively assumed to be a 'Tier 2' type)

2.1.2 Fugitive Emissions from Roads and Storage Piles

Fugitive emissions include the following processes which potentially release air emissions:

- Truck loading of material at active face
- Transfers of materials to stockpiles
- Road dust emissions from unpaved roads (internal roads in the gravel pit).

2.2 Emission Estimating

Emission calculations, the associated data quality and sample calculations are provided in Appendix C.

Supporting documents for emission calculations are provided in Appendix D.

3.0 DISPERSION MODELLING

This section provides a description of how the dispersion modelling was conducted for the Site to determine the maximum concentration at a point of impingement (POI). The dispersion modelling was conducted in accordance with the MOECC publication "Air Dispersion Modelling Guideline for Ontario", PIBS 5165e (ADMGO).

Air dispersion modelling is the mathematical estimation of pollutant impacts from emissions sources within a study area. Several factors impact the fate and transport of pollutants in the atmosphere including meteorological conditions, site configuration, emission release characteristics, and surrounding terrain.

The AERMIC (American Meteorological Society/EPA Regulatory Model Improvement Committee) Regulatory Model, AERMOD, was specially designed to support the U.S. EPA's regulatory modelling programs. AERMOD is the next-generation air dispersion model that incorporates building downwash algorithms, local and regional weather data, and terrain data to provide a more realistic prediction of impacts at the point of impingement.

The Ministry of Environment and Climate Change (MOECC) recently adopted new updated versions of several regulatory air dispersion models. The mandatory use of the new versions of AERMOD and AERMET models became effective as of the date the MOECC posted an Information Notice on the EBR (November 2, 2015). The new versions of AERMOD and AERMET are 14134 (dated May 14, 2014) and it is these versions that have been used to show compliance.

3.1 Meteorological Conditions and Land Use

Based on the land-use characteristics around the site, the "crops" meteorological dataset for the region was used. The surface data is from the London, ON, and the Upper Air Data is from White Lake, MI. The meteorological data covers the dates from January 1, 1996 to December 31, 2000.

The zoning map of the area is included in Appendix B.

3.2 Terrain Data

Digital elevation model (DEM) data was obtained from the MOECC website and processed using the AERMOD terrain processor AERMAP. The terrain data used are 0904_3.DEM and 0904_4.DEM.

3.3 Coordinate System

A local coordinate system was used for the modelling, with the y-axis pointing true north, and the origin located at the south west corner of the property at 3rd Line East and 30 Sideroad:

Figure 2. Location of Modelling Origin

Anchor locations are used to anchor a local coordinate system to a UTM coordinate system ie. user location of 0,0 = 574153.86E, 4882809.34N, Zone 17.

This datum value is used by the program to align the various sources and receptors coordinates to the node coordinates of the individual DEM files.

3.4 Deposition

The deposition algorithm in the AERMOD model was not used for this assessment and therefore the predicted modelled POI concentrations are considered to be conservative.

3.5 Averaging Time and Conversions

O.Reg. 419/05 Schedule 3 standards and guidelines were used in this report to demonstrate compliance. All standards and guidelines are based on half-hour, 1-hour and 24-hour averaging periods, as applicable.

Conversion factors are required when modelling for averaging time periods less than one hour. For example, for contaminants where the MOECC POI Limit is based on a 30 minute averaging time period (such as carbon monoxide), the 1 hour averaging time period results obtained from the model can be converted to a 30 minute averaging time period by multiplying the concentration predicted by the model by 1.2.

3.6 Source Locations and Parameters

The gravel pit sources are modelled as single open pit sources. The use of the open pit source was considered appropriate because, in U.S. EPA AERMOD literature, it is stated that 'The aspect ratio (ie. length/width) of open pit sources should be less than 10 to 1'; for all pits modelled here, this is the case, and therefore the open pit sources are considered appropriate. There are assumed to be four open pit sources: two in the 'north area' and two in the 'south area'. To obtain conservative estimates, gravel pit dimensions that were inputted into the model were a maximum length and width obtained from the site plan, and a depth of ten metres. All sources (except generators which were modelled as a point source) are in a defined 'open pit' are lumped into a single source located at a height of four metres above the gravel pit floor. The AERMOD model for open pit sources determines the amount of material which makes it out of the pit, depending on the size distribution of the particulate, and then calculates off-site concentrations using the area source model for the escaping portion.

The modelling source types are summarized in Table 1 on the following pages.

Table 1. Modelled Sources

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only				
Source ID	Description	Source Type	Emission ID	Emission Source Description
1	Diesel Generators	Point	P1	Diesel Generators
2	North Area (A)	Open Pit	P2a	Truck Loading of Material at Active Face
			P2b	Truck Unloading of Aggregate to Crushing Plant
			P3a	Primary Crushing
			P3b	Secondary Crushing
			P4	Screening (Two Units)
			P5a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P5b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P6	Conveyor Transfer Points (Screening to Wash Screen)
			P7	Truck Loading of Material to Shipping Trucks
			P11	Aggregate Loading from Screening Plant to Storage Piles
			P12a	Aggregate transfer to crushing plant (in Area A)
			P15a	Product Shipping along Haul Road (portion below grade, Area A)
3	North Area (B and C)	Open Pit	P8a	Portable Primary Crushing
			P8b	Portable Secondary Crushing
			P9	Portable Screening (Two units)
			P10a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P10b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P10c	Conveyor Transfer Points (Screening to Stackers)
			P12b	Aggregate transfer to crushing plant (in North Pit 2)
			P15b	Product Shipping along Haul Road (portion below grade, Area B/C)
4	Haul Road	Line	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)				
Source ID	Description	Source Type	Emission ID	Emission Source Description
1	Diesel Generators	Point	P1	Diesel Generators
2	North Area (A)	Open Pit	P2a	Truck Loading of Material at Active Face
			P2b	Truck Unloading of Aggregate to Crushing Plant
			P3a	Primary Crushing
			P3b	Secondary Crushing
			P4	Screening (Two Units)
			P5a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P5b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P6	Conveyor Transfer Points (Screening to Wash Screen)
			P7	Truck Loading of Material to Shipping Trucks
			P11	Aggregate Loading from Screening Plant to Storage Piles
			P12a	Aggregate transfer to crushing plant (in Area A)
			P15a	Product Shipping along Haul Road (portion below grade, Area A)
2	North Area (B and C)	Open Pit	P8a	Portable Primary Crushing
			P8b	Portable Secondary Crushing
			P9	Portable Screening (Two units)
			P10a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P10b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P10c	Conveyor Transfer Points (Screening to Stackers)
			P12b	Aggregate transfer to crushing plant (in North Pit 2)
			P15b	Product Shipping along Haul Road (portion below grade, Area B/C)
3	Haul Road	Line	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)
4	South Area (D)	Open Pit	P14b	Aggregate transfer to crushing plant (from Area D)
5	South Area (E)	Open Pit	P14a	Aggregate transfer to crushing plant (from Area E)
6	30 Sideroad Crossing	Line	P13	Aggregate transfer to crushing plant (across 30 Sideroad)

Scenario 3 - Operations in North Area (crushing/screening/transport of material off-site only) and South Area (excavation)

Source ID	Description	Source Type	Emission ID	Emission Source Description
1	Diesel Generators	Point	P1	Diesel Generators
2	North Area (A)	Open Pit	P2a	Truck Loading of Material at Active Face
			P2b	Truck Unloading of Aggregate to Crushing Plant
			P3a	Primary Crushing
			P3b	Secondary Crushing
			P4	Screening (Two Units)
			P5a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P5b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P6	Conveyor Transfer Points (Screening to Wash Screen)
			P7	Truck Loading of Material to Shipping Trucks
			P11	Aggregate Loading from Screening Plant to Storage Piles
			P15a	Product Shipping along Haul Road (portion below grade, Area A)
2	North Pit 2	Open Pit	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)
3	Haul Road	Line	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)
4	South Area (D)	Open Pit	P14b	Aggregate transfer to crushing plant (from Area D)
5	South Area (E)	Open Pit	P8a	Primary Crushing
			P8b	Secondary Crushing
			P9	Screening (Two units)
			P10a	Conveyor Transfer Points (Primary to Secondary Crushing)
			P10b	Conveyor Transfer Points (Secondary Crushing to Screening)
			P10c	Conveyor Transfer Points (Screening to Stackers)
			P14a	Aggregate transfer to crushing plant (from Area E)
6	30 Sideroad Crossing	Line	P13	Aggregate transfer to crushing plant (across 30 Sideroad)

Emissions of carbon monoxide, sulphur dioxide and nitrogen oxides from the diesel generators were modelled as a point source located to the west of North Area 1 (A); it was determined that the setback distance would ideally be at least 150 metres. They were conservatively modelled at this distance; in reality, the generators will be moved, typically following the screening/wash plant.

The locations of the sources are graphically represented in a series of figures in Appendix E. There are two figures for each modelling scenario.

3.7 Receptor Grid

A multi-tiered receptor grid was defined starting with a rectangular boundary that enclosed all the modelled sources (no receptors were placed inside the site's property line when modelling with the grid). The receptor spacing is listed below:

- 10 metre receptor spacing along property line
- 20 metre receptor spacing, extending 1150 metres from the approximate centre of the source (ie. every point on the boundary of the rectangle is at least 200 metres from every source of contaminant)
- 50 metre receptor spacing, extending 300 metres from the first grid tier, above, to a distance of 1450 metres from the approximate centre of the site
- 100 metre receptor spacing, extending 800 metres from the first grid tier, to a distance of 1950 metres from the approximate centre of the site

This multi-tiered grid is graphically represented on three figures, Figures E-1, E-3 and E-5 included in Appendix E (one for each modelling scenario).

In addition, nineteen discrete receptors, representing the potential receptor areas (ie. residences) around the site. While sixteen are off-site (ie. R1-R16, inclusive), three are currently indicated on the site plan are being within the site's property boundaries ie. R17, R18, and R19. These receptors are graphically represented on two figures, Figures E-2 and E-4 included in Appendix E (E-2 for Scenario 1; E-4 for Scenarios 2 and 3).

3.8 Dispersion Modelling Input and Output Files

The summary of the AERMOD model inputs are provided in Appendix E. Per section 6.6 of the MOECC Air Dispersion Modelling Guideline for Ontario (Version 2.0), in modelling applications using regional or local meteorological data sets, certain extreme, rare and transient metrological conditions may be present in the data sets that may be considered outliers. For assessments of 24-hour concentrations, the highest 24-hour average predicted concentration in each single meteorological year can be discarded. For assessments of one-hour concentrations, the eight highest one-hour concentrations in each meteorological year can be discarded. The results of this part of the assessment are included in Appendix F.

4.0 RESULTS AND DISCUSSION

This section includes a summary of the air dispersion modelling and a discussion of the results.

4.1 Emission Summary Tables

A table of the results for each contaminant by averaging period is included for each of the three modelling scenarios (refer to following tables). In addition, the results by contaminant for the closest off-site receptors are also included.

The results are based on the emissions from fugitive road dusts having a control efficiency of 98% (refer to Table D-1, Appendix C).

TABLE 2.
Emission Summary Table
Scenario 1 - Operation in 'North Area' (Areas A, B, C) only

Contaminant	CAS No.	Total Facility Emission Rate (g/s)	Air Dispersion Model Used [Version]	Averaging Period (hours)	Maximum POI Conc. (ug/m³)	MOECC POI Limit [Note 1] (ug/m³)	Regulation Schedule # *	Basis of Criteria	% of MOECC Limit
Total Particulate	N/A - PM	1.118	AERMOD [14134]	24	71.72	120	3	Visibility standard	59.8%
Fine Particulate <10 um (PM10)	N/A - PM10	0.416	AERMOD [14134]	24	26.69	50	n/a	Ambient Air Quality Criteria	53.4%
Fine Particulate <2.5 um (PM2.5)	N/A - PM2.5	0.158	AERMOD [14134]	24	10.11	30	n/a	Canada-wide Standard	33.7%
Crystalline silica	14808-60-7	0.037	AERMOD [14134]	24	2.40	5	n/a	Health-based guideline	48.0%
Carbon Monoxide	630-08-0	0.424	AERMOD [14134]	0.5	321.36	6000	3	Health-based standard	5.4%
Sulphur dioxide	7446-09-5	0.001	AERMOD [14134]	24	119.21	275	3	Health & Vegetation Standard	43.4%
				1	321.70	690	3	Health & Vegetation Standard	46.6%
Nitrogen oxides	10102-44-0	2.062	AERMOD [14134]	24	51.09	200	3	Health-based standard	25.5%
				1	137.87	400	3	Health-based standard	34.5%

Note 1: The limit for PM10 is an interim Ambient Air Quality Criteria (AAQC). The limit for PM2.5 is not an AAQC per se but is included in MOECC Guidance Document "Ontario's Ambient Air Quality Criteria" (April 2012) as a guide for decision-making. This value of 30 μg/m3 (24 hr) is the Canada-wide Standard (CWS) for PM2.5, developed jointly by the Federal government and the Provinces, including Ontario, as a step towards the long-term goal of minimizing the risk that fine particles impose on human health and the environment,

Ground Level Concentrations at the Closest Sensitive Receptors

Receptor	Maximum POI Concentration (ug/m³)								
	Total Particulate	Fine Particulate <10 um (PM10)	Fine Particulate <2.5 um (PM2.5)	Crystalline Silica	Carbon Monoxide	Sulphur dioxide		Nitrogen oxides	
	N/A - PM	N/A - PM10	N/A - PM2.5	14808-60-7	630-08-0	7446-09-5		10102-44-0	
	24-hour	24-hour	24-hour	24-hour	Half hour	24-hour	1-hour	24-hour	1-hour
R1	28.20	10.50	3.98	0.94	156.99	16.93	155.51	7.25	66.65
R2	25.71	9.57	3.62	0.86	145.52	14.24	144.14	6.10	61.78
R3	31.34	11.67	4.42	1.05	146.42	16.29	145.04	6.98	62.16
R4	36.38	13.54	5.13	1.22	155.14	19.17	153.67	8.22	65.86
R5	42.77	15.92	6.03	1.43	160.31	19.79	159.02	8.51	68.15
R6	50.70	18.87	7.15	1.70	164.96	29.94	163.40	12.83	70.03
R7	37.18	13.84	5.24	1.25	186.94	39.83	185.17	17.07	79.36
R8	42.21	15.71	5.95	1.41	224.80	53.57	223.39	22.96	95.74
R9	48.49	18.05	6.84	1.62	253.57	57.54	251.17	24.66	107.64
R10	31.21	11.62	4.40	1.05	211.27	56.30	209.28	24.13	89.69
R11	40.99	15.25	5.78	1.37	223.04	40.26	220.93	17.25	94.68
R12	13.51	5.03	1.90	0.45	96.46	15.97	95.55	6.84	40.95
R13	30.53	11.36	4.30	1.02	160.86	36.54	159.34	15.66	68.29
R14	48.93	18.21	6.90	1.64	223.70	55.72	221.59	23.88	94.97
R15	28.85	10.74	4.07	0.97	140.53	25.72	139.20	11.02	59.66
R16	23.55	8.76	3.32	0.79	129.24	18.09	128.02	7.75	54.87
R17	69.85	25.99	9.85	2.34	259.71	95.89	257.26	41.10	109.50
R18	47.88	17.82	6.75	1.60	199.30	62.60	197.42	26.83	84.61
R19	85.38	31.77	12.04	2.86	172.97	33.90	171.33	14.53	73.43

TABLE 3.
Emission Summary Table
Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)

Contaminant	CAS No.	Total Facility Emission Rate (g/s)	Air Dispersion Model Used	Averaging Period (hours)	Maximum POI Conc. (ug/m³)	MOECC POI Limit [Note 1] (ug/m³)	Regulation Schedule # *	Basis of Criteria	% of MOECC Limit
Total Particulate	N/A - PM	1.283	AERMOD [14134]	24	85.87	120	3	Visibility standard	71.6%
Fine Particulate <10 um (PM10)	N/A - PM10	0.458	AERMOD [14134]	24	30.66	50	n/a	Ambient Air Quality Criteria	61.3%
Fine Particulate <2.5 um (PM2.5)	N/A - PM2.5	0.162	AERMOD [14134]	24	10.83	30	n/a	Canada-wide Standard	36.1%
Crystalline silica	14808-60-7	0.041	AERMOD [14134]	24	2.76	5	n/a	Health-based guideline	55.2%
Carbon Monoxide	630-08-0	0.424	AERMOD [14134]	0.5	321.36	6000	3	Health-based standard	5.4%
Sulphur dioxide	7446-09-5	0.001	AERMOD [14134]	24	119.21	275	3	Health & Vegetation Standard	43.4%
				1	321.70	690	3	Health & Vegetation Standard	46.6%
Nitrogen oxides	10102-44-0	2.062	AERMOD [14134]	24	51.09	200	3	Health-based standard	25.5%
				1	137.87	400	3	Health-based standard	34.5%

Note 1: The limit for PM10 is an interim Ambient Air Quality Criteria (AAQC). The limit for PM2.5 is not an AAQC per se but is included in MOECC Guidance Document "Ontario's Ambient Air Quality Criteria" (April 2012) as a guide for decision-making. This value of 30 µg/m3 (24 hr) is the Canada-wide Standard (CWS) for PM2.5, developed jointly by the Federal government and the Provinces, including Ontario, as a step towards the long-term goal of minimizing the risk that fine particles impose on human health and the environment,

Ground Level Concentrations at the Closest Sensitive Receptors

Receptor	Maximum POI Concentration (ug/m³)								
	Total Particulate	Fine Particulate <10 um (PM10)	Fine Particulate <2.5 um (PM2.5)	Crystalline Silica	Carbon Monoxide	Sulphur dioxide		Nitrogen oxides	
	N/A - PM	N/A - PM10	N/A - PM2.5	14808-60-7	630-08-0	7446-09-5		10102-44-0	
	24-hour	24-hour	24-hour	24-hour	Half hour	24-hour	1-hour	24-hour	1-hour
R1	30.19	10.78	3.81	0.97	156.99	16.93	155.51	7.25	66.65
R2	27.58	9.85	3.48	0.89	145.52	14.24	144.14	6.10	61.78
R3	33.73	12.04	4.25	1.08	146.42	16.29	145.04	6.98	62.16
R4	38.31	13.68	4.83	1.23	155.14	19.17	153.67	8.22	65.86
R5	44.02	15.72	5.55	1.41	160.31	19.79	159.02	8.51	68.15
R6	53.34	19.04	6.73	1.71	164.96	29.94	163.40	12.83	70.03
R7	39.66	14.16	5.00	1.27	186.94	39.83	185.17	17.07	79.36
R8	43.92	15.68	5.54	1.41	224.80	53.57	223.39	22.96	95.74
R9	50.45	18.01	6.36	1.62	253.57	57.54	251.17	24.66	107.64
R10	41.30	14.75	5.21	1.33	211.27	56.30	209.28	24.13	89.69
R11	44.61	15.93	5.63	1.43	223.04	40.26	220.93	17.25	94.68
R12	21.91	7.82	2.76	0.70	96.46	15.97	95.55	6.84	40.95
R13	30.85	11.02	3.89	0.99	160.86	36.54	159.34	15.66	68.29
R14	49.34	17.62	6.22	1.59	223.70	55.72	221.59	23.88	94.97
R15	31.54	11.26	3.98	1.01	140.53	25.72	139.20	11.02	59.66
R16	25.69	9.17	3.24	0.83	129.24	18.09	128.02	7.75	54.87
R17	105.03	37.50	13.25	3.38	259.71	95.89	257.26	41.10	109.50
R18	54.17	19.34	6.83	1.74	199.30	62.60	197.42	26.83	84.61
R19	87.78	31.34	11.07	2.82	172.97	33.90	171.33	14.53	73.43

TABLE 4.
Emission Summary Table
Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

Contaminant	CAS No.	Total Facility Emission Rate (g/s)	Air Dispersion Model Used	Averaging Period (hours)	Maximum POI Conc. (ug/m³)	MOECC POI Limit [Note 1] (ug/m³)	Regulation Schedule # *	Basis of Criteria	% of MOECC Limit
Total Particulate	N/A - PM	1.128	AERMOD [14134]	24	105.28	120	3	Visibility standard	87.7%
Fine Particulate <10 um (PM10)	N/A - PM10	0.419	AERMOD [14134]	24	39.07	50	n/a	Ambient Air Quality Criteria	78.1%
Fine Particulate <2.5 um (PM2.5)	N/A - PM2.5	0.158	AERMOD [14134]	24	14.73	30	n/a	Canada-wide Standard	49.1%
Crystalline silica	14808-60-7	0.038	AERMOD [14134]	24	3.52	5	n/a	Health-based guideline	70.3%
Carbon Monoxide	630-08-0	0.424	AERMOD [14134]	0.5	321.36	6000	3	Health-based standard	5.4%
Sulphur dioxide	7446-09-5	0.001	AERMOD [14134]	24	119.21	275	3	Health & Vegetation Standard	43.4%
				1	321.70	690	3	Health & Vegetation Standard	46.6%
Nitrogen oxides	10102-44-0	2.062	AERMOD [14134]	24	51.09	200	3	Health-based standard	25.5%
				1	137.87	400	3	Health-based standard	34.5%

Note 1: The limit for PM10 is an interim Ambient Air Quality Criteria (AAQC). The limit for PM2.5 is not an AAQC per se but is included in MOECC Guidance Document "Ontario's Ambient Air Quality Criteria" (April 2012) as a guide for decision-making. This value of 30 µg/m3 (24 hr) is the Canada-wide Standard (CWS) for PM2.5, developed jointly by the Federal government and the Provinces, including Ontario, as a step towards the long-term goal of minimizing the risk that fine particles impose on human health and the environment,

Ground Level Concentrations at the Closest Sensitive Receptors

Receptor	Maximum POI Concentration (ug/m³)								
	Total Particulate	Fine Particulate <10 um (PM10)	Fine Particulate <2.5 um (PM2.5)	Crystalline Silica	Carbon Monoxide	Sulphur dioxide		Nitrogen oxides	
	N/A - PM	N/A - PM10	N/A - PM2.5	14808-60-7	630-08-0	7446-09-5		10102-44-0	
	24-hour	24-hour	24-hour	24-hour	Half hour	24-hour	1-hour	24-hour	1-hour
R1	26.54	9.85	3.71	0.89	156.99	16.93	155.51	7.25	66.65
R2	16.42	6.09	2.30	0.55	145.52	14.24	144.14	6.10	61.78
R3	14.44	5.36	2.02	0.48	146.42	16.29	145.04	6.98	62.16
R4	17.93	6.65	2.51	0.60	155.14	19.17	153.67	8.22	65.86
R5	19.19	7.12	2.69	0.64	160.31	19.79	159.02	8.51	68.15
R6	26.62	9.88	3.73	0.89	164.96	29.94	163.40	12.83	70.03
R7	27.05	10.04	3.78	0.90	186.94	39.83	185.17	17.07	79.36
R8	31.51	11.69	4.41	1.05	224.80	53.57	223.39	22.96	95.74
R9	33.91	12.58	4.74	1.13	253.57	57.54	251.17	24.66	107.64
R10	48.59	18.03	6.80	1.62	211.27	56.30	209.28	24.13	89.69
R11	60.59	22.48	8.48	2.02	223.04	40.26	220.93	17.25	94.68
R12	48.68	18.06	6.81	1.63	96.46	15.97	95.55	6.84	40.95
R13	22.78	8.45	3.19	0.76	160.86	36.54	159.34	15.66	68.29
R14	41.11	15.25	5.75	1.37	223.70	55.72	221.59	23.88	94.97
R15	20.87	7.75	2.92	0.70	140.53	25.72	139.20	11.02	59.66
R16	21.45	7.96	3.00	0.72	129.24	18.09	128.02	7.75	54.87
R17	82.13	30.48	11.49	2.74	259.71	95.89	257.26	41.10	109.50
R18	50.18	18.62	7.02	1.68	199.30	62.60	197.42	26.83	84.61
R19	32.77	12.16	4.59	1.09	172.97	33.90	171.33	14.53	73.43

4.2 Conclusions

The results show that all point of impingement concentrations are below current MOECC criteria.

Greenwood Aggregates has further identified the following dust minimization measures and best management practices to be implemented at the site:

1. Travel speeds for trucks, scrapers, loaders, and any other equipment at the site will remain below 35 km/hr on paved roads and 20 km/hr on unpaved roads.

2. All truck loads will be tarped/covered before leaving the site.

3. The site entrance and exit will be swept as necessary to minimize tracking of dust off-site.

4. In the event of dust complaints, the complaint will be directed to the Site Supervisor, who will follow the protocols outlined in the Greenwood Complaints Procedures document which is kept on-site.

5. A water truck will be employed to moisten ground surfaces to minimize dust. Additional watering will occur when significant dust plumes are observed trailing from trucks or otherwise migrating off-site.

6. Other commercial dust suppressants may be employed at the discretion of the Site Supervisor should dust issues persist.

7. Extraction shall be suspended at the discretion of the Site Supervisor if the condition of the pit is dry and dusty and the wind is sufficient to cause wide-spread visible erosion of the open face with plumes directed off-site.

8. The site will maintain all water truck and water spray equipment in good working order to ensure reliability of operation.

9. Weather reports will be checked daily to plan for next-day operations and watering needs.

10. The dust control measures listed here serve as a standard operating procedure and should be kept on site in a conspicuous location and used for staff training and guidance.

APPENDIX A

Site Plan

Legend

- Boundary of Area to be Licensed
- Area to be Excavated
- Elevation, 1M Contour
- Elevation, Spot
- Parcel Fabric
- Surface Drainage
- Setbacks, Metres
- Direction of Excavation
- Sequence of Excavation
- Existing Tree Cover
- Existing Fences
- Building/Structure — Use and Receptor Number
- Monitoring Well MW1-MW11 — Location and Number
- Existing Entrance/Exit
- Cross Sections — Location and Identifier
- Berm — Height and Top Elevation

PLAN DETAILS YET TO BE ADDED

Notes

1. TOPOGRAPHIC BASE MAPPING DERIVED FROM 2010 AIRPHOTO AS PREPARED BY FIRST BASE SOLUTIONS INC. CONTOUR INTERVAL IS 1M. MAPPING SUPPLEMENTED WITH ADDITIONAL INFORMATION FROM LOCAL PLANNING DOCUMENTS.

Preliminary

References

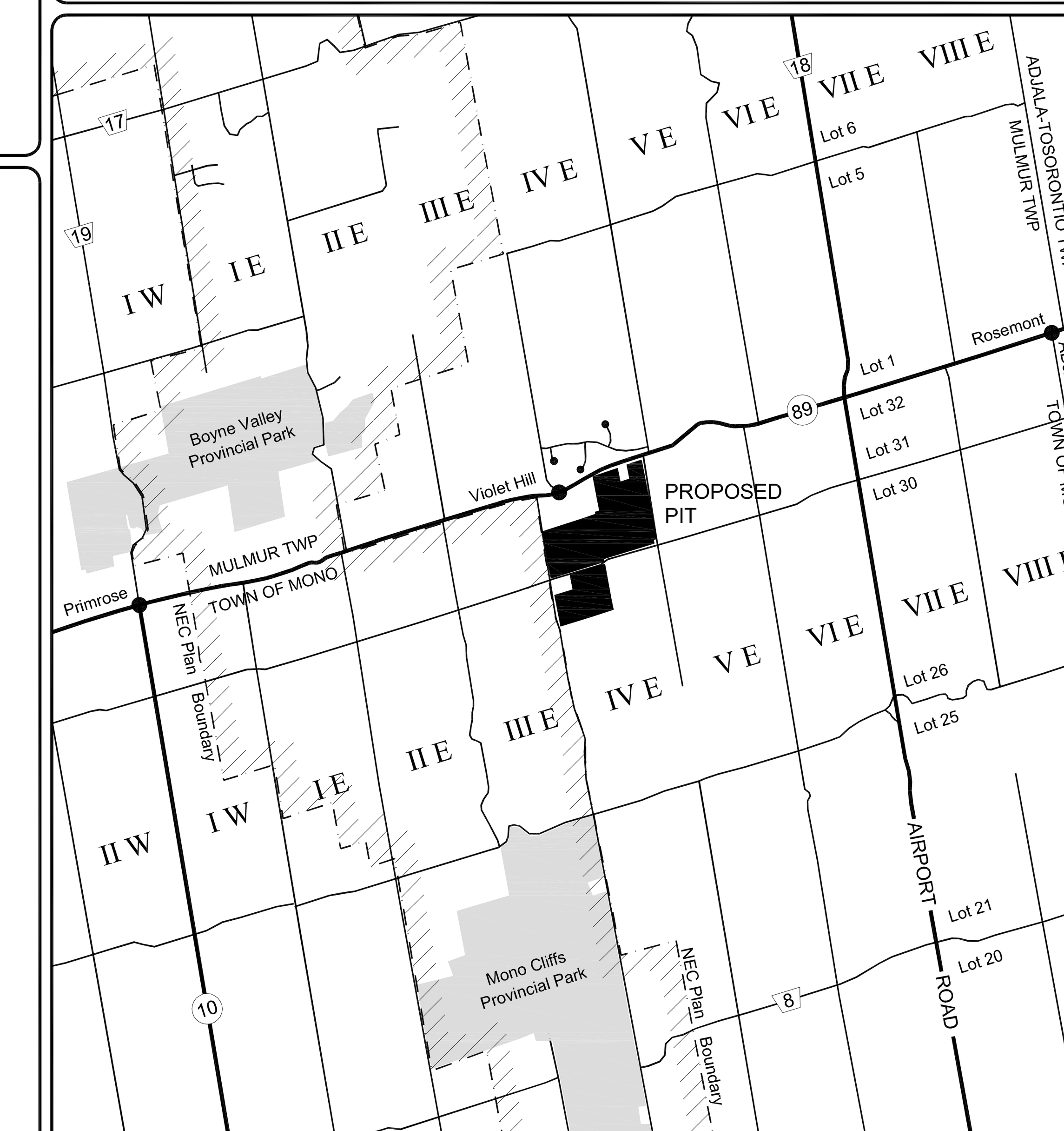
1. SURVEY OF MONITORING WELL LOCATIONS BY VAN HARTEN SURVEYING AND ENGINEERING.
2. VALCOUSTICS VIOLET HILL PIT MITIGATION REQUIREMENTS AND TOP OF BERM ELEVATIONS MARCH 03, 2015.

Greenwood AGGREGATES LIMITED
205467 County Rd. 109, Amaranth ON L9W 0V1

VIOLET HILL PIT

Part Lots 30, 31 & 32, Conc. 4 E.H.S.
Town of Mono
Dufferin County

OPERATIONAL CONCEPT



0 1000 2000m 3000
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Key Map

North

DRAWN: J.A.R.
APPROVED: S.G.
FILE: April 2015 Prelim model.dwg
PLOTTED: 04 May, 2015

AMENDMENT NO.

No.	DATE	DESCRIPTION	APP'D

Amendments

North

0 50 100 150m 300
ORIGINAL SCALE 1:4,000 @ 22x34

ROLLINGS HYLAND CONSULTING
Orangeville, Ontario 519.942.1961

CERTIFIED TO PREPARE SITE PLANS UNDER SECTION 8(4) OF THE AGGREGATE RESOURCES ACT

APPENDIX B

Zoning Plans

Zoning Map Schedule "A" to Zoning Bylaw 78-1

as amended

Office Consolidation 2010

Town of Mono

This is an Office Consolidation of comprehensive Zoning Bylaw 78-1, as amended, to December 2008. This consolidation includes new digital mapping which accurately reflects the mapping in Zoning Bylaw 78-1, as amended, and lot configuration to December 2008. Please refer to the original Zoning Bylaw 78-1, and any amendments thereto for additional information.

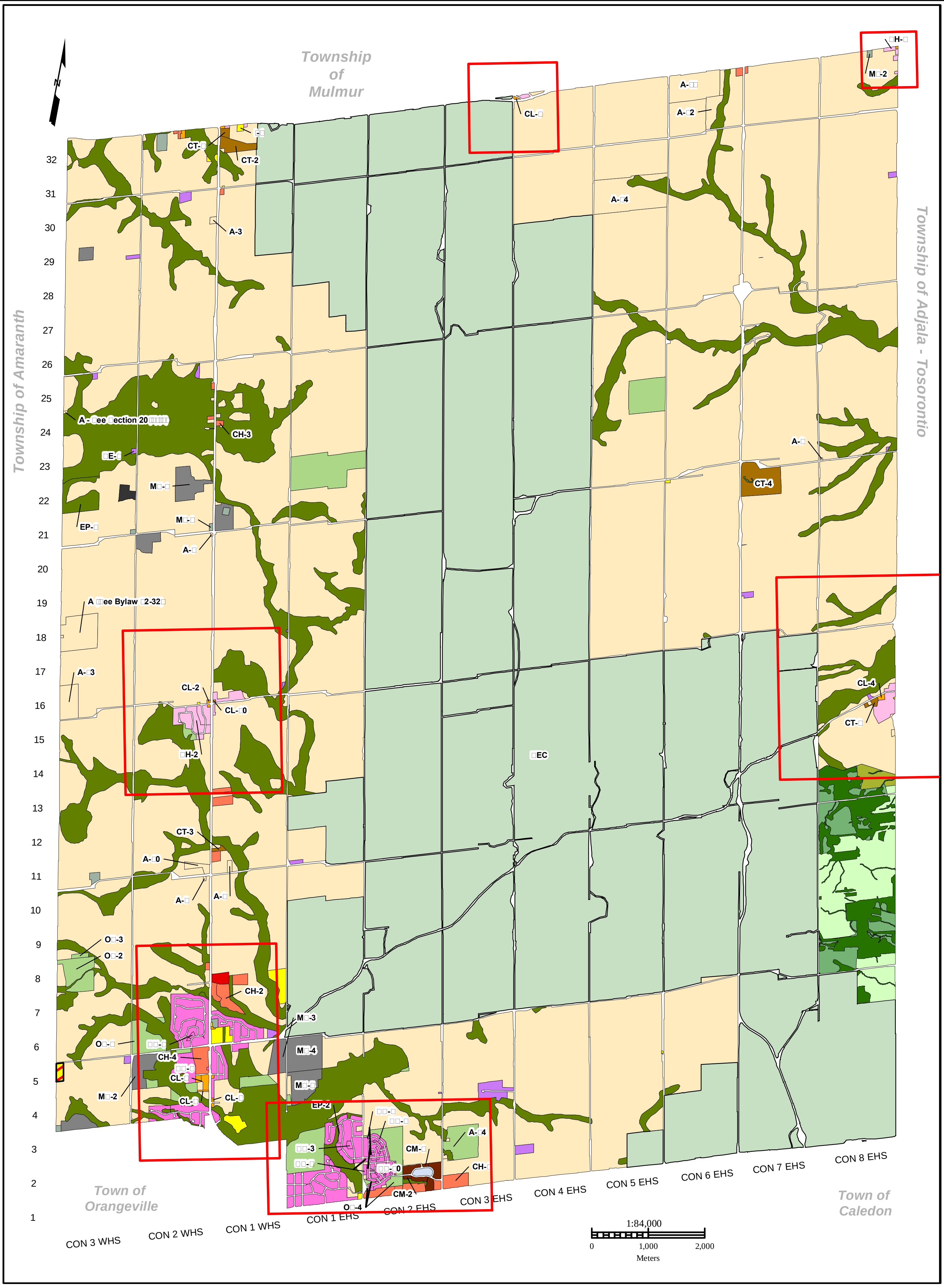
Only Special Policy Areas (e.g. MX-1) are labled to differentiate them from Zones (e.g. MX), which are represented by the colour in the legend.

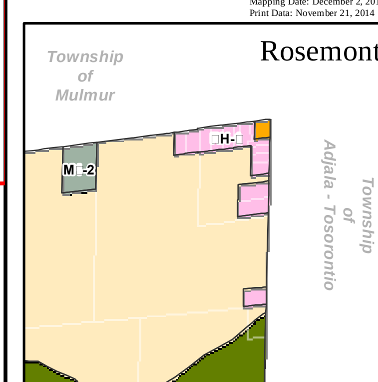
Lot Parcels are overlayed.

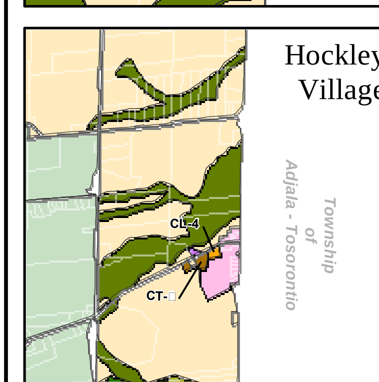
Roads are represented by road allowances. These do not represent actual road locations, widths, or the existence of a road.

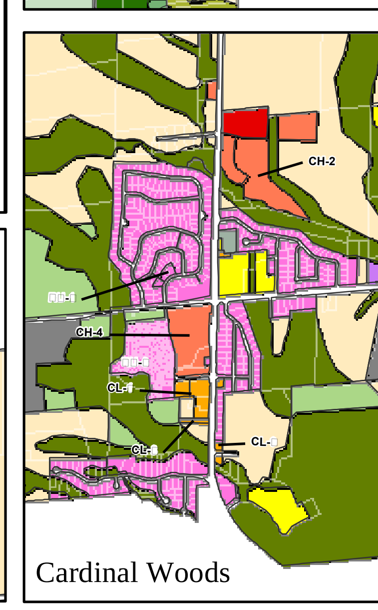
H	Hamlet Residential
	Suburban Residential
E	Rural Estate
A	Rural
O	Open Space
EP	Environmental Protection Zone
CL	Local Commercial
CT	Tourist Commercial
CH	Highway Commercial
CP	Plaza Commercial
CM	Commercial Light Industrial
	Major Institutional
	Special Institutional
ML	Special Light Industrial
M	General Industrial
M	Extractive Industrial
MD	Disposal Industrial
EC	Niagara Escarpment Development Control Area
OMEP	Oak Ridges Moraine Environmental Protection
OMC	Oak Ridges Moraine Natural Core
OMC	Oak Ridges Moraine Countryside
OML	Oak Ridges Moraine Natural Linkage

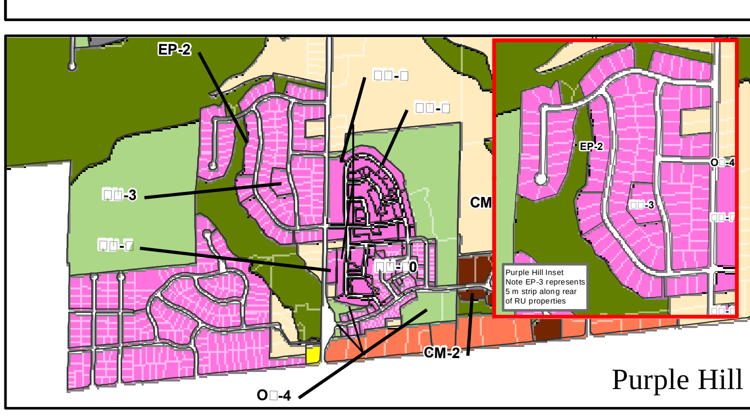
Datum: NAD83
Coordinate System: UTM - Zone 17
Mapping Date: December 2, 2010
Print Data: November 21, 2014

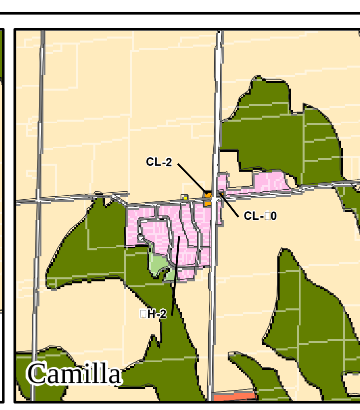


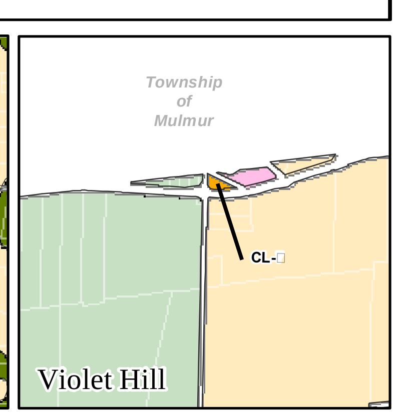












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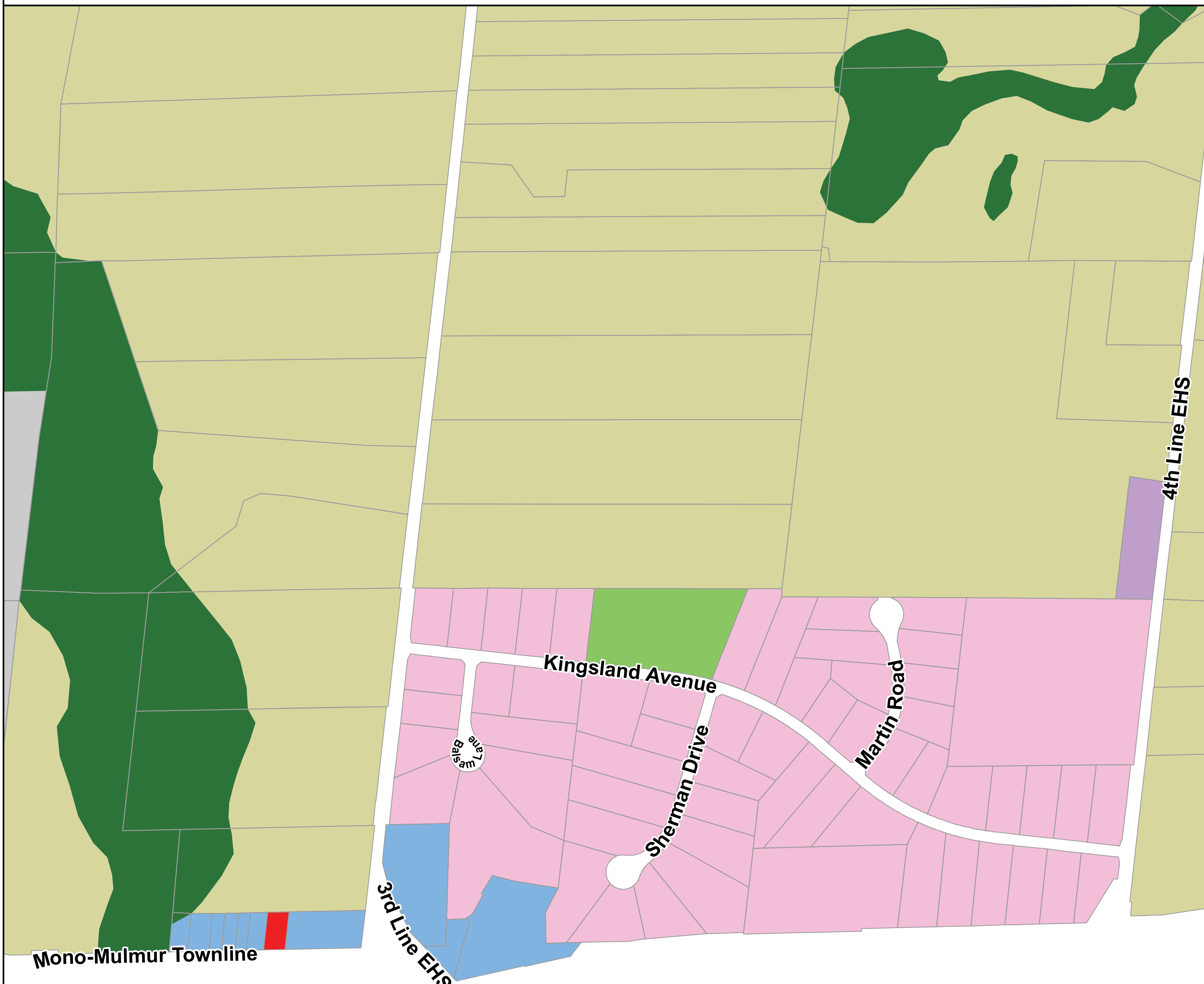
Township of Mulmur
Schedule A-5 (Violet Hill)



- Agricultural
- Business Park Transition Holding
- Business Park Transition
- Business Park Core (H)
- Business Park Gateway (H)
- Business Park Gateway
- Environmental Protection
- Estate Residential
- Extractive Industrial
- General Commercial
- Hamlet Residential
- Highway Commercial
- Institutional
- Niagara Escarpment Commission
- Open Space
- Recreational
- Rural
- Rural Commercial
- Rural Residential
- Waste Disposal Industrial

N

0 100 200 300 400 500
Meters

mulmur BURNSIDE

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APPENDIX C

Emission Rate Calculations

TABLE A: Emission Estimates for Diesel Generators

Emissions from the combustion of diesel were calculated based on the emission factors specified in US EPA AP-42 “Chapter 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines” (October 1996), Tables 3.4-1, 3.4-3 and 3.4-4, as this US EPA AP-42 document addresses diesel engines greater than 600 horsepower.

The plant will use one large diesel engine with a maximum power output rating of 1000 kVA = 800 kW, which has a maximum fuel input (usage) of 2,729,712 BTU/hr. In addition, there could be up to three smaller units each with a maximum power output rating of 150 kVA = 120 kW (409,457 BTU/hr). Therefore, the total maximum fuel usage is 2,729,712 BTU/hour + (3 x 409,457) BTU/hour = 2,729,712 BTU/hour + 1,228,370 BTU/hour = 3,958,082 BTU/hour

Example Calculations

Particulate Matter Emission Rate - Source ID P1 (Diesel Generators)

Emission Rate (g/s) = (Emission Factor [lb/MMBTU]) x (Maximum Fuel Input [MMBTU/hr]) x (conversion from lb to grams) x (conversion from hour to seconds)
= (0.1 lb/MMBTU) x (3.96 MMBTU/hr) x (453.59 grams / 1 lb) x (1 hr / 3600 seconds)
= 4.99E-02

Emission Calculations

The following table calculates emissions of some pollutants using emission factors for uncontrolled diesel industrial engines from U.S. EPA AP-42 Chapter 3.4, Table 3.4-1 (SCC 2-02-004-01)

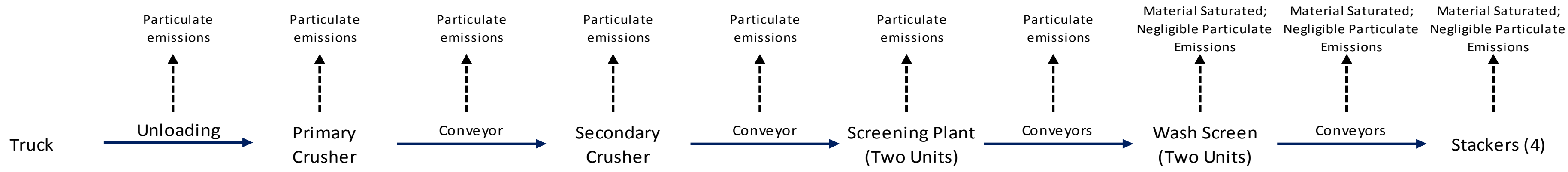
Emission ID	Description	Contaminant	CAS #	Emission Factor Source	US EPA Emission Factor (lb/MMBTU)	Emission Factor Units (Fuel Input)	US EPA AP 42 Emission Factor Rating	Data Quality	Maximum Fuel Input (MMBTU/hr)	Emission Rate (g/s)
P1	Diesel Generators	Total Particulate	N/A - PM	Reference #1	1.00E-01	lb/MMBTU	B	Above Average	3.96	4.99E-02
		Fine Particulate <10 um (PM_{10})	N/A - PM10	Reference #2	1.00E-01	lb/MMBTU	B	Above Average	3.96	4.99E-02
		Fine Particulate <2.5 um ($PM_{2.5}$)	N/A - PM2.5	Reference #2	1.00E-01	lb/MMBTU	B	Above Average	3.96	4.99E-02
		Nitrogen Oxides	10102-44-0	Reference #3	4.14E+00	lb/MMBTU	B	Above Average	3.96	2.06E+00
		Sulphur dioxide	7446-09-5	Reference #4	1.52E-03	lb/MMBTU	B	Above Average	3.96	7.56E-04
		Carbon Monoxide	630-08-0	Reference #1	8.50E-01	lb/MMBTU	C	Average	3.96	4.24E-01

Reference:

#1: U.S. EPA AP-42 Chapter 3.4, Table 3.4-1 (SCC 2-02-004-01)
#2 PM10 and PM2.5 were conservatively assumed to be the same as total particulate
#3 The emission factor for nitrogen oxide is a conservative 'Tier 2' factor
#4 Since 2010, diesel fuel sold for off-road use in Canada must be ultra-low sulphur fuel (sulphur content of approximately 0.0015%)

TABLE B-1: Emission Estimates for Aggregate Processing and Handling (Total Particulate Matter)

Emission rate estimates were calculated using emission factors from the US EPA AP-42 Chapter 11.19.2 "Crushed Stone Processing and Pulverized Mineral Processing".



Example Calculations

Particulate Matter Emission Rate - Crushing

Emission Rate (g/s) = (Emission Factor [kg/Mg]) x (Maximum Hourly Material Throughput Rate [Mg/hour]) x (conversion from hour to seconds) x (conversion from kg to grams)
= (6.00E-04 kg/ Mg) x (600 Mg/hour) x (1 hour / 3,600 seconds) x (1000 g / 1 kg)
= 1.00E-01

Emission Calculations

The maximum daily production capacity of the crushing and screening plant is 600 metric tonnes of aggregate per hour, operating a maximum of twelve hours per day.

Emission ID	Description	US EPA Reference	US EPA Emission Factor	Emission Factor Units	US EPA AP 42 Emission Factor Rating	Data Quality	Maximum Material Throughput (Mg/hour)	Emission Rate (g/s)
Permanent (Stationary) Processing Plant								
P2a	Truck Loading of Material at Active Face	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-31; Uncontrolled (NOTE 1)	1.60E-05	kg/Mg material throughput	E	Marginal	600	2.67E-03
P2b	Truck Unloading of Aggregate to Crushing Plant	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	1.00E-04	kg/Mg material throughput	E	Marginal	600	1.67E-02
P3a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	6.00E-04	kg/Mg material throughput	E	Marginal	600	1.00E-01
P3b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	6.00E-04	kg/Mg material throughput	E	Marginal	600	1.00E-01
P4	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	1.10E-03	kg/Mg material throughput	E	Marginal	600	1.83E-01
P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	600	1.17E-02
P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	600	1.17E-02
P6	Conveyor Transfer Points (Screening to Wash Screen)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	600	1.17E-02

TABLE B-1: Emission Estimates for Aggregate Processing and Handling (Total Particulate Matter)

P7	Truck Loading of Material to Shipping Trucks	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	1.00E-04	kg/Mg material throughput	E	Marginal	600	1.67E-02
Portable crushing and screening plant								
P8a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	6.00E-04	kg/Mg material throughput	E	Marginal	500	8.33E-02
P8b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	6.00E-04	kg/Mg material throughput	E	Marginal	500	8.33E-02
P9	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	1.10E-03	kg/Mg material throughput	E	Marginal	500	1.53E-01
P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	500	9.72E-03
P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	500	9.72E-03
P10c	Conveyor Transfer Points (Screening to Stackers)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	7.00E-05	kg/Mg material throughput	E	Marginal	500	9.72E-03

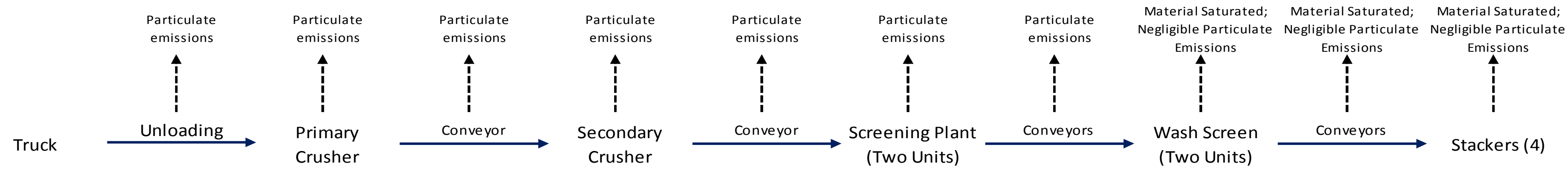
Notes:

1. Emission factor for only PM-10 from truck unloading (SCC 3-05-020-32) is available in U.S. EPA AP-42 Chapter 11.19, but no emission factor for total particulate matter is available. However, according to Table B.2.2 of U.S. EPA AP-42 Appendix B.2, Category 3 (Mechanically Generated; Aggregate, Unprocessed Ores) activities typically have 51% of total particulate matter less than or equal to 10 µm (PM-10). As such, the PM-10 emission factor from U.S. EPA AP-42 Chapter 11.19 for truck unloading (SCC 3-05-020-32) was considered to be 50% of the total particulate matter, and the emission factor for total particulate matter was taken as twice the emission factor of PM-10.

2. Emission factor is not available for Primary Crushing and Secondary Crushing from U.S. EPA AP-42 Chapter 11.19. Footnote 'n' of Table 11.19.1-2 of U.S. EPA AP-42 Chapter 11.19 permits the use of the emission factor for Tertiary Crushing as the upper limit to calculate emission rates for Primary Crushing and Secondary Crushing. This method for the calculation of emissions from Primary Crushing and Secondary Crushing is considered to be conservative as it is expected that the emissions from Tertiary Crushing will be greater than emissions from Primary Crushing and Secondary Crushing due to the greater quantity of fine material present in Tertiary Crushing. Other jurisdictions, including Georgia Department of Natural Resources ("Crushed Stone Modeling Guideline, Rev. August 7, 2012), and State of Washington Deparment of Ecology ("Technical Support Document for Stationary and Portable Rock Crushing Operations", December 6, 2011) have also adopted and allowed the use of Tertiary Crushing emission factors to be used for Primary and Secondary crushers. The Government of Canada has made available an on-line document titled "Pits and Quarries Guidance" (last modified May 27, 2014) which has also adopted US EPA's tertiary crushing emission factor for primary and secondary crushing.

TABLE B-2: Emission Estimates for Aggregate Processing and Handling (PM10)

Emission rate estimates were calculated using emission factors from the US EPA AP-42 Chapter 11.19.2 "Crushed Stone Processing and Pulverized Mineral Processing".



Example Calculations

PM_{10} Emission Rate - Crushing

Emission Rate (g/s) = (Emission Factor [kg/Mg]) x (Maximum Hourly Material Throughput Rate [Mg/hour]) x (conversion from hour to seconds) x (conversion from kg to grams)
= (2.70E-04 kg/ Mg) x (600 Mg/hour) x (1 hour / 3,600 seconds) x (1000 g / 1 kg)
= 4.50E-02

Emission Calculations

The maximum daily production capacity of the crushing and screening plant is 600 metric tonnes of aggregate per hour, operating a maximum of twelve hours per day.

Emission ID	Description	US EPA Reference	US EPA Emission Factor	Emission Factor Units	US EPA AP 42 Emission Factor Rating	Data Quality	Maximum Material Throughput (Mg/hour)	Emission Rate (g/s)
Permanent (Stationary) Processing Plant								
P2a	Truck Loading of Material at Active Face	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-31; Uncontrolled (NOTE 1)	8.00E-06	kg/Mg material throughput	E	Marginal	600	1.33E-03
P2b	Truck Unloading of Aggregate to Crushing Plant	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.00E-05	kg/Mg material throughput	E	Marginal	600	8.33E-03
P3a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	600	4.50E-02
P3b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	600	4.50E-02
P4	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	3.70E-04	kg/Mg material throughput	E	Marginal	600	6.17E-02
P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.83E-03
P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.83E-03
P6	Conveyor Transfer Points (Screening to Wash Screen)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.83E-03

TABLE B-2: Emission Estimates for Aggregate Processing and Handling (PM10)

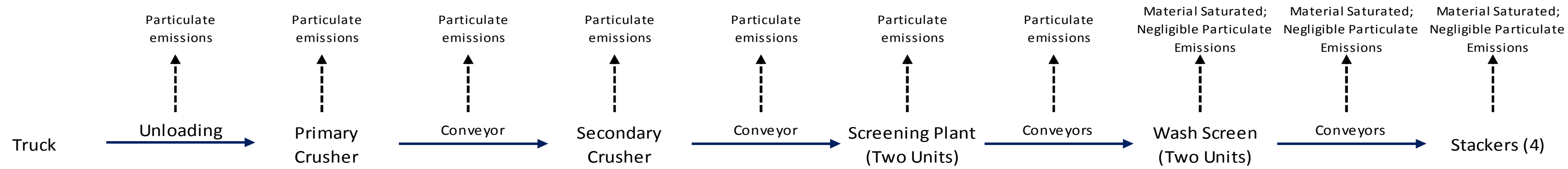
P7	Truck Loading of Material to Shipping Trucks	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.00E-05	kg/Mg material throughput	E	Marginal	600	8.33E-03
Portable crushing and screening plant								
P8a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	500	3.75E-02
P8b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	500	3.75E-02
P9	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	3.70E-04	kg/Mg material throughput	E	Marginal	500	5.14E-02
P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	3.19E-03
P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	3.19E-03
P10c	Conveyor Transfer Points (Screening to Stackers)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	3.19E-03

Notes:

1. Emission factor is not available for Primary Crushing and Secondary Crushing from U.S. EPA AP-42 Chapter 11.19. Footnote 'n' of Table 11.19.1-2 of U.S. EPA AP-42 Chapter 11.19 permits the use of the emission factor for Tertiary Crushing as the upper limit to calculate emission rates for Primary Crushing and Secondary Crushing. This method for the calculation of emissions from Primary Crushing and Secondary Crushing is considered to be conservative as it is expected that the emissions from Tertiary Crushing will be greater than emissions from Primary Crushing and Secondary Crushing due to the greater quantity of fine material present in Tertiary Crushing. Other jurisdictions, including Georgia Department of Natural Resources ("Crushed Stone Modeling Guideline, Rev. August 7, 2012), and State of Washington Deparment of Ecology ("Technical Support Document for Stationary and Portable Rock Crushing Operations", December 6, 2011) have also adopted and allowed the use of Tertiary Crushing emission factors to be used for Primary and Secondary crushers. The Government of Canada has made available an on-line document titled "Pits and Quarries Guidance" (last modified April 22, 2009) which has also adopted US EPA's tertiary crushing emission factor for primary and secondary crushing.

TABLE B-3: Emission Estimates for Aggregate Processing and Handling (PM2.5)

Emission rate estimates were calculated using emission factors from the US EPA AP-42 Chapter 11.19.2 "Crushed Stone Processing and Pulverized Mineral Processing".



Example Calculations

$PM_{2.5}$ Emission Rate - Crushing

Emission Rate (g/s) = (Emission Factor [kg/Mg]) x (Maximum Hourly Material Throughput Rate [Mg/hour]) x (conversion from hour to seconds) x (conversion from kg to grams)
= (5.00E-05 kg/ Mg) x (600 Mg/hour) x (1 hour / 3,600 seconds) x (1000 g / 1 kg)
= 8.33E-03

Emission Calculations

The maximum daily production capacity of the crushing and screening plant is 600 metric tonnes of aggregate per hour, operating a maximum of twelve hours per day.

Emission ID	Description	US EPA Reference	US EPA Emission Factor	Emission Factor Units	US EPA AP 42 Emission Factor Rating	Data Quality	Maximum Material Throughput (Mg/hour)	Emission Rate (g/s)
Permanent (Stationary) Processing Plant								
P2a	Truck Loading of Material at Active Face	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-31; Uncontrolled (NOTE 1)	8.00E-06	kg/Mg material throughput	E	Marginal	600	1.33E-03
P2b	Truck Unloading of Aggregate to Crushing Plant	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.00E-05	kg/Mg material throughput	E	Marginal	600	8.33E-03
P3a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	5.00E-05	kg/Mg material throughput	E	Marginal	600	8.33E-03
P3b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	5.00E-05	kg/Mg material throughput	E	Marginal	600	8.33E-03
P4	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	2.50E-05	kg/Mg material throughput	E	Marginal	600	4.17E-03
P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	600	1.08E-03
P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	600	1.08E-03
P6	Conveyor Transfer Points (Screening to Wash Screen)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	600	1.08E-03

TABLE B-3: Emission Estimates for Aggregate Processing and Handling (PM2.5)

P7	Truck Loading of Material to Shipping Trucks	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.50E-04	kg/Mg material throughput	E	Marginal	600	9.17E-02
Portable crushing and screening plant								
P8a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	5.00E-05	kg/Mg material throughput	E	Marginal	500	6.94E-03
P8b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	5.00E-05	kg/Mg material throughput	E	Marginal	500	6.94E-03
P9	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	2.50E-05	kg/Mg material throughput	E	Marginal	500	3.47E-03
P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	500	9.03E-04
P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	500	9.03E-04
P10c	Conveyor Transfer Points (Screening to Stackers)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	6.50E-06	kg/Mg material throughput	E	Marginal	500	9.03E-04

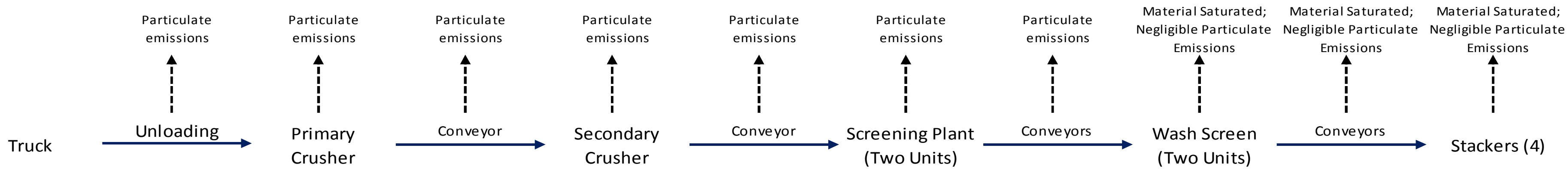
Notes:

1. Emission factor for only PM-10 from truck unloading (SCC 3-05-020-31) is available in U.S. EPA AP-42 Chapter 11.19, but no emission factor for total particulate matter is available. It is conservatively assumed that the PM-2.5 emission factor from U.S. EPA AP-42 Chapter 11.19 for truck unloading (SCC 3-05-020-031) is the same as the emission factor of PM-10.

2. Emission factor is not available for Primary Crushing and Secondary Crushing from U.S. EPA AP-42 Chapter 11.19. Footnote 'n' of Table 11.19.1-2 of U.S. EPA AP-42 Chapter 11.19 permits the use of the emission factor for Tertiary Crushing as the upper limit to calculate emission rates for Primary Crushing and Secondary Crushing. This method for the calculation of emissions from Primary Crushing and Secondary Crushing is considered to be conservative as it is expected that the emissions from Tertiary Crushing will be greater than emissions from Primary Crushing and Secondary Crushing due to the greater quantity of fine material present in Tertiary Crushing. Other jurisdictions, including Georgia Department of Natural Resources ("Crushed Stone Modeling Guideline, Rev. August 7, 2012), and State of Washington Deparment of Ecology ("Technical Support Document for Stationary and Portable Rock Crushing Operations", December 6, 2011) have also adopted and allowed the use of Tertiary Crushing emission factors to be used for Primary and Secondary crushers. The Government of Canada has made available an on-line document titled "Pits and Quarries Guidance" (last modified April 22, 2009) which has also adopted US EPA's tertiary crushing emission factor for primary and secondary crushing.

TABLE B-4: Emission Estimates for Aggregate Processing and Handling (Crystalline Silica)

Emission rate estimates were calculated using emission factors from the US EPA AP-42 Chapter 11.19.2 "Crushed Stone Processing and Pulverized Mineral Processing".



Example Calculations

Crystalline Silica Emission Rate - Crushing

Emission Rate (g/s) = (Emission Factor [kg/Mg]) x (Maximum Hourly Material Throughput Rate [Mg/hour]) x (conversion from hour to seconds) x (conversion from kg to grams) x (Silica fraction)
= (2.70E-04 kg/ Mg) x (600 Mg/hour) x (1 hour / 3,600 seconds) x (1000 g / 1 kg) x (9%)
= 4.05E-03

Emission Calculations

The maximum daily production capacity of the crushing and screening plant is 600 metric tonnes of aggregate per hour, operating a maximum of twelve hours per day.

Emission ID	Description	US EPA Reference	US EPA Emission Factor	Emission Factor Units	US EPA AP 42 Emission Factor Rating	Data Quality	Maximum Material Throughput (Mg/hour)	Emission Rate (g/s)
Permanent (Stationary) Processing Plant								
P2a	Truck Loading of Material at Active Face	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-31; Uncontrolled (NOTE 1)	8.00E-06	kg/Mg material throughput	E	Marginal	600	1.20E-04
P2b	Truck Unloading of Aggregate to Crushing Plant	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.00E-05	kg/Mg material throughput	E	Marginal	600	7.50E-04
P3a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	600	4.05E-03
P3b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	600	4.05E-03
P4	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	3.70E-04	kg/Mg material throughput	E	Marginal	600	5.55E-03
P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.45E-04
P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.45E-04
P6	Conveyor Transfer Points (Screening to Wash Screen)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	600	3.45E-04

TABLE B-4: Emission Estimates for Aggregate Processing and Handling (Crystalline Silica)

P7	Truck Loading of Material to Shipping Trucks	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-32; Uncontrolled (NOTE 1)	5.00E-05	kg/Mg material throughput	E	Marginal	600	7.50E-04
Portable crushing and screening plant								
P8a	Primary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	500	3.38E-03
P8b	Secondary Crushing	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-050030-03; Controlled (NOTE 2)	2.70E-04	kg/Mg material throughput	E	Marginal	500	3.38E-03
P9	Screening (Two units)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-02, 03; Controlled (NOTE 2)	3.70E-04	kg/Mg material throughput	E	Marginal	500	4.63E-03
P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	2.88E-04
P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	2.88E-04
P10c	Conveyor Transfer Points (Screening to Stackers)	U.S. EPA AP-42 Chapter 11.19; Table 11.19.2-1, SCC 3-05-020-06; Controlled	2.30E-05	kg/Mg material throughput	E	Marginal	500	2.88E-04

Notes:

1. Emission factor is not available for Primary Crushing and Secondary Crushing from U.S. EPA AP-42 Chapter 11.19. Footnote 'n' of Table 11.19.1-2 of U.S. EPA AP-42 Chapter 11.19 permits the use of the emission factor for Tertiary Crushing as the upper limit to calculate emission rates for Primary Crushing and Secondary Crushing. This method for the calculation of emissions from Primary Crushing and Secondary Crushing is considered to be conservative as it is expected that the emissions from Tertiary Crushing will be greater than emissions from Primary Crushing and Secondary Crushing due to the greater quantity of fine material present in Tertiary Crushing. Other jurisdictions, including Georgia Department of Natural Resources ("Crushed Stone Modeling Guideline, Rev. August 7, 2012), and State of Washington Deparment of Ecology ("Technical Support Document for Stationary and Portable Rock Crushing Operations", December 6, 2011) have also adopted and allowed the use of Tertiary Crushing emission factors to be used for Primary and Secondary crushers. The Government of Canada has made available an on-line document titled "Pits and Quarries Guidance" (last modified April 22, 2009) which has also adopted US EPA's tertiary crushing emission factor for primary and secondary crushing.

TABLE C: Emission Estimates for Aggregate Transfers to Stockpiles

Emission rate estimates for the transfer (dropping) of aggregates from the conveyors to the storage piles were calculated using U.S. EPA AP-42 Chapter 13.2.4 "Aggregate Handling and Storage Piles"

The maximum production capacity of the crushing and screening plant, defined as the maximum quantity handled by the primary crusher is 600 metric tonnes of aggregate per hour. The maximum transfer rate of aggregates from the conveyors to the storage piles is equal to the maximum quantity of stones that can be fed into the primary crusher. Since the maximum feed rate of aggregate into the crusher is 600 metric tonnes per hour, the total aggregates transferred to the storage piles is conservatively assumed to be equal to 600 metric tonnes per hour.

Example Calculations

Particulate Matter Emission Factor - Source ID C14-C17 (Aggregate Transfers to Stockpiles)

Emission Factor (kg/Mg) from Source ID 11 = (0.0016) x (Particle Size Multiplier) x [((mean wind speed)/2.2)^1.3] / [((Material Moisture Content)/2)^1.4]
= (0.0016) x (0.74) x [(4/2.2)^1.3] / [(4.8/2)^1.4]
= 5.20E-04

Particulate Matter Emission Rate - Source ID C14-C17 (Aggregate Transfers to Stockpiles)

Emission Rate (g/s) = (Emission Factor [kg/Mg]) x (Maximum Hourly Transfer Rate [Mg/hour]) x (conversion from hour to seconds) x (conversion from kg to grams)
= (7.56E-04 kg/Mg) x (600 Mg / hour) x (1 hour / 3,600 seconds) x (1000 g / 1 kg)
= 8.67E-02

The emission are conservatively assumed to occur over 12 hours per day. To assess the impacts against the 24 hour standard, it is permissible to average the emission rate over 24 hours, ie
= 0.100 g/s x (12 hours/day) x (1 day/24 hours)
= 4.33E-02 (24-hour emission rate)

Emisson Calculations

Emission ID	Source Description	Contaminant	US EPA Reference	Particle Size Multiplier (Dimensionless)	Mean Wind Speed (m/s)	Material Moisture Content (%)	Emission Factor (kg/Mg)	Maximum Hourly Transfer Rate (Mg/hour)	Emission Factor Rating	Data Quality Rating	Emission Rate (g/s)
P11	Aggregate Loading from Screening Plant to Storage Piles	Total Particulate Matter	13.2.4.3 - Equation 1	0.74	3	4.8	5.20E-04	600	A	Highest	8.67E-02
		Fine Particulate <10 um (PM_{10})	13.2.4.3 - Equation 1	0.35	3	4.8	2.46E-04	600	A	Highest	4.10E-02
		Fine Particulate <2.5 um ($PM_{2.5}$)	13.2.4.3 - Equation 1	0.053	3	4.8	3.73E-05	600	A	Highest	6.21E-03
		Crystalline silica	n/a	From the CDC article 'Analysis of the Silica Percent in Airborne Respirable Mine Dust Samples from U.S. Operations', February 2014, the geometric mean percentage of silica from surface sand and gravel mining is 9.0%.					A	Highest	3.69E-03

TABLE D-1: Emission Estimates for Fugitive Road Dusts-Unpaved Roadways

Emission rate estimates for the fugitive dust from movement of equipment on unpaved roads were calculated using U.S. EPA AP-42 Chapter 13.2.2 "Unpaved Roads", November 2006 - Equation 1a

Particulate Emission Factor (E) for Industrial Sites (size specific emission factor) - lb/VMT
E = k * (s/12)^a * (W/3)^b
s= Surface material silt content (%)
W= Average weight (tons) of the vehicle travelling the road

Constants	k (lb/VMT)	a	b
Total Particulate	4.9	0.7	0.45
Fine Particulate <10 um (PM_{10})	1.5	0.9	0.45
Fine Particulate <2.5 um ($PM_{2.5}$)	0.15	0.9	0.45

Example Calculation

Assumed Silt content of 4.8%, which is the average for sand and gravel processing plant roads to and from a pit
Assumed a mean truck weight of 39 ton (20 tons empty/57 tons loaded (ie. 37 tons of material)

Total Particulate Emission Factor, E = 4.9 * (4.8/12)^0.7 * (39/3)^0.45
= 8.14 lb/VMT
= 2293.43 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM10 Emission Factor, E = 1.5 * (4.8/12)^0.9 * (39/3)^0.45
= 2.07 lb/VMT
= 584.51 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM2.5 Emission Factor, E = 0.15 * (4.8/12)^0.9 * (39/3)^0.45
= 0.21 lb/VMT
= 58.45 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

Vehicle Kilometers Travelled (VKT) per day = # of trips * distance travelled per trip (km)
There is assumed to be a maximum of 162 trips per day and each truck would travel (0.160 km x 2) = 0.320 km (round trip
VKT = 51.84 per day

Total Particulate Matter, PM10 and PM2.5 Emission Rates - Source ID P13 (Product Shipping on Haul Road)

Emission Rate (g/s) = Emission Factor (g/VKT) x Vehicle Kilometres Travelled (VKT/day) x (1 day/24 hours) x (1 hour/3600 seconds)
Total Particulate = 1.38 g/s
PM10 = 0.35 g/s
PM2.5 = 0.04 g/s

Emission Calculations

Emission ID	Source Description	US EPA Reference	Mean Truck Weight (tons)	E (g/VKT)			Number of trips per day	Distance Travelled (km)	VKT/day
				Total Particulate	PM10	PM2.5			
P12a	Aggregate transfer to crushing plant (in North Area (A)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.600	97.20
P12b	Aggregate transfer to crushing plant (in North Area (B and C)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	1.200	194.40
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.320	51.84
P14a	Aggregate transfer to crushing plant (from South Area (E)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.700	113.40
P14b	Aggregate transfer to crushing plant (from South Area (D)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.900	145.80
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.150	24.30
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.650	105.30

Note 1: Conservative maximum distance from outer edge of pit to crushing plant; conservatively assumes every trip is a round trip along the same segment

Note 2: From C.C. Tatham & Associates Ltd. Traffic Review Report (June 15, 2015), the peak number of loads per day is conservatively assumed to be 162

Emission Rates - UNCONTROLLED

Emission ID	Source Description	US EPA Reference	Emission Rate (g/s)		
			Total Particulate	PM10	PM2.5
P12a	Aggregate transfer to crushing plant (in North Area (A))	13.2.2 - Equation 1a	2.58E+00	6.58E-01	6.58E-02
P12b	Aggregate transfer to crushing plant (in North Area (B and C))	13.2.2 - Equation 1a	5.16E+00	1.32E+00	1.32E-01
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	13.2.2 - Equation 1a	1.38E+00	3.51E-01	3.51E-02
P14a	Aggregate transfer to crushing plant (from South Area (E))	13.2.2 - Equation 1a	3.01E+00	7.67E-01	7.67E-02
P14b	Aggregate transfer to crushing plant (from South Area (D))	13.2.2 - Equation 1a	3.87E+00	9.86E-01	9.86E-02
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	13.2.2 - Equation 1a	6.45E-01	1.64E-01	1.64E-02
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	13.2.2 - Equation 1a	2.80E+00	7.12E-01	7.12E-02

Emission Rates - CONTROLLED (assume 98% control efficiency)

Emission ID	Source Description	Emission Rate (g/s)			
		Total Particulate	PM10	PM2.5	Crystalline Silica *
P12a	Aggregate transfer to crushing plant (in North Area (A))	5.16E-02	1.32E-02	1.32E-03	1.18E-03
P12b	Aggregate transfer to crushing plant (in North Area (B and C))	1.03E-01	2.63E-02	2.63E-03	2.37E-03
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-02	7.01E-03	7.01E-04	6.31E-04
P14a	Aggregate transfer to crushing plant (from South Area (E))	6.02E-02	1.53E-02	1.53E-03	1.38E-03
P14b	Aggregate transfer to crushing plant (from South Area (D))	7.74E-02	1.97E-02	1.97E-03	1.78E-03
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	1.29E-02	3.29E-03	3.29E-04	2.96E-04
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	5.59E-02	1.42E-02	1.42E-03	1.28E-03

* From the CDC article ‘Analysis of the Silica Percent in Airborne Respirable Mine Dust Samples from U.S. Operations’, February 2014, the geometric mean percentage of silica from surface sand and gravel mining is 9.0%.

TABLE D-1a: Emission Estimates for Fugitive Road Dusts-Unpaved Roadways

Emission rate estimates for the fugitive dust from movement of equipment on unpaved roads were calculated using U.S. EPA AP-42 Chapter 13.2.2 "Unpaved Roads", November 2006 - Equation 1a

Particulate Emission Factor (E) for Industrial Sites (size specific emission factor) - lb/VMT
E = k * (s/12)^a * (W/3)^b
s= Surface material silt content (%)
W= Average weight (tons) of the vehicle travelling the road

Constants	k (lb/VMT)	a	b
Total Particulate	4.9	0.7	0.45
Fine Particulate <10 um (PM_{10})	1.5	0.9	0.45
Fine Particulate <2.5 um ($PM_{2.5}$)	0.15	0.9	0.45

Example Calculation

Assumed Silt content of 4.8%, which is the average for sand and gravel processing plant roads to and from a pit
Assumed a mean truck weight of 39 ton (20 tons empty/57 tons loaded (ie. 37 tons of material) 39

Total Particulate Emission Factor, E = 4.9 * (4.8/12)^0.7 * (39/3)^0.45
= 8.14 lb/VMT
= 2293.43 g/VKT The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM10 Emission Factor, E = 1.5 * (4.8/12)^0.9 * (39/3)^0.45
= 2.07 lb/VMT
= 584.51 g/VKT The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM2.5 Emission Factor, E = 0.15 * (4.8/12)^0.9 * (39/3)^0.45
= 0.21 lb/VMT
= 58.45 g/VKT The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

Vehicle Kilometers Travelled (VKT) per day = # of trips * distance travelled per trip (km)
There is assumed to be a maximum of 162 trips per day and each truck would travel (0.160 km x 2) = 0.320 km (round trip
VKT = 51.84 per day

Total Particulate Matter, PM10 and PM2.5 Emission Rates - Source ID P13 (Product Shipping on Haul Road)

Emission Rate (g/s) = Emission Factor (g/VKT) x Vehicle Kilometres Travelled (VKT/day) x (1 day/24 hours) x (1 hour/3600 seconds)
Total Particulate = 1.38 g/s
PM10 = 0.35 g/s
PM2.5 = 0.04 g/s

Emission Calculations

Emission ID	Source Description	US EPA Reference	Mean Truck Weight (tons)	E (g/VKT)			Number of trips per day	Distance Travelled (km)	VKT/day
				Total Particulate	PM10	PM2.5			
P12a	Aggregate transfer to crushing plant (in North Area (A)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.600	97.20
P12b	Aggregate transfer to crushing plant (in North Area (B and C)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	1.200	194.40
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.320	51.84
P14a	Aggregate transfer to crushing plant (from South Area (E)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.700	113.40
P14b	Aggregate transfer to crushing plant (from South Area (D)) Note 1	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.900	145.80
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.150	24.30
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	13.2.2 - Equation 1a	39	2293.43	584.51	58.45	162	0.650	105.30

Note 1: Conservative maximum distance from outer edge of pit to crushing plant; conservatively assumes every trip is a round trip along the same segment

Note 2: From C.C. Tatham & Associates Ltd. Traffic Review Report (June 15, 2015), the peak number of loads per day is conservatively assumed to be 162

Emission Rates - UNCONTROLLED

Emission ID	Source Description	US EPA Reference	Emission Rate (g/s)		
			Total Particulate	PM10	PM2.5
P12a	Aggregate transfer to crushing plant (in North Area (A))	13.2.2 - Equation 1a	2.58E+00	6.58E-01	6.58E-02
P12b	Aggregate transfer to crushing plant (in North Area (B and C))	13.2.2 - Equation 1a	5.16E+00	1.32E+00	1.32E-01
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	13.2.2 - Equation 1a	1.38E+00	3.51E-01	3.51E-02
P14a	Aggregate transfer to crushing plant (from South Area (E))	13.2.2 - Equation 1a	3.01E+00	7.67E-01	7.67E-02
P14b	Aggregate transfer to crushing plant (from South Area (D))	13.2.2 - Equation 1a	3.87E+00	9.86E-01	9.86E-02
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	13.2.2 - Equation 1a	6.45E-01	1.64E-01	1.64E-02
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	13.2.2 - Equation 1a	2.80E+00	7.12E-01	7.12E-02

Emission Rates - CONTROLLED (assume 80% control efficiency)

Emission ID	Source Description	Emission Rate (g/s)			
		Total Particulate	PM10	PM2.5	Crystalline Silica *
P12a	Aggregate transfer to crushing plant (in North Area (A))	5.16E-01	1.32E-01	1.32E-02	1.18E-02
P12b	Aggregate transfer to crushing plant (in North Area (B and C))	1.03E+00	2.63E-01	2.63E-02	2.37E-02
P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-01	7.01E-02	7.01E-03	6.31E-03
P14a	Aggregate transfer to crushing plant (from South Area (E))	6.02E-01	1.53E-01	1.53E-02	1.38E-02
P14b	Aggregate transfer to crushing plant (from South Area (D))	7.74E-01	1.97E-01	1.97E-02	1.78E-02
P15a	Product Shipping along Haul Road (portion below grade, North Area (A))	1.29E-01	3.29E-02	3.29E-03	2.96E-03
P15b	Product Shipping along Haul Road (portion below grade, North Area (B and C))	5.59E-01	1.42E-01	1.42E-02	1.28E-02

* From the CDC article 'Analysis of the Silica Percent in Airborne Respirable Mine Dust Samples from U.S. Operations', February 2014, the geometric mean percentage of silica from surface sand and gravel mining is 9.0%.

TABLE D-2: Emission Estimates for Fugitive Road Dusts-Paved Roadways

Emission rate estimates for the fugitive dust from movement of equipment on unpaved roads were calculated using U.S. EPA AP-42 Chapter 13.2.2 "Unpaved Roads", November 2006 - Equation 1

Particulate Emission Factor (E) for Industrial Sites (size specific emission factor) - lb/VMT
E = k * (sL)^0.91 x (W)^1.02
s= Surface material silt content (%)
W= Average weight (tons) of the vehicle travelling the road

Constants	k (lb/VMT)	a	b
Total Particulate	0.011	0.7	0.45
Fine Particulate <10 um (PM_{10})	0.0022	0.9	0.45
Fine Particulate <2.5 um ($PM_{2.5}$)	0.00054	0.9	0.45

Example Calculation

Assumed Silt content of 4.8%, which is the average for sand and gravel processing plant roads to and from a pi
Assumed a mean truck weight of 39 ton (20 tons empty/57 tons loaded (ie. 37 tons of material

Total Particulate Emission Factor, E = 0.011 * (4.8)^0.91 * (39)^1.02
= 1.90 lb/VMT
= 535.29 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM10 Emission Factor, E = 1.5 * (4.8/12)^0.9 * (39/3)^0.45
= 0.38 lb/VMT
= 107.06 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

PM2.5 Emission Factor, E = 0.15 * (4.8/12)^0.9 * (39/3)^0.45
= 0.09 lb/VMT
= 26.28 g/VKT — The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows: 1 lb/VMT = 281.9 g/VKT

Vehicle Kilometers Travelled (VKT) per day = # of trips * distance travelled per trip (km
There is assumed to be a maximum of 162 trips per day and each truck would travel (0.160 km x 2) = 0.320 km (round trip
VKT = 51.84 per day

Total Particulate Matter, PM10 and PM2.5 Emission Rates - Source ID P13 (Product Shipping on Haul Road

Emission Rate (g/s) = Emission Factor (g/VKT) x Vehicle Kilometres Travelled (VKT/day) x (1 day/24 hours) x (1 hour/3600 seconds
Total Particulate = 0.32 g/s
PM10 = 0.06 g/s
PM2.5 = 0.02 g/s

Emission Calculations

Emission ID	Source Description	US EPA Reference	Mean Truck Weight (tons)	E (g/VKT)			Number of trips per day	Distance Travelled (km)	VKT/day
				Total Particulate	PM10	PM2.5			
P16	Product Shipping along Haul Road (portion above grade)	13.2.2 - Equation 1a	39	535.29	107.06	26.28	162	0.240	38.88

Note 1: Conservative maximum distance from outer edge of pit to crushing plant; conservatively assumes every trip is a round trip along the same segment

Note 2: From C.C. Tatham & Associates Ltd. Traffic Review Report (June 15, 2015), the peak number of loads per day is conservatively assumed to be 162

Emission Rates - UNCONTROLLED

Emission ID	Source Description	US EPA Reference	Emission Rate (g/s)		
			Total Particulate	PM10	PM2.5
P16	Product Shipping along Haul Road (portion above grade)	13.2.2 - Equation 1a	2.41E-01	4.82E-02	1.18E-02

* From the CDC article ‘Analysis of the Silica Percent in Airborne Respirable Mine Dust Samples from U.S. Operations’, February 2014, the geometric mean percentage of silica from surface sand and gravel mining is 9.0%.

Emission Rates - CONTROLLED (assume 98% control efficiency)

Emission ID	Source Description	Emission Rate (g/s)			
		Total Particulate	PM10	PM2.5	Crystalline Silica
P16	Product Shipping along Haul Road (portion above grade)	4.82E-03	9.64E-04	2.36E-04	8.67E-05

APPENDIX D

Emission Factor Documentation

Table 3.4-1. GASEOUS EMISSION FACTORS FOR LARGE STATIONARY DIESEL AND ALL STATIONARY DUAL-FUEL ENGINES[a]

	Diesel Fuel (SCC 2-02-004-01)			Dual Fuel[b] (SCC 2-02-004-02)		
Pollutant	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING
NO_x						
Uncontrolled	0.024	3.2	B	0.018	2.7	D
Controlled	0.013[c]	1.9[c]	B	ND	ND	NA
CO	5.5 E-03	0.85	C	7.5 E-03	1.16	D
SO_x[d]	8.09 E-03S_1	1.01S_1	B	4.06 E-04S_1 + 9.57 E-03S_2	0.05S_1 + 0.895S_2	B
CO_2[e]	1.16	165	B	0.772	110	B
PM	0.0007[c]	0.1[c]	B	ND	ND	NA
TOC (as CH_4)	7.05 E-04	0.09	C	5.29 E-03	0.8	D
Methane	f	f	E	3.97 E-03	0.6	E
Nonmethane	f	f	E	1.32 E-03	0.2[g]	E

[a] Based on uncontrolled levels for each fuel, from References 2,6-7. When necessary, the average heating value of diesel was assumed to be 19,300 Btu/lb with a density of 7.1 lb/gallon. The power output and fuel input values were averaged independently from each other, because of the use of actual brake-specific fuel consumption (BSFC) values for each data point and of the use of data possibly sufficient to calculate only 1 of the 2 emission factors (e. g., enough information to calculate lb/MMBtu, but not lb/hp-hr). Factors are based on averages across all manufacturers and duty cycles. The actual emissions from a particular engine or manufacturer could vary considerably from these levels. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code.

[b] Dual fuel assumes 95% natural gas and 5% diesel fuel.

[c] References 8-26. Controlled NO_x is by ignition timing retard.

[d] Assumes that all sulfur in the fuel is converted to SO_2. S_1 = % sulfur in fuel oil; S_2 = % sulfur in natural gas. For example, if sulfer content is 1.5%, then S = 1.5.

[e] Assumes 100% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 70 weight % carbon in natural gas, dual-fuel mixture of 5% diesel with 95% natural gas, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and natural gas heating value of 1050 Btu/scf.

[f] Based on data from 1 engine, TOC is by weight 9% methane and 91% nonmethane.

[g] Assumes that nonmethane organic compounds are 25% of TOC emissions from dual-fuel engines. Molecular weight of nonmethane gas stream is assumed to be that of methane.

Table 3.4-2. PARTICULATE AND PARTICLE-SIZING EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (lb/MMBtu) (fuel input)
Filterable particulate[b]	
< 1 µm	0.0478
< 3 µm	0.0479
< 10 µm	0.0496
Total filterable particulate	0.0620
Condensable particulate	0.0077
Total PM-10[c]	0.0573
Total particulate[d]	0.0697

[a] Based on 1 uncontrolled diesel engine from Reference 6. Source Classification Code 2-02-004-01. The data for the particulate emissions were collected using Method 5, and the particle size distributions were collected using a Source Assessment Sampling System. To convert from lb/MMBtu to ng/J, multiply by 430. PM-10 = particulate matter ≤ 10 micrometers (µm) aerometric diameter.

[b] Particle size is expressed as aerodynamic diameter.

[c] Total PM-10 is the sum of filterable particulate less than 10 µm aerodynamic diameter and condensable particulate.

[d] Total particulate is the sum of the total filterable particulate and condensable particulate.

Table 11.19.2-1 (Metric Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS (kg/Mg)[a]

Source [b]	Total Particulate Matter [r,s]	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Primary Crushing (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Primary Crushing (controlled) (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Secondary Crushing (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Secondary Crushing (controlled) (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Tertiary Crushing (SCC 3-050030-03)	0.0027[d]	E	0.0012[o]	C	ND[n]	
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0006[d]	E	0.00027[p]	C	0.00005[q]	E
Fines Crushing (SCC 3-05-020-05)	0.0195[e]	E	0.0075[e]	E	ND	
Fines Crushing (controlled) (SCC 3-05-020-05)	0.0015[f]	E	0.0006[f]	E	0.000035[q]	E
Screening (SCC 3-05-020-02, 03)	0.0125[c]	E	0.0043[l]	C	ND	
Screening (controlled) (SCC 3-05-020-02, 03)	0.0011[d]	E	0.00037[m]	C	0.000025[q]	E
Fines Screening (SCC 3-05-020-21	0.15[g]	E	0.036[g]	E	ND	
Fines Screening (controlled) (SCC 3-05-020-21)	0.0018[g]	E	0.0011[g]	E	ND	
Conveyor Transfer Point (SCC 3-05-020-06)	0.0015[h]	E	0.00055[h]	D	ND	
Conveyor Transfer Point (controlled) (SCC 3-05-020-06)	0.00007[i]	E	2.3×10^{-5}[i]	D	6.5×10^{-6}[q]	E
Wet Drilling - Unfragmented Stone (SCC 3-05-020-10)	ND		4.0×10^{-5}[j]	E	ND	
Truck Unloading - Fragmented Stone (SCC 3-05-020-31)	ND		8.0×10^{-6}[j]	E	ND	
Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32)	ND		5.0×10^{-5}[k]	E	ND	

a. Emission factors represent uncontrolled emissions unless noted. Emission factors in kg/Mg of material throughput. SCC = Source Classification Code. ND = No data.

b. Controlled sources (with wet suppression) are those that are part of the processing plant that employs current wet suppression technology similar to the study group. The moisture content of the study group without wet suppression systems operating (uncontrolled) ranged from 0.21 to 1.3 percent, and the same facilities operating wet suppression systems (controlled) ranged from 0.55 to 2.88 percent. Due to carry over of the small amount of moisture required, it has been shown that each source, with the exception of crushers, does not need to employ direct water sprays. Although the moisture content was the only variable measured, other process features may have as much influence on emissions from a given source. Visual observations from each source under normal operating conditions are probably the best indicator of which emission factor is most appropriate. Plants that employ substandard control measures as indicated by visual observations should use the uncontrolled factor with appropriate control efficiency that best reflects the effectiveness of the controls employed.

c. References 1, 3, 7, and 8

d. References 3, 7, and 8

e. Reference 4

f. References 4 and 15

g. Reference 4

h. References 5 and 6

i. References 5, 6, and 15

j. Reference 11

k. Reference 12

l. References 1, 3, 7, and 8

m. References 1, 3, 7, 8, and 15

n. No data available, but emission factors for PM-10 for tertiary crushers can be used as an upper limit for primary or secondary crushing

o. References 2, 3, 7, 8

p. References 2, 3, 7, 8, and 15

q. Reference 15

r. PM emission factors are presented based on PM-100 data in the Background Support Document for Section 11.19.2

s. Emission factors for PM-30 and PM-50 are available in Figures 11.19.2-3 through 11.19.2-6.

Note: Truck Unloading - Conveyor, crushed stone (SCC 3-05-020-32) was corrected to Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32). October 1, 2010.

Table 13.2.4-1. TYPICAL SILT AND MOISTURE CONTENTS OF MATERIALS AT VARIOUS INDUSTRIES[a]

Industry	No. Of Facilities	Material	Silt Content (%)			Moisture Content (%)		
			No. Of Samples	Range	Mean	No. Of Samples	Range	Mean
Iron and steel production	9	Pellet ore	13	1.3 - 13	4.3	11	0.64 - 4.0	2.2
		Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.0	5.4
		Coal	12	2.0 - 7.7	4.6	11	2.8 - 11	4.8
		Slag	3	3.0 - 7.3	5.3	3	0.25 - 2.0	0.92
		Flue dust	3	2.7 - 23	13	1	—	7
		Coke breeze	2	4.4 - 5.4	4.9	2	6.4 - 9.2	7.8
		Blended ore	1	—	15	1	—	6.6
		Sinter	1	—	0.7	0	—	—
		Limestone	3	0.4 - 2.3	1.0	2	ND	0.2
Stone quarrying and processing	2	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
		Various limestone products	8	0.8 - 14	3.9	8	0.46 - 5.0	2.1
Taconite mining and processing	1	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.0	0.9
		Tailings	2	ND	11	1	—	0.4
Western surface coal mining	4	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
		Overburden	15	3.8 - 15	7.5	0	—	—
		Exposed ground	3	5.1 - 21	15	3	0.8 - 6.4	3.4
Coal-fired power plant	1	Coal (as received)	60	0.6 - 4.8	2.2	59	2.7 - 7.4	4.5
Municipal solid waste landfills	4	Sand	1	—	2.6	1	—	7.4
		Slag	2	3.0 - 4.7	3.8	2	2.3 - 4.9	3.6
		Cover	5	5.0 - 16	9.0	5	8.9 - 16	12
		Clay/dirt mix	1	—	9.2	1	—	14
		Clay	2	4.5 - 7.4	6.0	2	8.9 - 11	10
		Fly ash	4	78 - 81	80	4	26 - 29	27
		Misc. fill materials	1	—	12	1	—	11

[a] References 1-10. ND = no data.

13.2.4.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016) \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (kg/megagram [Mg])}$$

$$E = k(0.0032) \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

[a] Multiplier for < 2.5 µm taken from Reference 14.

The equation retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows. Note that silt content is included, even though silt content does not appear as a correction parameter in the equation. While it is reasonable to expect that silt content and emission factors are interrelated, no significant correlation between the 2 was found during the derivation of the equation, probably because most tests with high silt contents were conducted under lower winds, and vice versa. It is recommended that estimates from the equation be reduced 1 quality rating level if the silt content used in a particular application falls outside the range given:

Ranges Of Source Conditions For Equation 1			
Silt Content (%)	Moisture Content (%)	Wind Speed	
		m/s	mph
0.44 - 19	0.25 - 4.8	0.6 - 6.7	1.3 - 15

To retain the quality rating of the equation when it is applied to a specific facility, reliable correction parameters must be determined for specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site-specific values for

Table 13.2.2-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIAL ON INDUSTRIAL UNPAVED ROADS[a]

Industry	Road Use Or Surface Material	Plant Sites	No. Of Samples	Silt Content (%)	
				Range	Mean
Copper smelting	Plant road	1	3	16 - 19	17
Iron and steel production	Plant road	19	135	0.2 - 19	6.0
Sand and gravel processing	Plant road	1	3	4.1 - 6.0	4.8
	Material storage area	1	1	-	7.1
Stone quarrying and processing	Plant road	2	10	2.4 - 16	10
	Haul road to/from pit	4	20	5.0-15	8.3
Taconite mining and processing	Service road	1	8	2.4 - 7.1	4.3
	Haul road to/from pit	1	12	3.9 - 9.7	5.8
Western surface coal mining	Haul road to/from pit	3	21	2.8 - 18	8.4
	Plant road	2	2	4.9 - 5.3	5.1
	Scraper route	3	10	7.2 - 25	17
	Haul road (freshly graded)	2	5	18 - 29	24
Construction sites	Scraper routes	7	20	0.56-23	8.5
Lumber sawmills	Log yards	2	2	4.8-12	8.4
Municipal solid waste landfills	Disposal routes	4	20	2.2 - 21	6.4

[a]References 1,5-15.

The following empirical expressions may be used to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT):

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$E = k\ (s/12)^a (W/3)^b \qquad (1a)$$

and, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions may be estimated from the following:

$$E = \frac{k\ (s/12)^a (S/30)^d}{(M/0.5)^c} - C \qquad (1b)$$

where k, a, b, c and d are empirical constants (Reference 6) given below and

E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The source characteristics s, W and M are referred to as correction parameters for adjusting the emission estimates to local conditions. The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows:

1 lb/VMT = 281.9 g/VKT

The constants for Equations 1a and 1b based on the stated aerodynamic particle sizes are shown in Tables 13.2.2-2 and 13.2.2-4. The PM-2.5 particle size multipliers (k-factors) are taken from Reference 27.

Table 13.2.2-2. CONSTANTS FOR EQUATIONS 1a AND 1b

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 13.2.2-2 also contains the quality ratings for the various size-specific versions of Equation 1a and 1b. The equation retains the assigned quality rating, if applied within the ranges of source conditions, shown in Table 13.2.2-3, that were tested in developing the equation:

Table 13.2.2-3. RANGE OF SOURCE CONDITIONS USED IN DEVELOPING EQUATION 1a AND 1b

Emission Factor	Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
		Mg	ton	km/hr	mph		
Industrial Roads (Equation 1a)	1.8-25.2	1.8-260	2-290	8-69	5-43	4-17[a]	0.03-13
Public Roads (Equation 1b)	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

[a] See discussion in text.

As noted earlier, the models presented as Equations 1a and 1b were developed from tests of traffic on unpaved surfaces. Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering, because of traffic-enhanced natural evaporation. (Factors influencing how fast a road dries are discussed in Section 13.2.2.3, below.) The quality ratings given above pertain to the mid-range of the measured source conditions for the equation. A higher mean vehicle weight and a higher than normal traffic rate may be justified when performing a worst-case analysis of emissions from unpaved roads.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [23]. The emission factor also varies with aerodynamic size range as shown in Table 13.2.2-4

Table 13.2.2-4. EMISSION FACTOR FOR 1980'S VEHICLE FLEET EXHAUST, BRAKE WEAR AND TIRE WEAR

Particle Size Range[a]	*C*, Emission Factor for Exhaust, Brake Wear and Tire Wear[b] lb/VMT
$PM_{2.5}$	0.00036
PM_{10}	0.00047
PM_{30}[c]	0.00047

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.
[b] Units shown are pounds per vehicle mile traveled (lb/VMT).
[c] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

It is important to note that the vehicle-related source conditions refer to the average weight, speed, and number of wheels for all vehicles traveling the road. For example, if 98 percent of traffic on the road are 2-ton cars and trucks while the remaining 2 percent consists of 20-ton trucks, then the mean weight is 2.4 tons. More specifically, Equations 1a and 1b are *not* intended to be used to calculate a separate emission factor for each vehicle class within a mix of traffic on a given unpaved road. That is, in the example, one should *not* determine one factor for the 2-ton vehicles and a second factor for the 20-ton trucks. Instead, only one emission factor should be calculated that represents the "fleet" average of 2.4 tons for all vehicles traveling the road.

Moreover, to retain the quality ratings when addressing a group of unpaved roads, it is necessary that reliable correction parameter values be determined for the road in question. The field and laboratory procedures for determining road surface silt and moisture contents are given in AP-42 Appendices C.1 and C.2. Vehicle-related parameters should be developed by recording visual observations of traffic. In some cases, vehicle parameters for industrial unpaved roads can be determined by reviewing maintenance records or other information sources at the facility.

In the event that site-specific values for correction parameters cannot be obtained, then default values may be used.In the absence of site-specific silt content information, an appropriate mean value from Table 13.2.2-1 may be used as a default value, but the quality rating of the equation is reduced by two letters. Because of significant differences found between different types of road surfaces and between different areas of the country, use of the default moisture content value of 0.5 percent in Equation 1b is discouraged. The quality rating should be downgraded two letters when the default moisture content value is used. (It is assumed that readers addressing industrial roads have access to the information needed to develop average vehicle information in Equation 1a for their facility.)

The effect of routine watering to control emissions from unpaved roads is discussed below in Section 13.2.2.3, “Controls”. However, all roads are subject to some natural mitigation because of rainfall and other precipitation. The Equation 1a and 1b emission factors can be extrapolated to annual

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Analysis of the Silica Percent in Airborne Respirable Mine Dust Samples From U.S. Operations

ABSTRACT: Exposure to crystalline silica in mining can lead to silicosis, a potentially fatal lung disease, and it may be contributing to the increase of coal workers' pneumoconiosis (CWP) seen in Appalachian miners. Exposure to silica in mines is controlled indirectly by reducing the respirable dust exposure limit through a formula that employs the % of silica in the dust. To reduce this exposure, control technologies and specific monitoring techniques need to be developed and implemented and the knowledge of the % of silica in mine dusts can help this process. This manuscript analyzes the % of silica in dust samples for the U.S. mining industry collected from 1997 to 2011. In the metal/nonmetal (M/NM) industry, metal and sand and gravel mines showed the highest silica % (8.2 %, 9.8 %) along with the highest variability. The silica % was found to be lower for samples collected in underground by comparison to surface and mill. In the coal industry, the samples collected in surface locations showed high silica % in the dust. For both the coal and M/NM industries, the % of silica and the respirable dust concentration were inversely related—i.e., the lower the dust concentration, the higher and more variable silica percentages were observed. The respirable dust limit formula suggests the first explanation: a mine with a high silica % in the dust is required to keep the dust concentration low under the reduced standard. Additional explanations

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are also proposed: the variability of the % of silica in the dust, the selective efficiency of control technologies, and different transport properties for dust with variable silica content. The findings improve the understanding of exposure to silica in mining environments and the data presented will be helpful in developing monitoring strategies for the measurement of silica and for the design of control technologies.

Introduction

Crystalline silica (hereafter referred to as silica) has long been recognized as an occupational hazard. The Occupational Safety and Health Administration (OSHA) in the U.S. estimated in 2003 that nearly 2×10^6 workers were potentially exposed to silica dust in general industry and the mining, construction, and maritime industries [1]. Occupational exposures to silica are associated with the development of silicosis [2], lung cancer [3,4], pulmonary tuberculosis, and airway diseases [5]. Mining is one of the sectors more impacted by the exposure to silica. Recent studies suggest that high silica exposure may explain, in part, the increase of coal workers' pneumoconiosis (CWP) and advanced CWP seen in Appalachian miners [6].

The mining industry in the U.S. is generally categorized by commodity: coal, metal, nonmetal, stone, and sand and gravel (S&G) mines. The Mine Safety and Health Administration (MSHA) divides the mining industry into coal mines and metal/nonmetal mines (M/NM) that include all the non-coal commodities. This division is mainly due to differences in history, mining operators, mining techniques, and geology associated with these different types of mines. In 2008, a total of 14 907 mining operations reported employment data to MSHA. Almost half (47.8 %) were sand and gravel mines, followed by stone mines (31.1 %), coal mines (14.3 %), nonmetal mines (4.8 %), and metal mines (2.0 %). There were 273 496 mine operator employees in 2008, with 85 693 and 187 803 employees reported by coal and M/NM mine operators, respectively. For mine operators, 20.6 % of the employee hours were for underground work locations, while 79.4 % were for surface work locations [7].

Coal and M/NM mines have different monitoring, measurement, and enforcement approaches relative to worker exposure to silica. For both industries, only respirable samples are subjected to analysis for silica, and the non-explicitly stated exposure limit for silica is an 8-h time-weighted average (TWA) concentration of 100 μg/m^3. In coal mines, the respirable dust standard is an 8-h TWA concentration of 2.0 mg/m^3. Silica exposure is controlled by reducing the 2.0 mg/m^3 standard when the content of silica in airborne dust exceeds 5 % by weight. The reduction is made by the following formula [8,9]:

$$\text{Reduced standard } \left(\text{mg/m}^3\right) = 10/[\%] \text{ silica}$$

When applicable, the silica content is determined by using a Fourier-Transform Infra-Red (FTIR) method [10]. In M/NM mines, the exposure limit to respirable silica-bearing dust is also dependent upon the % of silica if this content is greater than 1 %. The exposure limit considers three forms of crystalline silica (quartz, crystobalite, and tridimite) even though the first is the most common. The exposure limit is dependent upon the amount (%) of quartz(Q), cristobalite (C), and/or tridymite (T) present in the dust [11].

$$\text{Reduced standard mg/m}^3 = \frac{10\ \text{mg/m}^3}{[\%]\text{Q} + 2}$$

$$\text{Reduced standard mg/m}^3 = \frac{5\ \text{mg/m}^3}{[\%]\text{C} + 2}$$

$$\text{Reduced standard mg/m}^3 = \frac{5\ \text{mg/m}^3}{[\%]\text{T} + 2}$$

Quartz composes at least of 99 % of the silica in the MSHA samples and tridimite is rarely present. The mass of silica in M/NM mine samples is measured via an X-ray diffraction (XRD) method [12]. The XRD technique was selected for M/NM samples because of the lower impact of interferences than FTIR. Only respirable (dust) samples greater than $100\,\mu$g are subject to analysis for silica. Significant differences do exist between coal and M/NM compliance sampling for silica and respirable dust: in M/NM mines, the compliance samples are collected exclusively by MSHA inspectors; in coal mines, most of the samples are collected by MSHA inspectors, but operators are allowed by law to submit additional samples when a reduced dust standard has been proposed or applied.

In a recent study, Joy showed that the current MSHA approach for regulating coal miner exposure to respirable quartz does not protect miners from excessive exposure in all cases [13]. Specific situations where this problem arises include when the quartz content of the airborne dust increases due to changes in geologic conditions—i.e., more rock, or rock with higher quartz content, is extracted. The overexposure also occurs under reduced standard conditions when the presence of high silica has already been assessed. Adding to the prob lem, if the mine operator submits optional samples for quartz analysis, the pro cess may be extended by several weeks. Overexposure can cause adverse health effects and, potentially, dust concentrations below compliance standards may not be sufficient to protect the workers' health, based on the National Institute for Occupational Safety and Health (NIOSH) hazard review report [5].

The Office of Mine Safety and Health Research (OMSHR) NIOSH, recently initiated an effort for the development of end-of-shift techniques, specifically a laboratory-successful FTIR technique and an innovative elemental analysis technique [14,15]. An end-of-shift monitoring approach would allow operators to estimate the average concentration of silica in the area where they just sampled. Taking this one step further, OMSHR is also conducting research on methods for determining silica exposure during the shift. Due to limited sensitivity of most silica measurement methods, collecting an adequate sample mass in a short time can be problematic. A possible solution is the use of a high-volume sampler, and promising results have been published [16]. Another approach is the determination of silica % in an area of the mine or for a specific job by long-term static sampling and the use of this information in conjunction with real-time dust monitors. This approach requires constant or at least predictable silica content in the mine dust.

From a general perspective, the control and assessment of the exposure to silica in mining is dependent on the knowledge of two quantities: the respirable dust concentration and the % of silica in the respirable sample. While long-term trends of dust concentration and silica concentration in mining have been documented and analyzed [17–19], few studies analyzed in detail the % of silica in mine dust [19]. In a report from 1992, the National Occupational Health Survey of Mining examined the quartz content in bulk dust samples collected over six years in coal and M/NM mines [20]. The goal of the survey was to characterize health-related agents to which U.S. miners are exposed. The survey considered exclusively bulk and not respirable dust; therefore, it could be misleading to apply the findings of that study to respirable samples.

This manuscript investigates the % of silica in respirable dust samples collected in different mining industries and available in the MSHA database. Data gathered from 1997 to 2011 for both the coal and M/NM industries were used for this study. The findings provide valuable information for the development of specific sampling and analytical techniques for the monitoring of crystalline silica in the mining industry. In addition, the results can be useful for the design and evaluation of control technologies implemented for the reduction of crystalline silica exposure in mining.

Methodology

Information from MSHA archived respirable dust samples from 1997 through 2011 was retrieved from the MSHA Standardized Information System (MSIS) Samples database. Different information can be retrieved from the database regarding each sample. From the coal database it was possible to retrieve directly the % of silica in the dust collected and the respirable concentration relative to the sample. From the M/NM database it was possible to obtain the respirable dust concentration for each sample, while data on the % of silica in the dust was derived from the exposure limit associated with each sample. In addition, information related to the location where the sample was collected was retrieved. There are several known limitations of using a similar database: first and foremost the samples are taken for enforcement and not scientific reasons. This approach implies that: (1) MSHA inspectors sample workers suspected to be at the greatest risk of overexposure and not randomly [18], (2) samples collected in M/NM mines and containing less than 1 % of silica are coded differently and they are not used to calculate a reduced exposure limit. The use of these censored samples for the analysis of the % of silica in the mine dust would require several assumptions and potential introduction of errors. The authors decided to not consider these samples. In general, the MSHA database is a partially biased view of the true respirable mine dust and most likely is shifted towards the upper ends of the overall exposure distributions. Because the exposure is measured as silica concentration and it is function of the % silica and the concentration of respirable dust also the data of the % of silica in the dust can be partially biased. In spite of these shortcomings, the MSHA database is uniquely valuable in that it contains information on thousands of respirable dust samples collected in the US mining industry over a relatively long time period.

Results and Discussion

An analysis of the % of silica in the respirable dust samples collected in the mining industry was initiated by dividing the industry by commodities and locations. Figure 1 presents the % of silica in the M/NM respirable dust for the period 1997–2011 and Table 1 summarizes the statistical data of all the charts. Because the data of silica % in the dust is distributed in a lognormal fashion—Rankit test passed—the boxplots are reported in lognormal scale. The bottom and top of the box are the 25th and 75th percentiles (the lower and upper quartiles, respectively), and the band near the middle of the box is the 50th percentile (the median). The ends of the whiskers represent one standard deviation above and below the mean of the data and the additional dots represent 95 % and 5 %. In addition, the geometric mean of each set is included in Table 1 for each set. The silica % is substantially lower in the samples collected underground, and also shows a low variability. For every M/NM commodity, a single factor analysis of variance (ANOVA) ($\alpha = 0.05$) was conducted on the log-transformed data for the samples collected in the three locations. A significant difference was found among locations and a post hoc Tukey–Kramer analysis identified underground as different from both mill and surface locations. The reason for this is not clear, but it is likely a function of mine geology, as well as mining practices (i.e. methods of excavation and ore handling). It is also possible that the crushing and refining processes and subsequent handling of the ores in mill and surface locations can generate a respirable dust that is richer in silica.

The Tukey–Kramer analysis underscored also that the % of silica in samples collected in mill and surface locations are different for both stone and

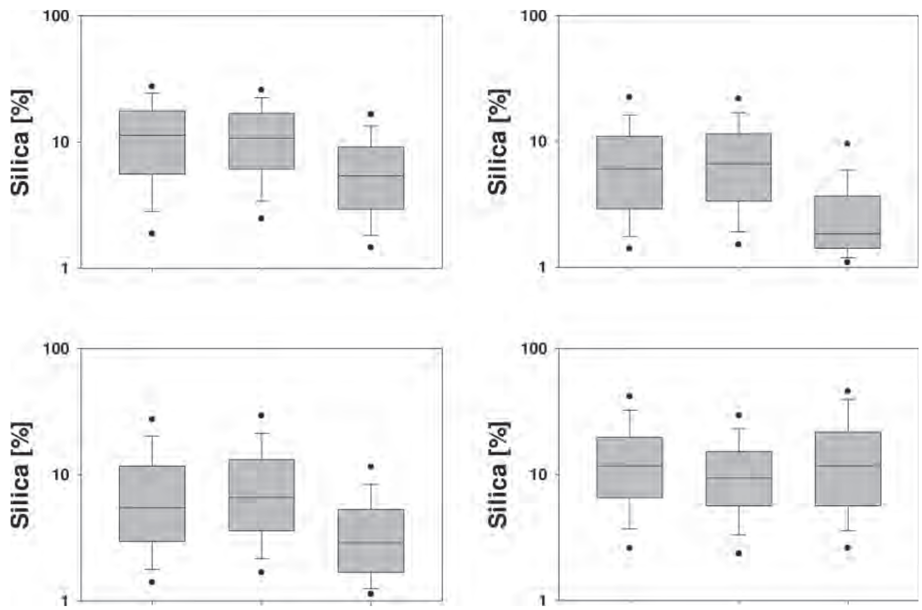

FIG. 1—*Percent of silica in respirable samples collected in M/NM mines from 1997 to 2011. For each chart the data are (left to right): mill, surface, and underground. Metal mines (top left), nonmetal mines (top right), stone mines (bottom left), S&G mines (bottom right).*

S&G industry. These findings can have implications in the development of monitoring strategies: in specific underground locations, the estimation of an area's silica % by using long-term stationary sampling might produce relatively good accuracy. On the other hand, simply employing dust monitors in mill and surface locations and assuming constant and reliable information on silica % might induce poor estimation in the exposure to silica. In this case, a timely measurement of the silica % in the dust by the end-of-shift approach could be beneficial.

For all the M/NM industries, the samples collected in mill and surface locations showed similar geometric mean % of silica (Table I). The geometric mean is close to 10 % for both metal and S&G mines (11.2 %, 9.0 %, 9.6 %, and 9.6 %, respectively for mill and surface locations) and it is substantially lower for nonmetal and stone mines in both locations. The upper quartile is highest for samples collected in S&G mill locations where in general high values for all the parameters are found. The difference between the upper and lower quartile is a good indication of the variability in the silica % in non-underground locations. This value is in general around 10 % and, on average, slightly higher for metals (11.4 %) and S&G (11.4 %) dust samples than for nonmetal (8.1 %) and stone (9.1 %). This implies that the industries with higher

TABLE 1—*Statistical summary data on the percent of silica in respirable dust samples collected in M/NM mines from 1997 to 2011.*

			Mill	Surface	Underground	Total
Metal		*Sample #*	*1328*	*1016*	*866*	
	% silica	Geometric Mean	9.6	9.6	5.3	8.2
		Median	11.3	10.7	5.4	9.2
		1 quartile	5.6	6.1	2.9	4.6
		3 quartile	17.6	16.9	9.1	15.2
		5 %	1.9	2.5	1.5	1.8
		95 %	27.4	25.8	16.5	25.8
Nonmetal		*Sample #*	*2431*	*1101*	*156*	*3688*
	% silica	Geometric Mean	5.8	6.2	2.3	5.7
		Median	6.1	6.6	1.8	6.0
		1 quartile	2.9	3.4	1.4	2.8
		3 quartile	11.0	11.5	3.7	11.0
		5 %	1.4	1.5	1.1	1.4
		95 %	22.4	21.8	9.4	21.8
Stone		*Sample #*	*8188*	*16 131*	*1084*	*25 403*
	% silica	Geometric Mean	5.9	6.8	3.1	5.3
		Median	5.5	6.6	2.9	6.0
		1 quartile	3.0	3.6	1.7	3.2
		3 quartile	11.7	13.2	5.3	12.3
		5 %	1.4	1.7	1.1	1.5
		95 %	27.4	29.3	11.5	27.4
S & G		*Sample #*	*6807*	*11 048*	*134*	*17 989*
	% silica	Geometric Mean	11.2	9.0	11.2	9.8
		Median	11.7	9.4	11.7	10.2
		1 quartile	6.6	5.6	5.6	5.9
		3 quartile	19.7	15.2	21.7	16.9
		5 %	2.6	2.4	2.8	2.4
		95 %	41.5	29.3	45.6	35.0

silica % (median) in the dust also have a higher likelihood of variability in silica %. In order to compare the % of silica in the dust samples collected in different M/NM commodities, a single factor ANOVA ($\alpha = 0.05$) was conducted by considering a single combined set of samples from each commodity: the post hoc Tukey–Kramer analysis showed that the means for each industry are significantly different. This finding is probably affected by the very large number of samples for each industry.

The MSHA database also reports the year when each sample was collected, which allowed for an investigation of how the silica % in the dust evolved through the years in the respirable dust samples collected in the M/NM

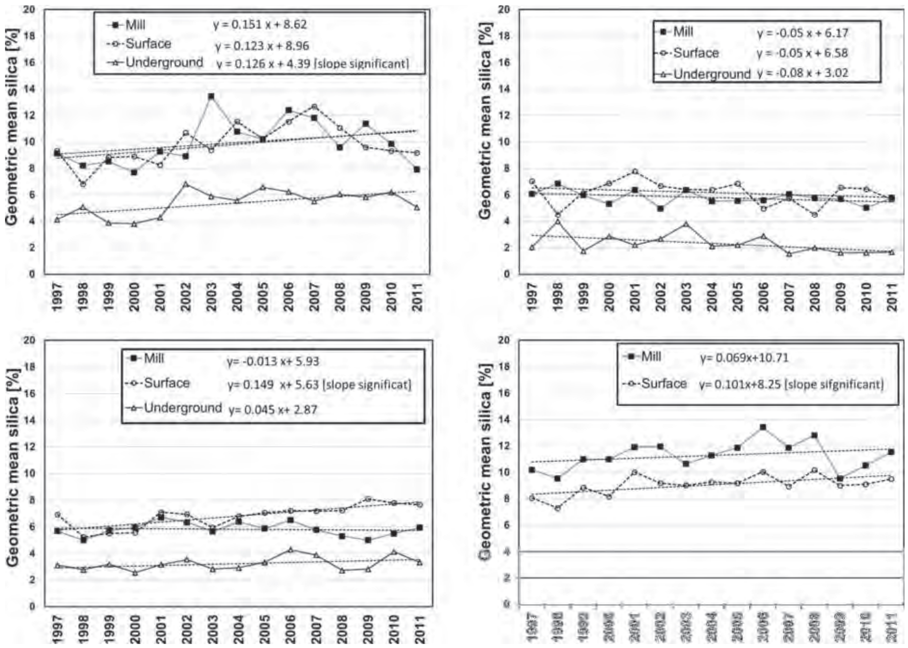

FIG. 2—*Year by year geometric mean % of silica in the M/NM dust from 1997 to 2011. Metal mines (top left), nonmetal mines (top right), stone mines (bottom left), S&G mines (bottom right).*

industry (Fig. 2). For the metal and S&G industries and for the samples collected in surface stone mines, the regression for each line underscores a pronounced positive trend—an increase in the geometric mean % of silica—with time for the years 1997–2011. An analysis of regression ($\alpha = 0.05$) showed that the slope are significantly different than zero only for the samples collected in underground metal mines, in surface stone mines, and in surface S&G locations.

The % of silica in the respirable dust samples collected between 1997 and 2011 in coal mines is substantially different for underground and surface coal locations (Fig. 3). The variability is significantly higher for samples collected in surface locations. The data summarized in Table 2 shows that the geometric mean for samples collected in surface locations is slightly higher than for underground (5.6 versus 4.7)—and that the difference is significant (single factor ANOVA $\alpha = 0.05$) In underground locations, 95 % of the samples did not show a silica % higher than 20 %, while this value reached almost 40 % for surface locations. The % of silica in the respirable dust is also much more variable if the sample was collected on the surface. In addition, 50 % of the samples around the median showed a silica % between 17 % and 1.7 %. For underground samples, these values were narrower: 8.4 % and 2.8 %. An

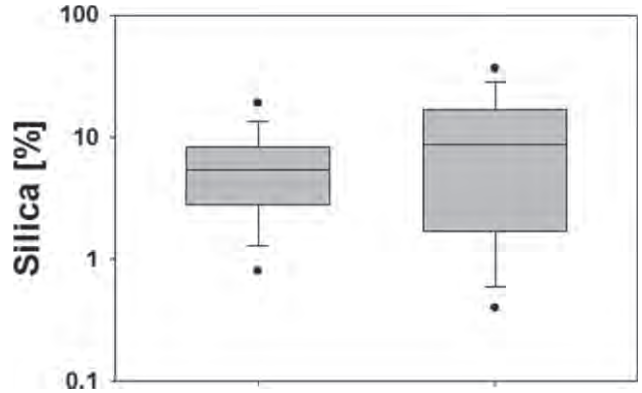

FIG. 3—*Percent of silica in respirable samples collected in coal mines from 1997 to 2011.*

explanation for this finding could be found by considering the different mining process—i.e., the presence of non-coal silica-rich dust is much more prevalent in surface coal mines or surface locations of underground coal mines. Surface mine operators might need to mine through a substantial amount of rock material in order to retrieve sufficient coal and this process can generate dust with variable silica %.

Figure 4 provides a means for visualizing how the median silica % in the respirable dust in coal mines varied yearly from 1997 to 2011. For both samples collected in surface and underground locations, the geometric mean of the silica % decreases during the years with a slope that is significantly different than zero. The decrease is more pronounced in the first years for both surface and underground samples. For this reason, a second analysis was conducted only on samples collected between 2003 and 2011; in this case, the positive relationship is still significant, but substantially reduced for underground and reversed for surface location.

TABLE 2—*Statistical summary data on the percent of silica in respirable dust samples collected in coal mines from 1997 to 2011.*

		Underground	Surface	Total
	Sample #	*66 721*	*11 104*	*77 825*
% silica	Geometric Mean	4.7	5.6	4.8
	Median	5.4	8.7	5.6
	1 quartile	2.8	1.7	2.7
	3 quartile	8.4	17.0	9.1
	5 %	0.8	0.4	0.7
	95 %	19.2	36.6	22.6

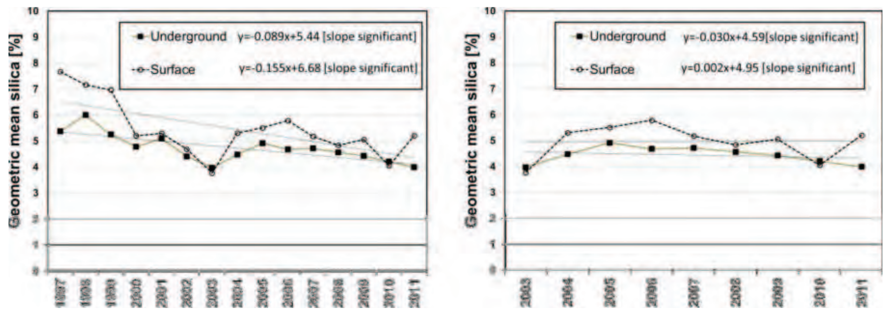

FIG. 4—*Year by year geometric mean % of silica in the coal mine dust from 1997 to 2011 (left) and from 2003 to 2011 (right).*

The relationship between the % of silica in the respirable dust samples collected and the number of samples collected was also explored. This analysis investigates how the sampling strategy by MSHA inspectors is affected by the industry and if the % of silica in the dust is a factor in this selection. The geometric mean for the % of silica in dust samples collected every year from 1997 to 2011 in each M/NM industry and location were plotted against the relative number of samples (Fig. 5 left panel). Preliminary analysis of the plot showed how a positive correlation was visually detected only if the number of samples were log-normally transformed; in this case, a regression slope significantly different from zero was assessed. In a similar fashion, the geometric mean of the % of silica in dust samples collected every year from 1997 to 2011 in coal mines were compared with the number of samples collected. In this case, the results were divided between samples collected in underground and surface locations (Fig. 5 central and right panel); a positive significant relationship was found even without the log-transformation of the number of samples.

As described in the Introduction, silica % is the metric used to calculate the reduced dust exposure limit in both the coal and M/NM mine industries,

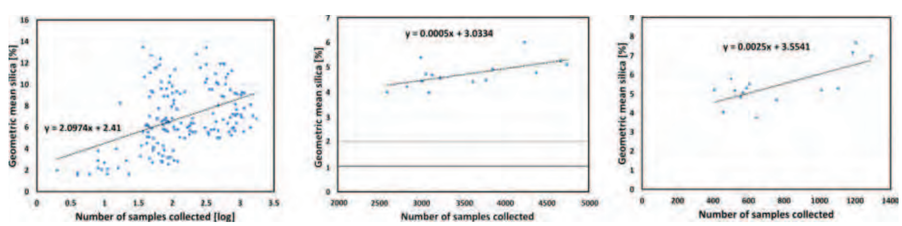

FIG. 5—*Relationship between silica % in the dust samples and number of samples collected in the mining industry: (left) samples collected in M/NM industry between 1997 and 2011, (central) samples collected in underground coal mines between 1997 and 2011, (right) samples collected in surface coal mines between 1997 and 2011.*

and the actual respirable dust concentration is used in conjunction with the reduced limit to verify the compliance status. For this reason, it is important to investigate the relationship between the respirable dust concentration and the silica % in the dust. The data of the two values were plotted for each sample collected from 1997 to 2011 in metal, nonmetal, stone, and S&G mines (Fig. 6). The black line in each chart represents the dust standard. Intuitively, the samples located on the right of the line were characterized by a silica content higher than 100 μg. In each chart, the % of silica is inversely correlated with the dust concentration—i.e., the lower the dust concentration, the higher the variability of the silica %. This data trend is similar for every location in the four industries. The similarity of the boundaries of the area populated by data and the reduced standard lines is evident.

Possible explanations for this pattern can be made. The first explanation is based on the reduced standard formula: if a mine is regulated under a reduced standard, its dust is more likely to have a high silica % and consequently the mine is required to keep the dust concentration low. In other words, the trend proves that the regulation as it is structured is effective: the higher the % of silica, the lower is the respirable dust concentration. On the other hand, it is more difficult to explain the complete absence of samples with both high respirable mass concentration and high silica %—in other words, to understand why the samples in non-compliance status also present the inverse relationship. The periodic MSHA inspections provide the operators information on the % of silica in the dust. This value is used to generate the reduced dust standard, but it might change before the following MSHA inspection. This change can move the point in the chart from the left side of the reduced standard line to the right side. This transposition from the left side (in compliance) to the right side (not in compliance) of the line can occur even if the same dust concentration is maintained or, in other words, even if the same dust control strategy is implemented. Described from a different perspective, the charts show that the % of silica in M/NM mine dust is extremely variable and it can span from a few % up to 80–90 %. Because of this high variability, it is extremely difficult for operators to predict with accuracy and precision the % of silica in the dust and its evolution over time with the tools currently available. However, the operators might have knowledge of an area with a high silica % dust, and for this reason, the data trend with a pattern similar to the reduced standard line. However, the lack of timely characterization in silica % connotes a *limited* and *non-complete* knowledge by operators of the dust's characteristics present in the mine.

Other possible explanations for the trends are connected with dust control technologies and their performance. If the efficiency of the dust control approaches is more selective to dust with lower silica percentage because of size distribution effects, the results of their application is a lower respirable dust concentration but a higher silica %. Along the same lines, different transport properties for aerosols with low and high % in silica could explain this effect. The transport of an aerosol from the generation of the dust to the sampler is affected by physical (size) properties—i.e., if the aerosol with a higher % in silica is more likely to reach the sampler because of its smaller size, there will be a lower mass concentration but a higher silica %. The authors did not find any reference to support these hypotheses but feel they should be further explored.

A similar analysis of the relationship between the % of silica and the relative respirable dust concentration has been carried out on samples collected in surface and underground coal mine locations (Fig. 7). The black line is the reduced standard for coal dust affected by the % of silica. The samples at the right of the black line have a silica content higher than 100 μg. As noted for the M/NM industry, the trend for the % of silica in coal dust samples also has a distinctive evolution—the lower the dust concentration, the higher the

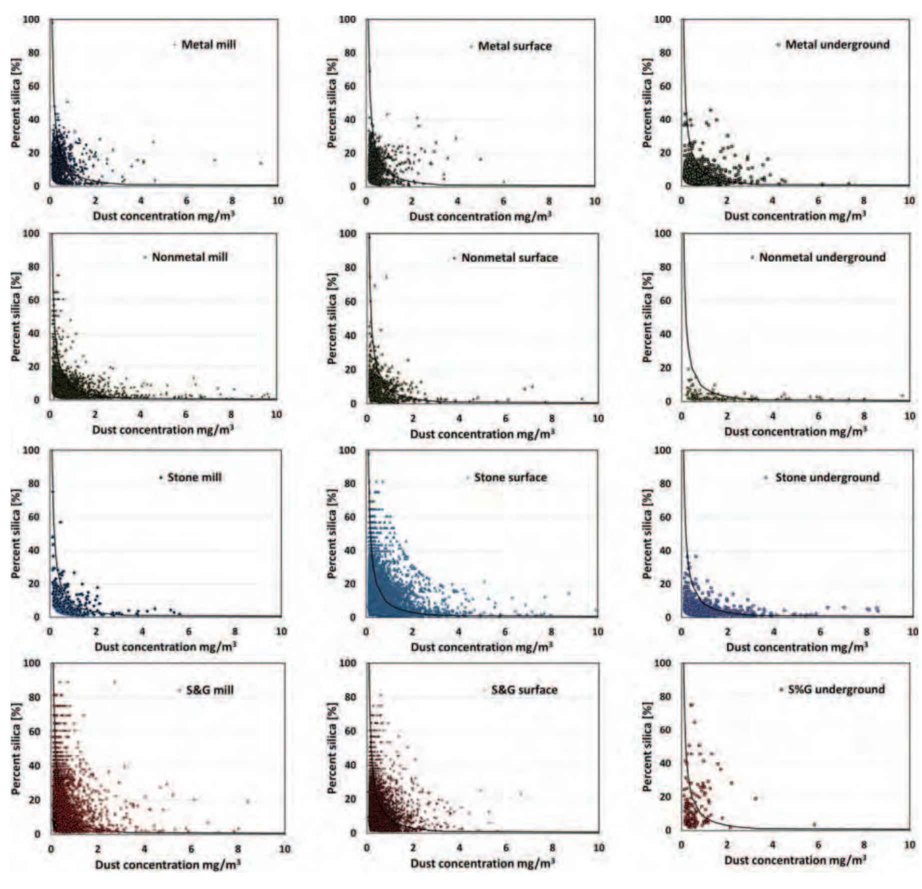

FIG. 6—*Percent of silica versus respirable dust concentration for M/NM dust samples.*

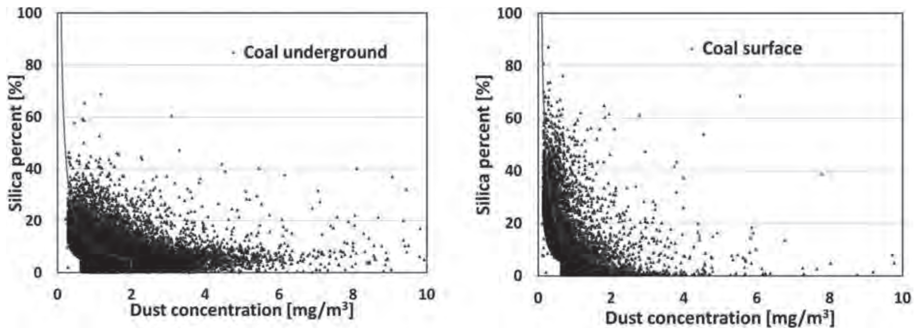

FIG. 7—*Percent of silica versus respirable dust concentration for coal dust samples.*

variability of silica %. This is particularly true for surface coal samples where this inverse trend is more pronounced. This reinforces the idea that the dust samples collected are characterized by a % of silica that is not random.

As proposed above, it is possible that the changing conditions in the % of silica in the dust do not allow the mine operators to predict the dust concentration level below the reduced standard. In other words, the lack of certainty about the silica % in the dust is a possible limiting factor for the operators in maintaining the concentration below the reduced dust standard. Also in this case, the hypothesis of the effect of more selective dust control approaches towards samples less rich in silica dust cannot be excluded. A study conducted in 1987 by Penn State University on the size and elemental composition of airborne coal mine dust showed coal mine dust present underground in bi-modal distributions with a smaller mode around 2 μm [21]. A previous study on silica (more than 90 % silica) particle distribution in respirable coal mine dust samples (surface and underground) showed a median around 1 μm [22]. It should be noted that these studies are more than 20 years old and they might not reflect the current conditions in the coal mine industry. Nevertheless, their findings are an indication of the possible co-presence in the coal mine atmosphere of different separate aerosols with different % in silica, which could explain the trends in Fig. 7. These findings should be considered when designing specific monitoring and control technology strategies with the focus on silica dust in coal mines.

Summary

This study analyzed the % of crystalline silica in respirable dust samples collected by MSHA inspectors from around the U.S. between 1997 and 2011. The results for the M/NM industry showed that the % of silica in the dust was significantly higher and more variable for samples collected in surface and mill locations than for those underground. The % was also found to be higher and more variable in sand and gravel and metal mines, as opposed to other M/NM mines. The % of silica in respirable samples collected in underground metal mines, surface stone mines, and S&G surface mines is slowly increasing over the years of the study. In coal mines, the silica % is significantly higher and more variable for samples collected in surface locations. While the % of silica in samples collected from 1997 to 2011 has been decreasing for both surface and underground locations, the trend stopped or reversed in the last 8 years. The analysis also showed that a positive relationship exists between the geometric mean of the % of silica in respirable dust samples collected in a certain year in both M/NM and coal industry and the number of samples collected. For both coal and M/NM dust samples, the relationship between the silica % and the respirable dust concentration showed a distinctive negative trend: the lower the dust concentration, the higher the variability in the % of silica. A few explanations were proposed to explain these trends, and the possible mathematic relationships need to be further evaluated and verified via specific testing or data analysis by considering different variables.

Acknowledgments

The mention of any company or product does not constitute an endorsement by the National Institute for Occupational Safety and Health. The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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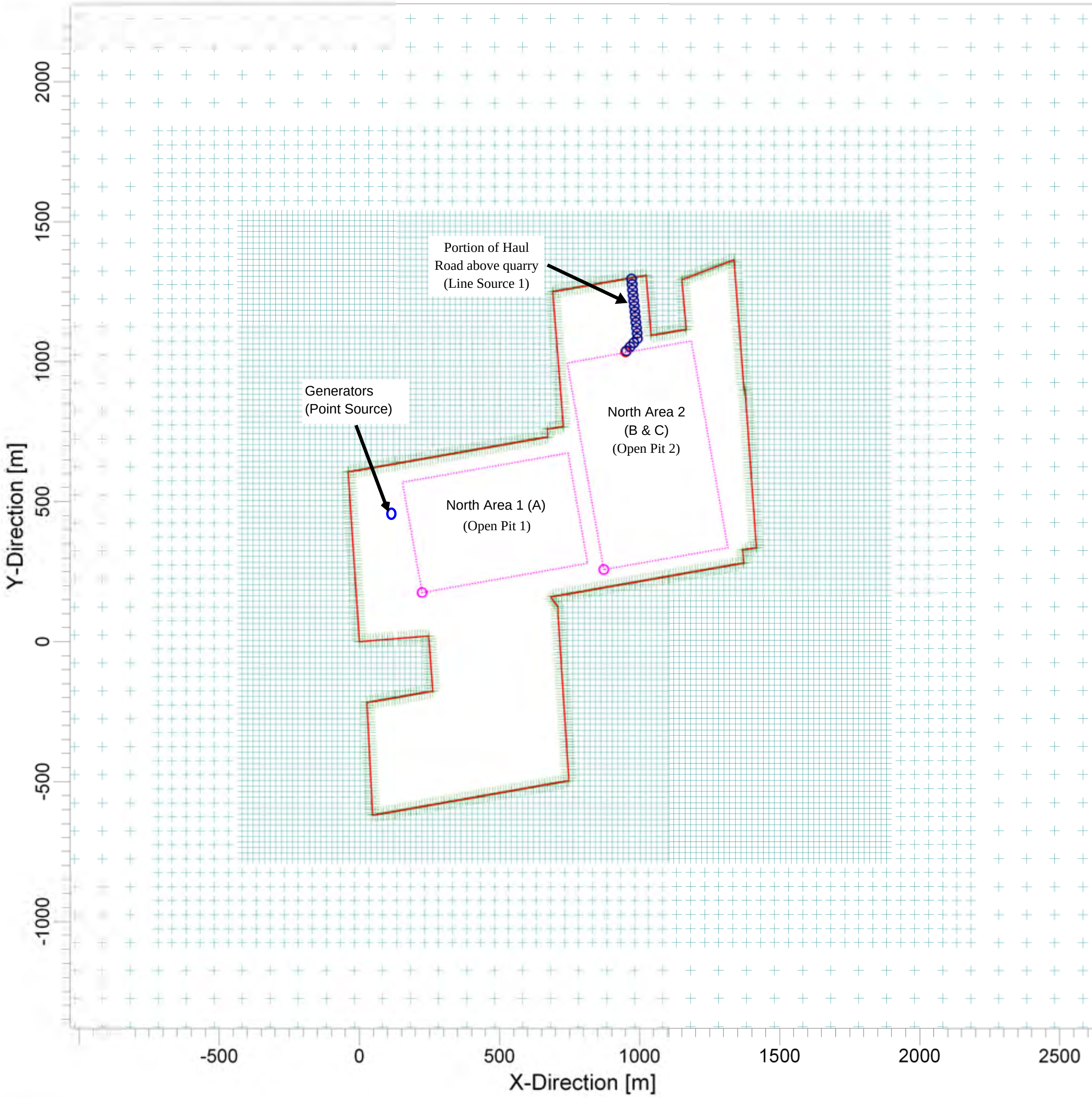
APPENDIX E

Graphical Representations of Models and Modelling Source Summaries

Figure E-1

PROJECT TITLE:

Violet Hill Air Quality Assessment
Scenario 1 Sources and Multi-Grid Receptors



COMMENTS:	SOURCES:	COMPANY NAME:	
	4	**Trinity Consultants Ontario Inc.**	
	RECEPTORS:	MODELER:	
	12324	**Ulla Jokinen**	
		SCALE: 1:23,006 0 ▬ ▬ ▬ 0.5 km	
			PROJECT NO.: **TCI 147201.0364**

AERMOD View - Lakes Environmental Software

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Figure E-2

PROJECT TITLE:

Violet Hill Air Quality Assessment
Scenario 1 Sources and Closest Sensitive Receptors

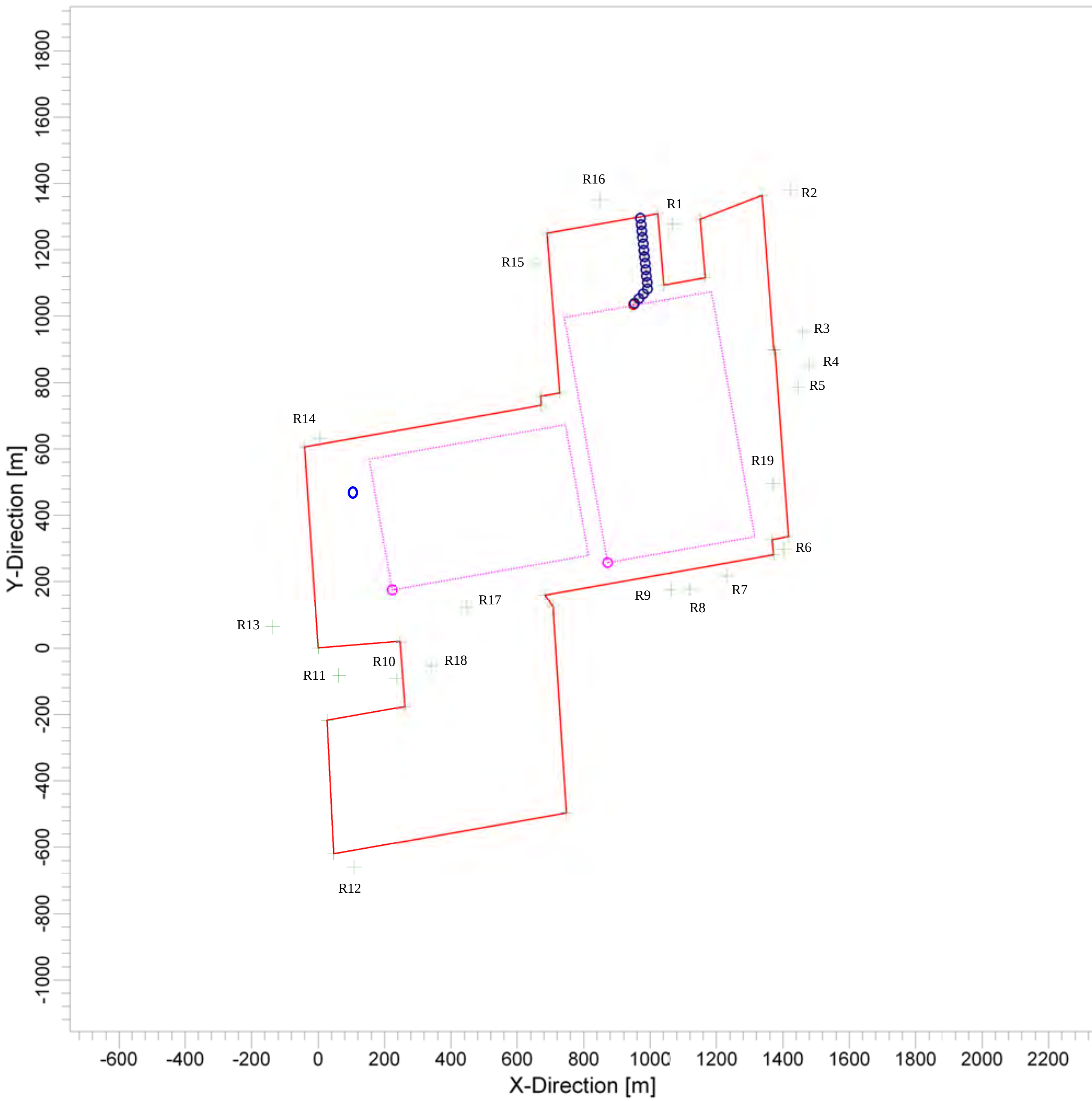

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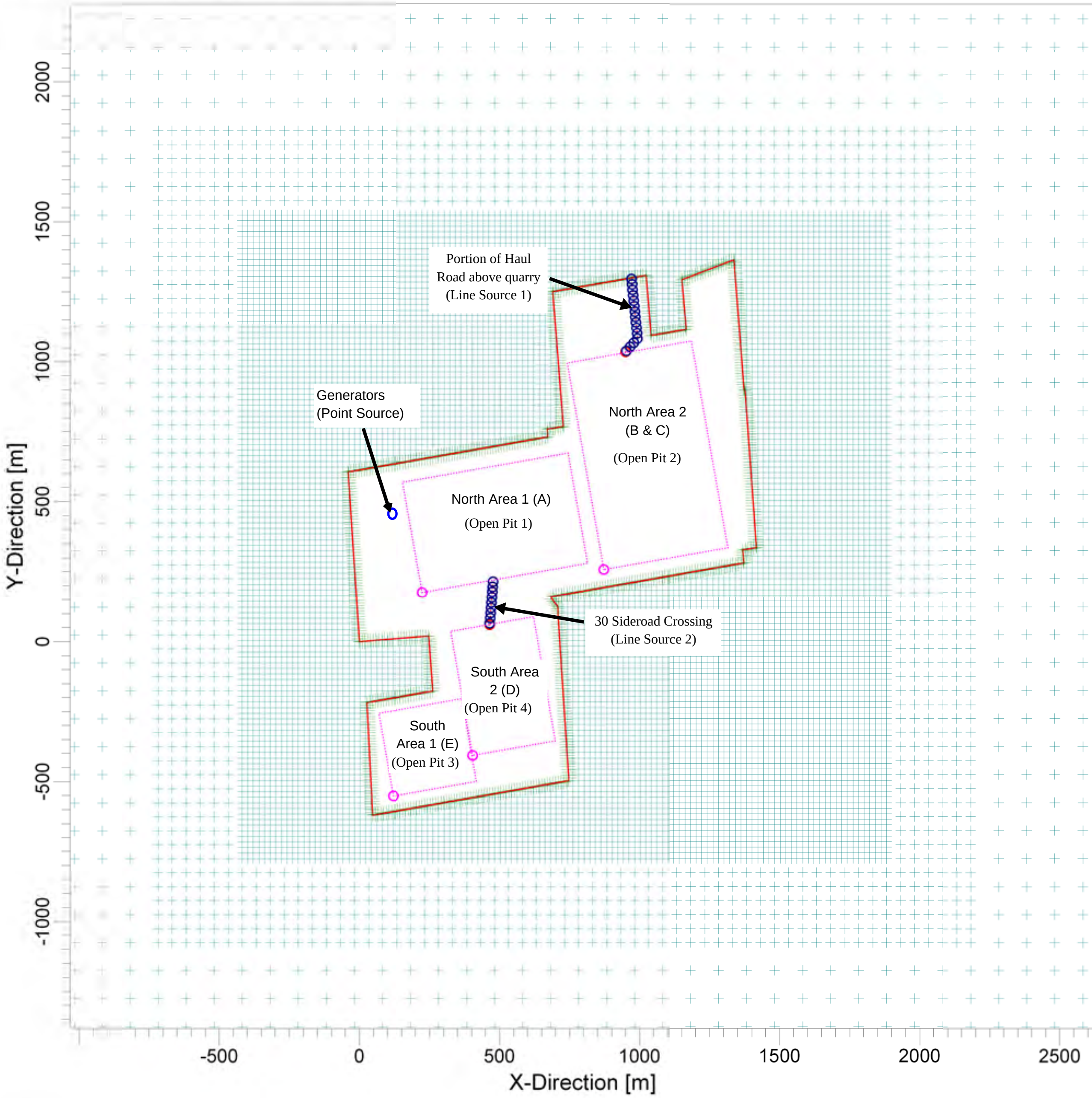
Figure E-3

PROJECT TITLE:

Violet Hill Air Quality Assessment
Scenario 2 Sources and Multi-Grid Receptors

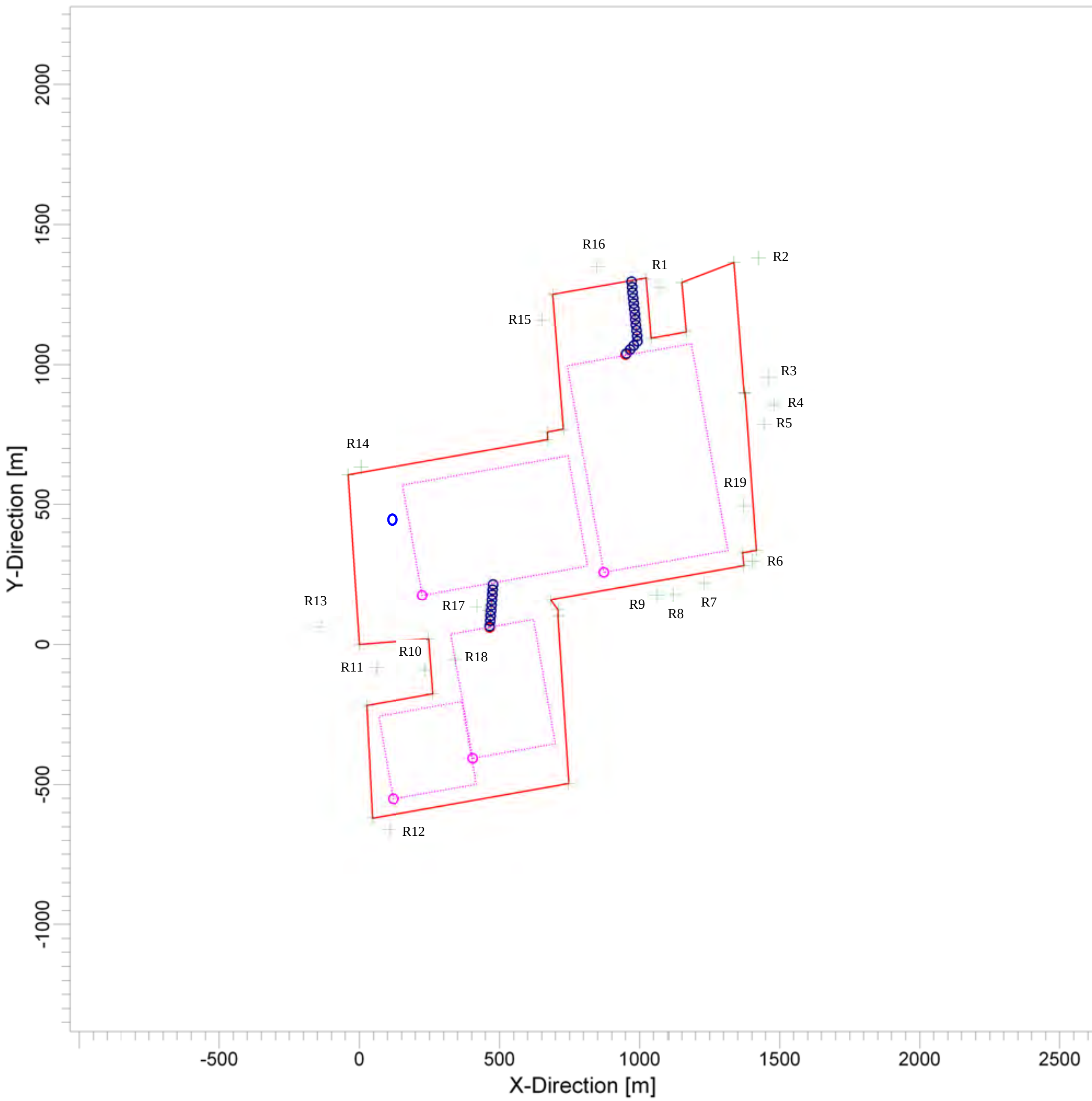


COMMENTS:	SOURCES: 7	COMPANY NAME: **Trinity Consultants Ontario Inc.**	
	RECEPTORS: **12324**	MODELER: **Ulla Jokinen**	Trinity Consultants
		SCALE: 1:23,006 — 0 ▬ 0.5 km	
			PROJECT NO.: **TCI 147201.0364**

Figure E-4

PROJECT TITLE:

Violet Hill Air Quality Assessment
Scenario 2 Sources and Closest Sensitive Receptors/Scenario 3 Sources and Closest Sensitive Receptors



COMMENTS:	SOURCES: 7	COMPANY NAME: Trinity Consultants Ontario Inc.	
	RECEPTORS: 43	MODELER: Ulla Jokinen	Trinity Consultants
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			PROJECT NO.: TCI 147201.0364

AERMOD View - Lakes Environmental Software

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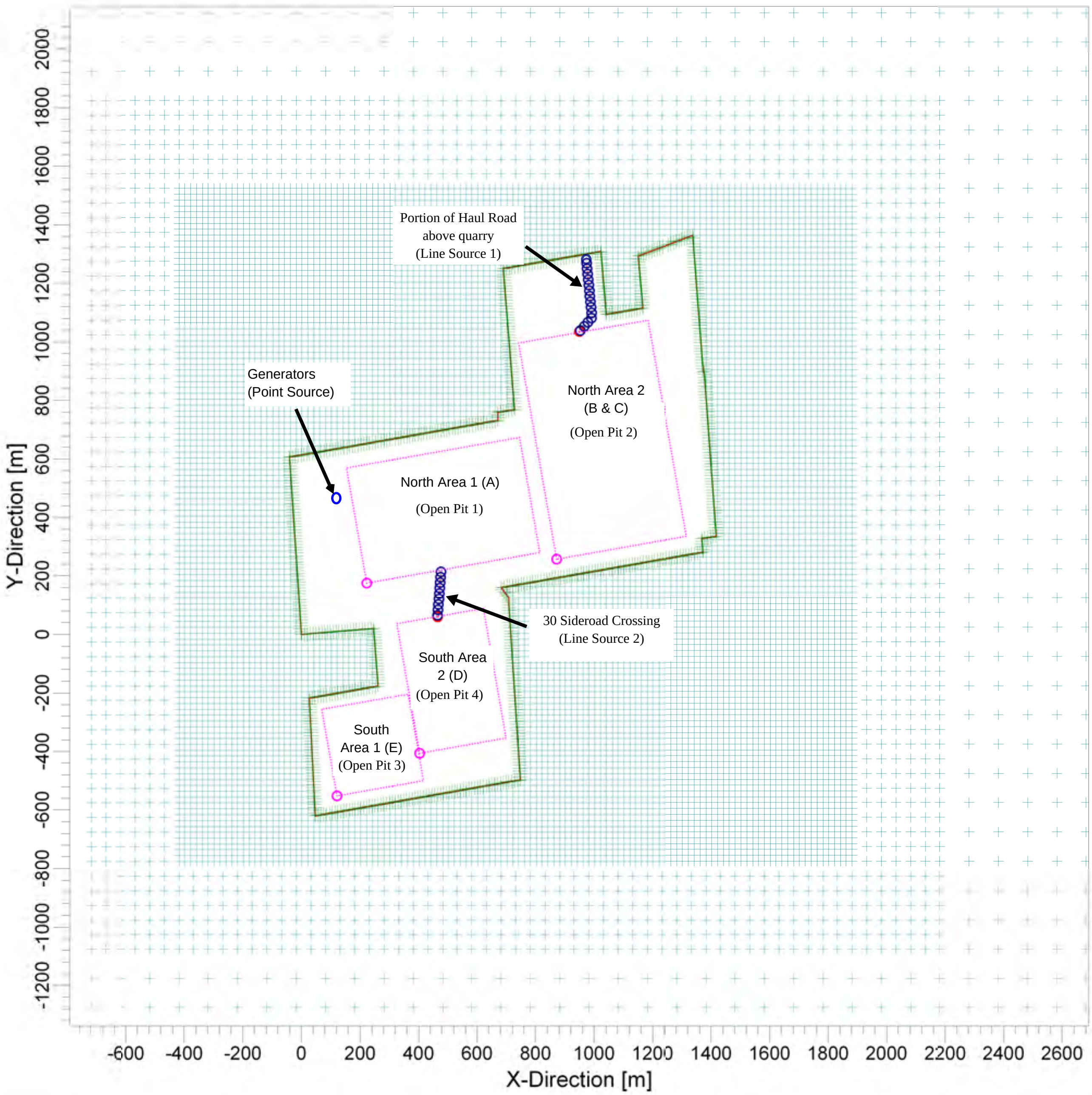
Figure E-5

PROJECT TITLE:

Violet Hill Air Quality Assessment
Scenario 3 Sources and Multi-Grid Receptors



COMMENTS:	SOURCES: 7	COMPANY NAME: **Trinity Consultants Ontario Inc.**	
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			PROJECT NO.: **TCI 147201.0364**

AERMOD View - Lakes Environmental Software

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Modelling Summary Table - Total Particulate

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only **PM98S1**

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.30	33.95	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	2.52E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	5.16E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-02	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	8.33E-02	1.56E-06
												P8b	Portable Secondary Crushing	8.33E-02	
												P9	Portable Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	1.03E-01	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-02	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-03	

Modelling Summary Table - Total Particulate

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E) **PM98S2**

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	2.52E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	5.16E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-02	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	8.33E-02	1.56E-06
												P8b	Portable Secondary Crushing	8.33E-02	
												P9	Portable Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	1.03E-01	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-02	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-03	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	7.74E-02	5.73E-07
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate	N/A - PM	P14a	Aggregate transfer to crushing plant (from Area E)	6.02E-02	6.69E-07
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-02	

Modelling Summary Table - Total Particulate

Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

PM98S3

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	2.31E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-02	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-02	1.71E-07
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-03	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	7.74E-02	5.73E-07
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate matter	N/A - PM	P8a	Primary Crushing	8.33E-02	4.54E-06
												P8b	Secondary Crushing	8.33E-02	
												P9	Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P14a	Aggregate transfer to crushing plant (from Area E)	6.02E-02	
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-02	

Modelling Summary Table - PM10

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.30	33.95	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	9.94E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	4.50E-02	
												P3b	Secondary Crushing	4.50E-02	
												P4	Screening (Two Units)	6.17E-02	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.83E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.83E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.83E-03	
												P7	Truck Loading of Material to Shipping Trucks	8.33E-03	
												P11	Aggregate Loading from Screening Plant to Storage Piles	4.10E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.32E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-03	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	3.75E-02	5.23E-07
												P8b	Portable Secondary Crushing	3.75E-02	
												P9	Portable Screening (Two units)	5.14E-02	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.19E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.19E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	3.19E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.63E-02	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-02	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	9.64E-04	

Modelling Summary Table - PM10

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	9.94E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	4.50E-02	
												P3b	Secondary Crushing	4.50E-02	
												P4	Screening (Two Units)	6.17E-02	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.83E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.83E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.83E-03	
												P7	Truck Loading of Material to Shipping Trucks	8.33E-03	
												P11	Aggregate Loading from Screening Plant to Storage Piles	4.10E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.32E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-03	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	3.75E-02	5.41E-07
												P8b	Portable Secondary Crushing	3.75E-02	
												P9	Portable Screening (Two units)	5.14E-02	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.19E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.19E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	3.19E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.63E-02	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-02	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	9.64E-04	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.97E-02	1.46E-07
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate	N/A - PM	P14a	Aggregate transfer to crushing plant (from Area E)	1.53E-02	1.70E-07
SLINE2	30 Sideroad	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres,							Suspended particulate	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	7.01E-03	

Modelling Summary Table - PM10

Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	9.39E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	4.50E-02	
												P3b	Secondary Crushing	4.50E-02	
												P4	Screening (Two Units)	6.17E-02	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.83E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.83E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.83E-03	
												P7	Truck Loading of Material to Shipping Trucks	8.33E-03	
												P11	Aggregate Loading from Screening Plant to Storage Piles	4.10E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-03	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-02	4.22E-08
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	9.64E-04	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.97E-02	1.46E-07
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate matter	N/A - PM	P8a	Primary Crushing	3.75E-02	1.68E-06
												P8b	Secondary Crushing	3.75E-02	
												P9	Screening (Two units)	5.14E-02	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.19E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.19E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	3.19E-03	
												P14a	Aggregate transfer to crushing plant (from Area E)	1.53E-02	
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	7.01E-03	

Modelling Summary Table - PM2.5

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.30	33.95	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	5.55E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	8.33E-03	
												P3b	Secondary Crushing	8.33E-03	
												P4	Screening (Two Units)	4.17E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.08E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.08E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.08E-03	
												P7	Truck Loading of Material to Shipping Trucks	9.17E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	6.21E-03	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.32E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	6.94E-03	7.15E-08
												P8b	Portable Secondary Crushing	6.94E-03	
												P9	Portable Screening (Two units)	3.47E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.03E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.03E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.03E-04	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.63E-03	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-03	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	2.36E-04	

Modelling Summary Table - PM2.5

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate (g/s/m^2)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	5.55E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	8.33E-03	
												P3b	Secondary Crushing	8.33E-03	
												P4	Screening (Two Units)	4.17E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.08E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.08E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.08E-03	
												P7	Truck Loading of Material to Shipping Trucks	9.17E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	6.21E-03	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.32E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	6.94E-03	7.39E-08
												P8b	Portable Secondary Crushing	6.94E-03	
												P9	Portable Screening (Two units)	3.47E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.03E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.03E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.03E-04	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.63E-03	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-03	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	2.36E-04	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.97E-03	1.46E-08
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate	N/A - PM	P14a	Aggregate transfer to crushing plant (from Area E)	1.53E-03	1.70E-08
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	7.01E-04	

Modelling Summary Table - PM2.5

Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.33E-03	5.50E-07
												P2b	Truck Unloading of Aggregate to Crushing Plant	8.33E-03	
												P3a	Primary Crushing	8.33E-03	
												P3b	Secondary Crushing	8.33E-03	
												P4	Screening (Two Units)	4.17E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.08E-03	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.08E-03	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.08E-03	
												P7	Truck Loading of Material to Shipping Trucks	9.17E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	6.21E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	3.29E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.42E-03	4.22E-09
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	2.36E-04	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.97E-03	1.46E-08
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate matter	N/A - PM	P8a	Primary Crushing	6.94E-03	2.40E-07
												P8b	Secondary Crushing	6.94E-03	
												P9	Screening (Two units)	3.47E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.03E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.03E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.03E-04	
												P14a	Aggregate transfer to crushing plant (from Area E)	1.53E-03	
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	7.01E-04	

Modelling Summary Table - Crystalline Silica

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.30	33.95	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.20E-04	8.95E-08
												P2b	Truck Unloading of Aggregate to Crushing Plant	7.50E-04	
												P3a	Primary Crushing	4.05E-03	
												P3b	Secondary Crushing	4.05E-03	
												P4	Screening (Two Units)	5.55E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.45E-04	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.45E-04	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.45E-04	
												P7	Truck Loading of Material to Shipping Trucks	7.50E-04	
												P11	Aggregate Loading from Screening Plant to Storage Piles	3.69E-03	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.18E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	2.96E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	3.38E-03	4.71E-08
												P8b	Portable Secondary Crushing	3.38E-03	
												P9	Portable Screening (Two units)	4.63E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	2.88E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	2.88E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	2.88E-04	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.37E-03	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.28E-03	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	8.67E-05	

Modelling Summary Table - Crystalline Silica

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.20E-04	8.95E-08
												P2b	Truck Unloading of Aggregate to Crushing Plant	7.50E-04	
												P3a	Primary Crushing	4.05E-03	
												P3b	Secondary Crushing	4.05E-03	
												P4	Screening (Two Units)	5.55E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.45E-04	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.45E-04	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.45E-04	
												P7	Truck Loading of Material to Shipping Trucks	7.50E-04	
												P11	Aggregate Loading from Screening Plant to Storage Piles	3.69E-03	
												P12a	Aggregate transfer to crushing plant (in Area A)	1.18E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	2.96E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	3.38E-03	4.87E-08
												P8b	Portable Secondary Crushing	3.38E-03	
												P9	Portable Screening (Two units)	4.63E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	2.88E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	2.88E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	2.88E-04	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	2.37E-03	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.28E-03	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	8.67E-05	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.78E-03	1.32E-08
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate	N/A - PM	P14a	Aggregate transfer to crushing plant (from Area E)	1.38E-03	1.53E-08
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	6.31E-04	

Modelling Summary Table - Crystalline Silica

Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	1.20E-04	8.45E-08
												P2b	Truck Unloading of Aggregate to Crushing Plant	7.50E-04	
												P3a	Primary Crushing	4.05E-03	
												P3b	Secondary Crushing	4.05E-03	
												P4	Screening (Two Units)	5.55E-03	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	3.45E-04	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	3.45E-04	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	3.45E-04	
												P7	Truck Loading of Material to Shipping Trucks	7.50E-04	
												P11	Aggregate Loading from Screening Plant to Storage Piles	3.69E-03	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	2.96E-04	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	1.28E-03	3.80E-09
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	8.67E-05	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate matter	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	1.78E-03	1.32E-08
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate matter	N/A - PM	P8a	Primary Crushing	3.38E-03	1.51E-07
												P8b	Secondary Crushing	3.38E-03	
												P9	Screening (Two units)	4.63E-03	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	2.88E-04	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	2.88E-04	
												P10c	Conveyor Transfer Points (Screening to Stackers)	2.88E-04	
												P14a	Aggregate transfer to crushing plant (from Area E)	1.38E-03	
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	6.31E-04	

Modelling Summary Table - Carbon monoxide

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.24E-01	2.40	458.0	731	0.30	33.95	3.50

Modelling Summary Table - Nitrogen oxides

Source ID	Description	X Coord.	Y Coord.	Emission Rate	Flow rate	Temp		Diameter	Velocity	Release Height
		(m)	(m)	(g/s)	(m^3/s)	(deg C)	(K)	(m)	(m/s)	(m)
P1	Diesel generators	64.0	526.0	2.06E+00	2.40	458.0	731	0.30	33.95	3.50

Modelling Summary Table - Sulphur dioxide

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	7.56E-04	2.40	458.0	731	0.30	33.95	3.50

Modelling Summary Table - Total Particulate (80% Control Efficiency)

Scenario 1 - Operation in 'North Area' (Areas A, B, C) only

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.30	33.95	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	4.94E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	5.16E-01	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-01	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	8.33E-02	5.75E-06
												P8b	Portable Secondary Crushing	8.33E-02	
												P9	Portable Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	1.03E+00	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-01	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-02	

Modelling Summary Table - Total Particulate (80% Control Efficiency)

Scenario 2 - Operations in North Area (Areas A, B, C) and South Area (Areas D, E)

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	4.94E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P12a	Aggregate transfer to crushing plant (in Area A)	5.16E-01	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-01	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	725	450	10	3,262,500	Suspended particulate matter	N/A - PM	P8a	Portable Primary Crushing	8.33E-02	5.95E-06
												P8b	Portable Secondary Crushing	8.33E-02	
												P9	Portable Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P12b	Aggregate transfer to crushing plant (in North Pit 2)	1.03E+00	
												P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-01	
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-02	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	7.74E-01	5.73E-06
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate	N/A - PM	P14a	Aggregate transfer to crushing plant (from Area E)	6.02E-01	6.69E-06
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-01	

Modelling Summary Table - Total Particulate (80% Control Efficiency)

Scenario 3 - Operations in North Area (Areas A, B, C - crushing/screening/transport of material off-site only) and South Area (Areas D, E - excavation)

PM80S3

Source ID	Description	X Coord. (m)	Y Coord. (m)	Emission Rate (g/s)	Flow rate (m^3/s)	Temp (deg C)	Temp (K)	Diameter (m)	Velocity (m/s)	Release Height (m)
P1	Diesel generators	64.0	526.0	4.99E-02	2.40	458.0	731	0.20	76.39	3.50

Source ID	Description	Source Type	X Coord. (m)	Y Coord. (m)	Release Height (m)	Length of Side (m)	Width of Side (m)	Depth (m)	Volume (m^3)	Contaminant	CAS #	Emission ID	Emission Source Description	Emission Rate (g/s)	Modelled Emission Rate ($g/s/m^2$)
AreaA	North Area (A)	Open Pit	223.20	175.37	4	600	400	10	2,400,000	Suspended particulate matter	N/A - PM	P2a	Truck Loading of Material at Active Face	2.67E-03	2.79E-06
												P2b	Truck Unloading of Aggregate to Crushing Plant	1.67E-02	
												P3a	Primary Crushing	1.00E-01	
												P3b	Secondary Crushing	1.00E-01	
												P4	Screening (Two Units)	1.83E-01	
												P5a	Conveyor Transfer Points (Primary to Secondary Crushing)	1.17E-02	
												P5b	Conveyor Transfer Points (Secondary Crushing to Screening)	1.17E-02	
												P6	Conveyor Transfer Points (Screening to Wash Screen)	1.17E-02	
												P7	Truck Loading of Material to Shipping Trucks	1.67E-02	
												P11	Aggregate Loading from Screening Plant to Storage Piles	8.67E-02	
												P15a	Product Shipping along Haul Road (portion below grade, Area A)	1.29E-01	
AreaBC	North Area (B and C)	Open Pit	871.85	257.23	4	750	450	10	3,375,000	Suspended particulate matter	N/A - PM	P15b	Product Shipping along Haul Road (portion below grade, Area B/C)	5.59E-01	1.66E-06
SLINE1	Haul Road	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P16	Unpaved Road-Product Shipping along Haul Road (portion outside Area B/C)	4.82E-02	
AreaD	South Area (D)	Open Pit	403.72	-406.24	4	300	450	10	1,350,000	Suspended particulate	N/A - PM	P14b	Aggregate transfer to crushing plant (from Area D)	7.74E-01	5.73E-06
AreaE	South Area (E)	Open Pit	121.38	-551.56	4	300	300	10	900,000	Suspended particulate matter	N/A - PM	P8a	Primary Crushing	8.33E-02	1.06E-05
												P8b	Secondary Crushing	8.33E-02	
												P9	Screening (Two units)	1.53E-01	
												P10a	Conveyor Transfer Points (Primary to Secondary Crushing)	9.72E-03	
												P10b	Conveyor Transfer Points (Secondary Crushing to Screening)	9.72E-03	
												P10c	Conveyor Transfer Points (Screening to Stackers)	9.72E-03	
												P14a	Aggregate transfer to crushing plant (from Area E)	6.02E-01	
SLINE2	30 Sideroad Crossing	Line	Modelled as a Line Source represented by Separate Volume Sources; length of side = 10 metres, vertical dimension = 2 metres							Suspended particulate matter	N/A - PM	P13	Aggregate transfer to crushing plant (across 30 Sideroad)	2.75E-01	

APPENDIX F

Dispersion Modelling Assessment

ELIMINATION OF METEOROLOGICAL ANOMALIES

Per MOECC "Air Dispersion Modelling Guideline for Ontario" (Version 2.0, March 2009), in modelling applications using regional or local meteorological data sets, certain extreme, rare and transient metrological conditions may be present in the data sets that may be considered outliers.

The listings of the ranked concentrations for each contaminant were retrieved from their respective model output file (only the top 80 are shown in the following pages).

The Lakes Environmental software has a 'MAXTABLE Viewer' with an option called "MOE Reg. 419/05 Discarded/Highest Values". This option was developed according to the Air Dispersion Modelling Guideline for Ontario (ADMGO), Canada, which states that the eight hours with the highest 1-hour average predicted concentrations in each single met year may be discarded. With a five year met file, this means that the Ontario MOECC will consider for compliance assessment the highest concentration after the elimination of these forty highest hours over the five year period from the modelling results. Note that repeat listings of the same hour should be treated as one hour eliminated. When this option is checked, the highest (discarded) 8 hours are highlighted in green and the final accepted value highlighted in red.

In each case, the compliance point has been block highlighted.

Rotating from Construction North Coord System
Rotating to True North Coord System

rotate -10 degree ccw [note: -ve ccw = cw]
= -0.175 rad

	Construction North Coord System			True North Coord System		
Point I.D.	x m	y m		x' m	y' m	Description
1	0.0	0.0		0.00	0.00	property line (574153.86E, 4882809.34N, Zone 17)
2	65.4	603.8		-40.44	605.98	property line
3	788.5	603.8		671.67	731.55	property line
4	792.3	630.8		670.73	758.80	property line
5	850.0	630.8		727.55	768.82	property line
6	896.2	1111.5		689.57	1250.24	property line
7	1234.6	1111.5		1022.83	1309.00	property line
8	1215.4	896.2		1041.31	1093.64	property line
9	1342.3	896.2		1166.28	1115.67	property line
10	1357.7	1073.1		1150.73	1292.56	property line
11	1553.8	1111.5		1337.18	1364.43	property line
12	1507.7	646.2		1372.58	898.19	property line
13	1511.5	646.2		1376.33	898.85	property line
14	1453.8	84.6		1417.02	335.76	property line
15	1403.8	84.6		1367.78	327.08	property line
16	1400.0	38.5		1372.05	281.02	property line
17	700.0	38.5		682.68	159.47	property line
18	719.2	0.0		708.27	124.89	property line
19	715.4	-23.1		708.54	101.48	property line
20	650.0	-619.2		747.65	-496.92	property line
21	-61.5	-619.2		46.96	-620.47	property line
22	-11.5	-219.2		26.74	-217.87	property line
23	226.9	-219.2		261.52	-176.47	property line
24	246.2	-23.1		246.47	20.00	property line
25	246.2	0.0		242.46	42.75	property line
26						
R1	1273.1	1073.0		1067.43	1277.77	
R2	1642.3	1111.5		1424.34	1379.80	
R3	1603.9	684.6		1460.65	952.71	
R4	1603.9	584.6		1478.02	854.23	
R5	1559.20	523.10		1444.68	785.91	
R6	1432.80	50.00		1402.35	298.04	
R7	1250.0	0.0		1231.01	217.06	
R8	1134.6	-19.2		1120.70	178.11	
R9	1076.9	-11.2		1062.48	175.97	
R10	215.4	-130.7		234.82	-91.31	
R11	46.20	-92.30		61.53	-82.88	
R12	-7.70	-669.2		108.62	-660.37	
R13	-61.50	657.60		-137.03	63.01	
R14	115.4	623.0		5.46	633.57	
R15	842.4	1026.9		651.28	1157.58	
R16	1069.30	1180.70		848.03	1348.44	
R17	461.50	42.30		447.14	121.80	
R18	326.90	-111.50		341.30	-53.04	
R19	1435.80	250.00		1370.57	495.53	

Trinity Consultants