FINAL REPORT

TROUT LAKE PIT

GORHAM TOWNSHIP, ONTARIO

AIR QUALITY ASSESSMENT

RWDI #1800123

March 17, 2021

SUBMITTED TO

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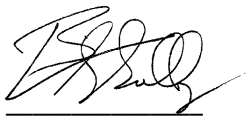
VERSION HISTORY

Index	Date	Pages	Author
1	October 6, 2017	All	Sarah Pellatt
2	March 17, 2021	Section 6, Section 8, Table 2 and Appendix C	Claire Finoro

REPORT SIGNATURES



Brian G. Sulley, B.A.Sc., P.Eng.

1 INTRODUCTION

RWDI was retained by Lempiala Sand & Gravel Ltd to conduct an air quality assessment in support of application for a site re-zoning and an Aggregate Resources Act (ARA) Class A, Category 1 license, with an annual extraction limit of up to 90,000 tonnes per year. This air quality assessment provides an estimate of emissions from operations at the proposed Trout Lake Pit (the Pit), and predicts impacts due to those emissions on nearby sensitive impact locations though a dispersion modelling analysis. The predicted impacts are then compared against the relevant provincial or federal air quality criteria. If predicted impacts are above the relevant criteria at nearby sensitive impact locations, mitigation measures are recommended, and the assessment is repeated. This process continues until predicted impacts are below the criteria. The recommendations will be incorporated into a Best Management Practices Plan (BMPP) for dust.

2 SITE DESCRIPTION & OPERATIONS

Trout Lake Pit is a proposed aggregate operation, to be operated under a Class A, Category 1 license (pit operations with excavation above the water table) under the Aggregate Resources Act (ARA). Operations at the proposed pit will consist of above water extraction of aggregate via loader, stockpiling and shipping, with an extraction capacity of 1,200 tonnes per day and 90,000 tonnes per year.

The North American Industrial Classification System NAICS code for the facility is 212323, Sand & Gravel Mining and Quarrying.

3 SENSITIVE IMPACT LOCATIONS

There are rural residences in the area near the Pit. Due to the nature of the sources of emission, potential receptor locations further from the site were not assessed, as impacts decrease rapidly with distance. The residential receptors considered in the assessment consist of one residence on the eastern side of Gilbride Road (Highway 591), three residences on the southern side of Trout Lake Road, as well as several residences on the northern side of Trout Lake Road.

The receptor locations are shown on Figure 1.

4 IDENTIFICATION OF CONTAMINANTS AND SOURCES

The primary contaminant of interest is airborne dust generated by operations at the site. The following key components of dust were modelled:

- Suspended particulate matter, which consists of particles with an aerodynamic diameter of 44 micrometres (μm) or less (known as TSP);

- Inhalable particulate matter, which consists of particles with an aerodynamic diameter of 10 micrometres (µm) or less (known as PM_{10}); and,
- Crystalline silica within the PM_{10} portion of the dust.

In addition to dust, on-site vehicles and heavy equipment also emit products of combustion. Nitrogen dioxide gas (NO_2), TSP, and PM_{10} were modelled as the key representatives of combustion products.

The potential sources of emissions in the Pit are as follows:

- Overburden stripping and rehabilitation operations;
- Extraction of gravel from the working face;
- Material handling operations (loading highway trucks at the extraction face for shipping);
- Equipment travel over unpaved surfaces (front end loaders and highway trucks); and,
- Tailpipe emissions from on-site vehicles and heavy equipment.

Figure 1 presents modelled source locations for operations in representative locations.

5 EMISSION ESTIMATION

Emissions were estimated in accordance with relevant guidance, using published emission factors. Detailed emission calculations are provided in the appendices to this report. The appendices contain details on assumptions, equipment types, sample calculations and other details that provide clarity as to RWDI's methodology. The emissions from sources that are wind-speed dependent (e.g., material handling) were calculated on an hour-by-hour basis, using the wind speed for each hour in the meteorological record. The emission values shown in the appendices for the wind-speed dependent emissions sources are example values, based on the average wind speed from the meteorological data.

6 DISPERSION MODELLING

The dispersion modelling was conducted to confirm that the proposed operations will be sufficient to control off-site impacts at the sensitive impact locations. The modelling was conducted in accordance with MOECC Guideline A11: Air Dispersion Modelling Guideline for Ontario, using the U.S. EPA AERMOD dispersion model. AERMOD assesses multiple sources of emissions at discrete off-site receptors, and is the current state-of-the-art regulatory model in Ontario.

Regional meteorological data obtained from the MOECC website were used within the model, in accordance with the MOECC's Guideline A11. Terrain information for the site was also obtained from the MOECC, in accordance with Guideline A11, but base elevations for sources within the site reflect the pit floor or appropriate elevations as provided by the proponent.

The model was run using the regulatory default options, without the addition of the dry depletion algorithms for particulate matter. The AERMOD model produced 1-hour and 24-hour average concentrations, as appropriate for each contaminant. The Oxygen Limiting Method (OLM) was used to convert NO_x to NO_2 and 99th percentile O_3 concentrations were conservatively assumed.

7 LOCAL EMISSION SOURCES

Environment Canada's National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases. Data for 2015 (the most recent available at the time of this report) was reviewed for locally significant emission sources that would have similar emission profiles to the Quarry. There are no facilities reporting emissions to NPRI within five (5) kilometres of the Pit.

Aerial photography for the area was also reviewed, along with the Ministry of Natural Resources and Forestry Pits and Quarries Online tool. There are 9 licensed sites located within five (5) kilometres of the Pit, but none reported emissions to the NPRI. The following facilities are in close proximity to the proposed Pit, and recent (June 2017) aerial photography suggests that these sites are currently active.

- Gilbride Road Pit, licensed to Laatu General Contracting Limited. This site is licensed to extract a maximum of 20,000 tonnes per year;
- Meredith Pit, licensed to Lempiala Sand and Gravel Limited. This site is licensed to extract a maximum of 20,000 tonnes per year;
- Old Hall Rd Pit, licensed to Nadin Contracting Ltd. The maximum extraction limit of this site is unknown;
- Nakfoor Pit, licensed to Lempiala Sand and Gravel Limited. The maximum extraction limit of this site is unknown;
- Tikkonen Pit, licensed to Lempiala Sand and Gravel Limited. The maximum extraction limit of this site is unknown; and,
- Hoxel Road Pit and Quarry, licensed to 1621748 Ontario Ltd. The maximum extraction limit of this site is unknown.

The location for each of these facilities is shown on Figure 2.

These sites are predominantly located from the northeast to the southwest of the proposed Trout Lake Pit. The Meredith Pit is the nearest active operation; located approximately one kilometer southeast of the Trout Lake Pit location. Most of the other active sites are located at a distance of three to five kilometers from the proposed Trout Lake Pit.

8 BACKGROUND AIR QUALITY DATA

This assessment considered the impact of emissions from the proposed extension and existing Pit in combination with background contaminant levels from other sources in the surrounding area. Data from stations in the MECP monitoring network were reviewed, with a focus on the stations nearest to the site, and stations that may reflect a similar level of land use patterns and regional air quality sources.

Since impacts from these types of operations decrease rapidly with distance, RWDI believes that the adoption of a suitable background air quality level will provide a sufficient estimate of cumulative impacts.

For the purposes of this assessment, ambient monitoring data from the MECP Thunder Bay station (#63203) was used to represent background concentrations. This particular station represents a reasonably conservative background level, as it is located within the City of Thunder Bay, adjacent to an industrial area. The ambient concentrations at this location would be expected to be higher than they would be at a rural location, dominantly comprised of forested land.

Table 1 summarizes air quality background data in the study area. TSP and PM_{10} were estimated from station measured $PM_{2.5}$ data using factors derived from the analysis of extensive monitoring data from other sites, as presented by the 2004 report by Lall et. al.[1]. Silica was estimated using published data for cities in the northeast U.S.[2].

The 90th percentile concentration from the background monitoring data was used in the cumulative effects assessment. This represents the highest background concentration that could reasonably be expected to coincide with maximum impacts from existing operations in the area.

9 RESULTS

The results of the assessment are presented in Table 2.

Maximum predicted concentrations from the proposed Trout Lake Pit were below the relevant criteria for all contaminants at the nearby receptors.

When the 90th percentile background concentration from the Thunder Bay ambient monitoring station was added to the predicted Trout Lake impacts, the cumulative concentrations continue to be below the relevant criteria for all contaminants at nearby receptors. Therefore, the Trout Lake Pit does not pose a significant impact, with appropriate mitigation measures in place.

10 RECOMMENDATIONS

This assessment is based on the following recommendations:

- Dust will be mitigated on site;
- Water or another provincially approved dust suppressant will be applied to internal haul roads as often as required to mitigate dust;

[1] Lall, R., M. Kendall, K. Ito and G. D. Thurston (2004). Estimation of Historical Annual $PM_{2.5}$ Exposures for Health Effects Assessments, Atmos. Env., 38, pp. 5217-5226.
[2] United States Environmental Protection Agency (1996). Ambient Levels and Noncancer Health effects of Inhaled Crystalline Silica and Amorphous Silica: Health Issue Assessment. EPA/600/R-95-115.

- A speed limit of 20 km/h shall be posted near the site entrance. Haul truck and highway truck operators will be directed to observe the speed limit;
- An earthen berm will be installed along the northeastern edge of the property, between the Trout Lake Pit and the residences along Trout Lake Road; and,
- A 30-meter-wide tree screen will be maintained along the northeastern edge of the property, between the Trout Lake Pit and the residences along Trout Lake Road.

11 CONCLUSIONS

The results in Table 2 indicate that operations at the Trout Lake Pit do not pose a significant impact relative to existing conditions, with appropriate mitigation measures in place. Furthermore, potential impacts from the Trout Lake Pit by itself are within the appropriate guideline levels.

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TABLES

Table 1: Ambient Air Quality Data

Project 1800123

Data from MOECC Thunder Bay Station (Station ID #63203)

Year	TSP [1]		PM10 [1]		Silica [2]	PM2.5		NO2 [3]				O3 [3]					
	90th Percentile 24-hour	Annual Average	90th Percentile 24-hour	Annual Average	90th Percentile 24-hour	90th Percentile 24-hour	Annual Average	90th Percentile 1-Hour		Annual Average		90th Percentile 1-Hour		Maximum 1-hour		Annual Average	
	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(ppb)	(µg/m³)	(ppb)	(µg/m³)	(ppb)	(µg/m³)	(ppb)	(µg/m³)	(ppb)	(µg/m³)
2013	40	21	22	12	1.3	12	6.3	15	30	7.3	14	42	87	63	130	26.3	54
2014	43	22	24	12	1.4	13	6.6	18	36	7.8	15	36	74	70	145	23.4	48
2015	37	22	20	12	1.2	11	6.5	16	32	7.5	15	39	81	62	128	24.0	50
2016	30	16	17	9	1.0	9	4.9	15	30	7.1	14	36	74	62	128	23.2	48
2017	33	17	19	9	1.1	10	5.1	14	28	6.7	13	37	76	51	105	23.4	48
Average	**37**	**20**	**20**	**11**	**1.0**	**11**	**6**	**16**	**31**	**7**	**14**	**38**	**78**	**62**	**127**	**24**	**50**

Notes:

[1] Estimated from PM2.5 measurements using published factors (Lall, et al., 2004)

[2] Estimated as 6% of PM10, from published data for cities in the northeast US (U.S. EPA, 1996)

[3] Conversion from ppb to µg/m³ based on 10ºC.

Table 2: Emission Summary Table - Cumulative Effects Analysis

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data: 1827

Relevant Criteria:

TSP	120	µg/m³ AAQC
PM10	50	µg/m³ Interim AAQC
Silica	5	µg/m³ AAQC
NO2	400	µg/m³ 1-Hour AAQC
	200	µg/m³ 24-Hour AAQC

Background Concentrations from MECP Thunder Bay Station (#63203)

TSP - 90th Percentile	37	µg/m³ (24-hour)
PM10 - 90th Percentile	20	µg/m³ (24-hour)
Silica - 90th Percentile	1.0	µg/m³ (24-hour)
NO2 - 90th Percentile	31	µg/m³ (1-hour)
	12	µg/m³ (24-hour)
O3 - 90th Percentile	78	µg/m³ (1-hour)
O3 - Maximum	127	µg/m³ (1-hour)

Receptor		UTM Coordinates		Contaminant	Averaging Period	With No Background Concentration				With Additional Background Concentrations			
ID	Type	X (m)	Y (m)		(hours)	Maximum Predicted 24-Hour Concentration (µg/m³)	Percentage of Revelant Criteria (%)	Number of Predicted Excursions Above Criteria over 5 Years	Frequency of Predicted Excursions Above Criteria (%)	Maximum Predicted 24-Hour Concentration (µg/m³)	Percentage of Revelant Criteria (%)	Number of Predicted Excursions Above Criteria over 5 Years	Frequency of Predicted Excursions Above Criteria (%)
R1	Residence	324,610	5,387,760	TSP	24	46	38%	0	0.0%	83	69%	0	0.0%
				PM10	24	13	25%	0	0.0%	33	65%	0	0.0%
				Silica	24	2	40%	0	0.0%	3	60%	0	0.0%
				NO2	1	151	38%	0	0.0%	182	45%	0	0.0%
					24	18	9%	0	0.0%	31	15%	0	0.0%
R2	Residence	324,684	5,387,684	TSP	24	27	23%	0	0.0%	64	53%	0	0.0%
				PM10	24	7	15%	0	0.0%	27	55%	0	0.0%
				Silica	24	1	24%	0	0.0%	2.2	44%	0	0.0%
				NO2	1	124	31%	0	0.0%	155	39%	0	0.0%
					24	7	3%	0	0.0%	19	10%	0	0.0%
R3	Residence	324,388	5,387,038	TSP	24	8	7%	0	0.0%	45	38%	0	0.0%
				PM10	24	2	4%	0	0.0%	22	44%	0	0.0%
				Silica	24	0.4	7%	0	0.0%	1.4	27%	0	0.0%
				NO2	1	13	3%	0	0.0%	44	11%	0	0.0%
					24	1	0%	0	0.0%	13	7%	0	0.0%
R4	Residence	324,384	5,388,087	TSP	24	4	4%	0	0.0%	41	35%	0	0.0%
				PM10	24	1	2%	0	0.0%	21	42%	0	0.0%
				Silica	24	0.2	4%	0	0.0%	1.2	24%	0	0.0%
				NO2	1	21	5%	0	0.0%	52	13%	0	0.0%
					24	1	1%	0	0.0%	14	7%	0	0.0%
R5	Residence	324,462	5,388,061	TSP	24	6	5%	0	0.0%	43	36%	0	0.0%
				PM10	24	2	3%	0	0.0%	22	43%	0	0.0%
				Silica	24	0.3	6%	0	0.0%	1.3	26%	0	0.0%
				NO2	1	19	5%	0	0.0%	50	12%	0	0.0%
					24	1	1%	0	0.0%	13	7%	0	0.0%
R6	Residence	324,489	5,388,029	TSP	24	8	6%	0	0.0%	45	37%	0	0.0%
				PM10	24	2	4%	0	0.0%	22	44%	0	0.0%
				Silica	24	0.3	7%	0	0.0%	1.3	27%	0	0.0%
				NO2	1	21	5%	0	0.0%	52	13%	0	0.0%
					24	1	1%	0	0.0%	14	7%	0	0.0%
R7	Residence	324,547	5,387,982	TSP	24	11	9%	0	0.0%	48	40%	0	0.0%
				PM10	24	3	6%	0	0.0%	23	46%	0	0.0%
				Silica	24	0.5	9%	0	0.0%	1.5	29%	0	0.0%
				NO2	1	39	10%	0	0.0%	70	17%	0	0.0%
					24	2	1%	0	0.0%	14	7%	0	0.0%
R8	Residence	324,578	5,387,928	TSP	24	14	12%	0	0.0%	51	42%	0	0.0%
				PM10	24	4	8%	0	0.0%	24	48%	0	0.0%
				Silica	24	0.6	12%	0	0.0%	1.6	32%	0	0.0%
				NO2	1	58	15%	0	0.0%	89	22%	0	0.0%
					24	3	1%	0	0.0%	15	8%	0	0.0%
R9	Residence	324,634	5,387,880	TSP	24	17	14%	0	0.0%	54	45%	0	0.0%
				PM10	24	5	9%	0	0.0%	25	49%	0	0.0%
				Silica	24	0.8	15%	0	0.0%	1.8	35%	0	0.0%
				NO2	1	62	16%	0	0.0%	93	23%	0	0.0%
					24	4	2%	0	0.0%	16	8%	0	0.0%

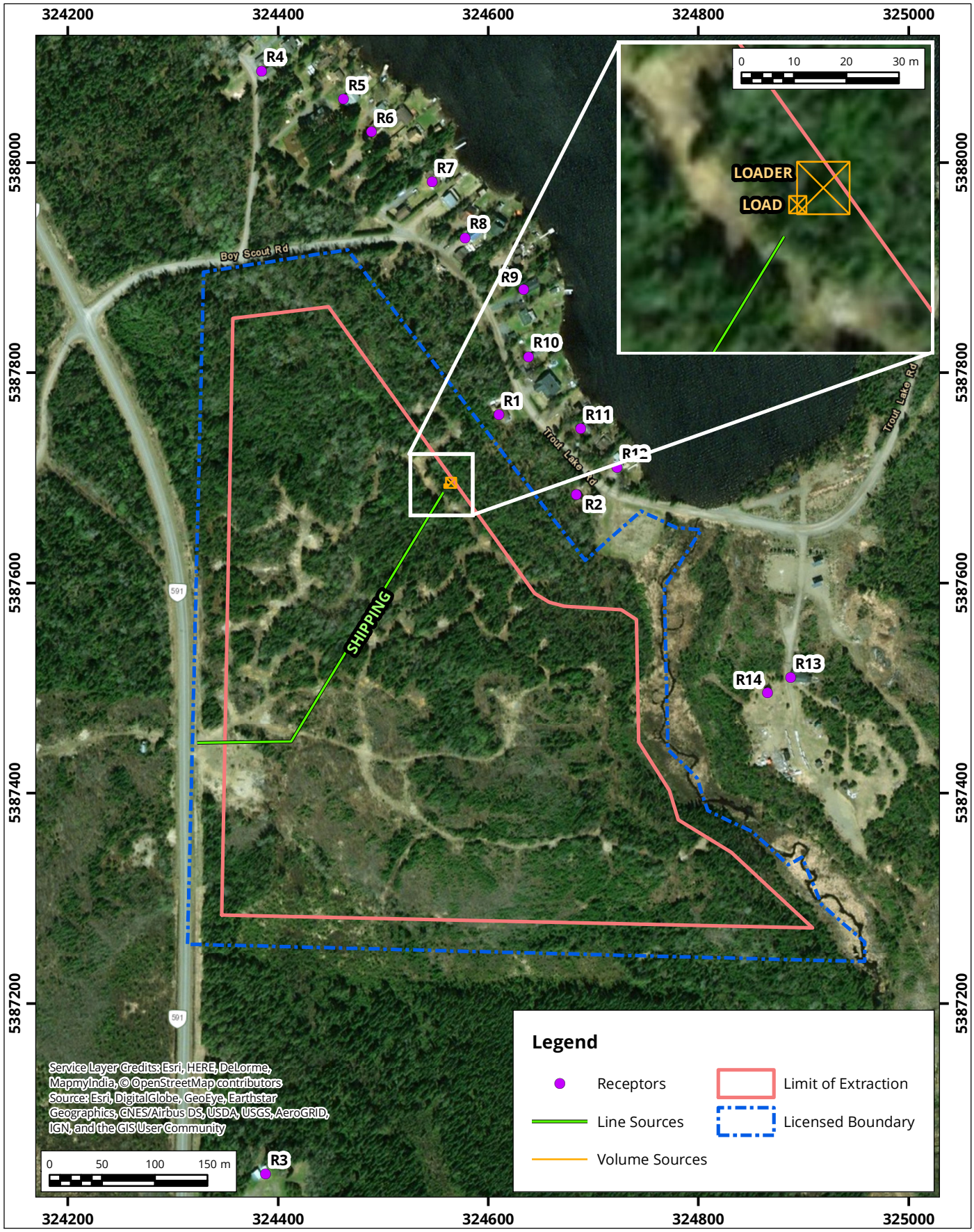
Receptor		UTM Coordinates		Contaminant	Averaging Period	With No Background Concentration				With Additional Background Concentrations			
ID	Type	X (m)	Y (m)		(hours)	Maximum Predicted 24-Hour Concentration (µg/m³)	Percentage of Revelant Criteria (%)	Number of Predicted Excursions Above Criteria over 5 Years	Frequency of Predicted Excursions Above Criteria (%)	Maximum Predicted 24-Hour Concentration (µg/m³)	Percentage of Revelant Criteria (%)	Number of Predicted Excursions Above Criteria over 5 Years	Frequency of Predicted Excursions Above Criteria (%)
R10	Residence	324,638	5,387,816	TSP	24	25	21%	0	0.0%	62	52%	0	0.0%
				PM10	24	7	14%	0	0.0%	27	54%	0	0.0%
				Silica	24	1.1	22%	0	0.0%	2.1	42%	0	0.0%
				NO2	1	119	30%	0	0.0%	150	38%	0	0.0%
					24	7	3%	0	0.0%	19	10%	0	0.0%
R11	Residence	324,688	5,387,747	TSP	24	26	22%	0	0.0%	63	52%	0	0.0%
				PM10	24	7	14%	0	0.0%	27	54%	0	0.0%
				Silica	24	1.1	22%	0	0.0%	2.1	42%	0	0.0%
				NO2	1	127	32%	0	0.0%	158	40%	0	0.0%
					24	7	4%	0	0.0%	20	10%	0	0.0%
R12	Residence	324,723	5,387,710	TSP	24	21	17%	0	0.0%	58	48%	0	0.0%
				PM10	24	6	11%	0	0.0%	26	51%	0	0.0%
				Silica	24	0.9	18%	0	0.0%	1.9	38%	0	0.0%
				NO2	1	92	23%	0	0.0%	123	31%	0	0.0%
					24	5	2%	0	0.0%	17	9%	0	0.0%
R13	Residence	324,888	5,387,510	TSP	24	9	8%	0	0.0%	46	38%	0	0.0%
				PM10	24	2	5%	0	0.0%	22	45%	0	0.0%
				Silica	24	0.4	8%	0	0.0%	1.4	28%	0	0.0%
				NO2	1	28	7%	0	0.0%	59	15%	0	0.0%
					24	2	1%	0	0.0%	14	7%	0	0.0%
R14	Residence	324,866	5,387,495	TSP	24	10	8%	0	0.0%	47	39%	0	0.0%
				PM10	24	3	5%	0	0.0%	23	45%	0	0.0%
				Silica	24	0.4	8%	0	0.0%	1.4	28%	0	0.0%
				NO2	1	31	8%	0	0.0%	62	15%	0	0.0%
					24	2	1%	0	0.0%	14	7%	0	0.0%

Notes:

Values in bold indicate excursions above the relevant crtieria

[1] Conservatively, maximum O_3 concentration was used when calculation hourly NO_2 concentrations using OLM method. Total conversion was used for 24 hour NO_2 concentrations.

FIGURES



Site Plan Showing Significant Sources, Limit of Extraction, and Property Line

Map Projection: NAD 1983 UTM Zone 16N

Trout Lake Pit - Trout Lake, Ontario

True North

Project #: 1800123

Drawn by: DJH	Figure: 1
Approx. Scale:	1:5,000
Date Revised:	Oct 10, 2017

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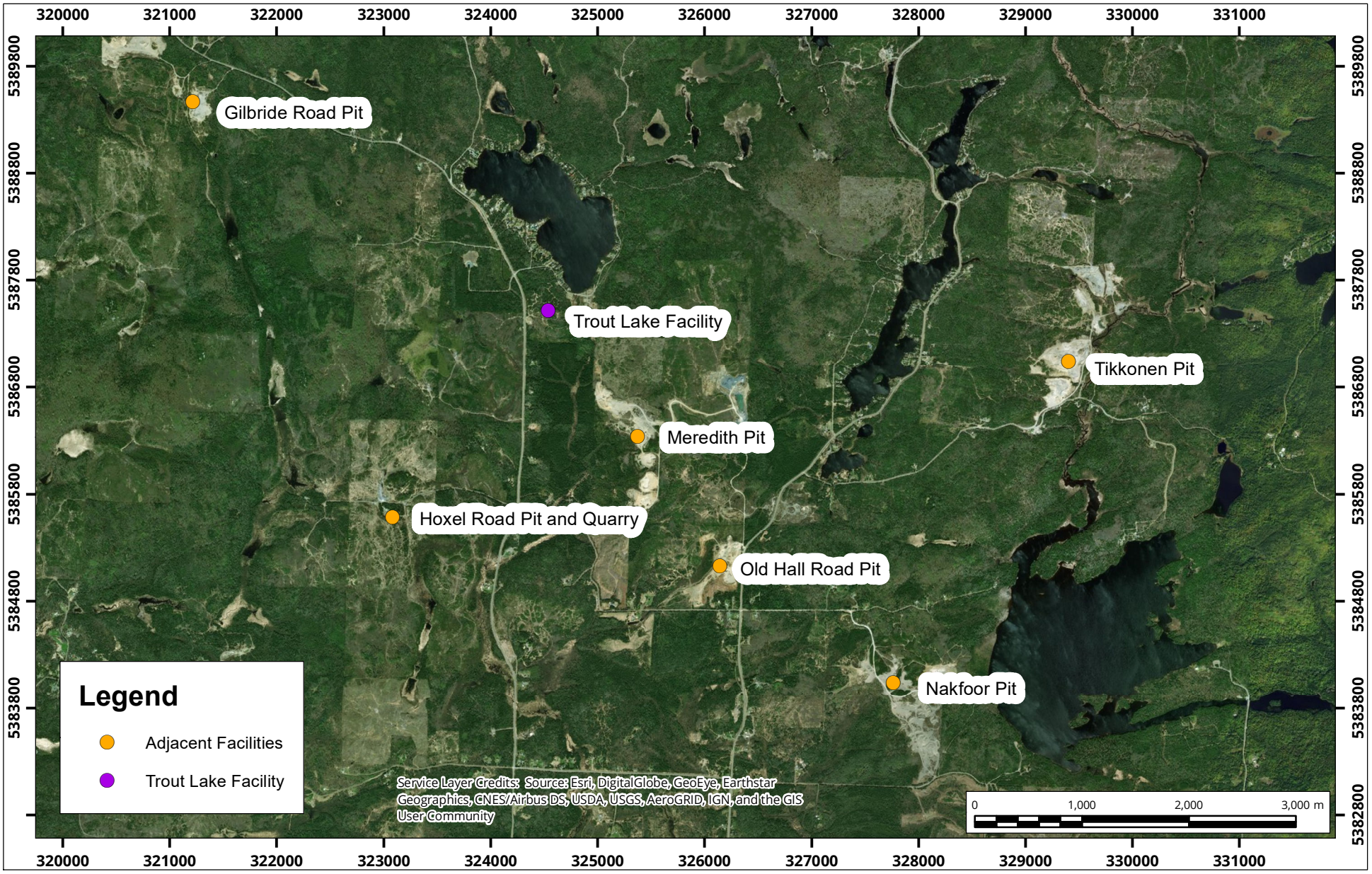


Operating Pits in the Vicinity of Trout Lake Pit

True North

Objective / Threshold Note

Map Projection: NAD 1983 UTM Zone 16N

Trout Lake Pit - Trout Lake, Ontario

Project #: 1800123

Drawn by: ACS	Figure: 2
Approx. Scale:	1:50,000
Date Revised:	Oct 6, 2017

Map Document: \\rwdgroup.net\Guelph\Jobs_2\1800123\4. Analysis\GIS\1800123_Trout_Lake_Pit - AQ Figure-buildings.mxd

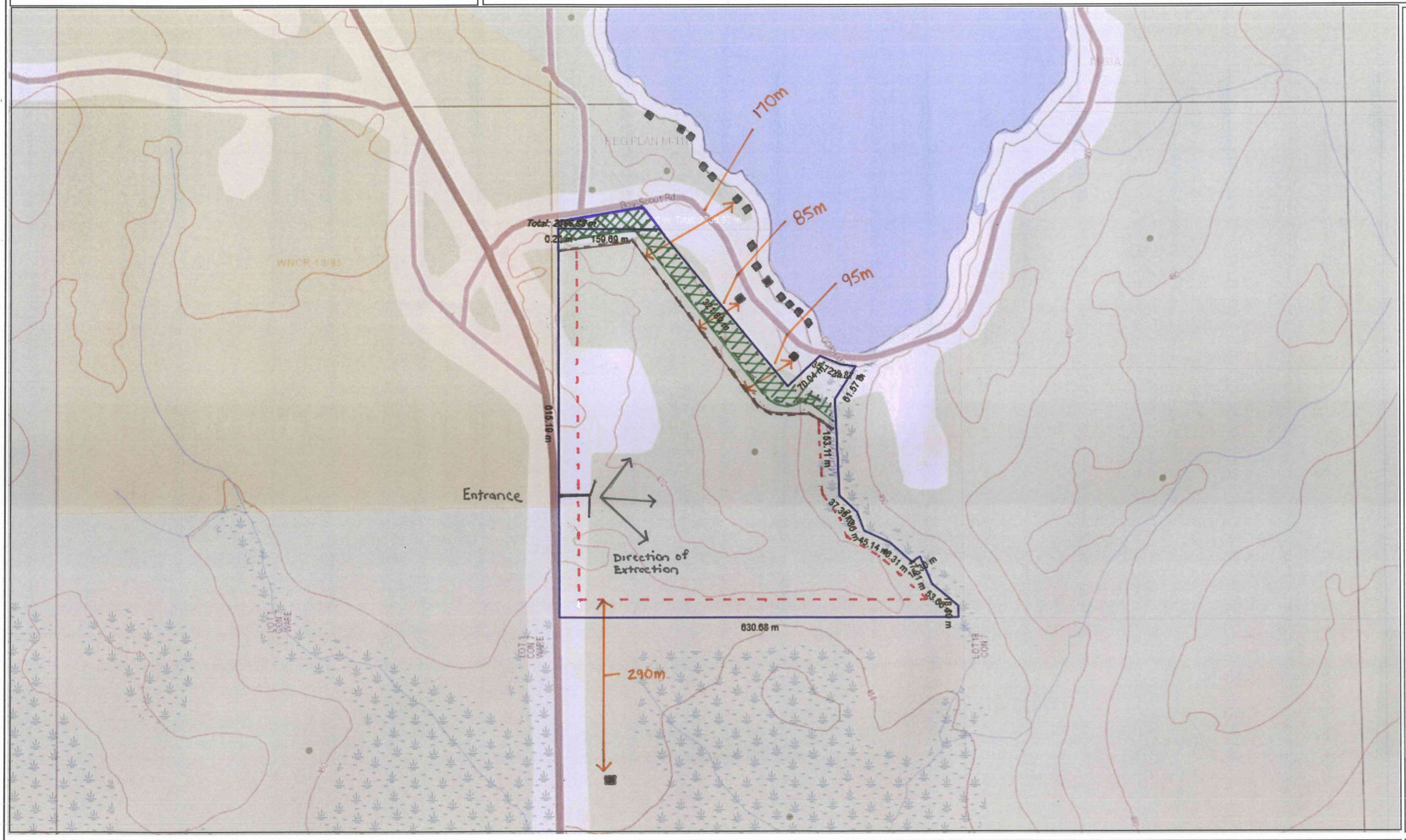
APPENDIX A

Ontario

MINISTRY OF NORTHERN DEVELOPMENT AND MINES
CLAIMaps

LAKEHEAD RURAL PLANNING BOARD

Notes: Lempiala Sand & Gravel Limited
Application to Amend Zoning By-Law



Legend

Administration Boundaries
- Mining Divisions
- Resident Geologist District
- Townships and Areas
- UTM Grid
- Geographic Lot Fabric
- Other Federal Land

Mineral Tenure Grid
- OMTG Tenure Grid

Alienations
- Withdrawal
- Notice

Unpatented Claim
- Active
- Reconciled
- Pending

Disposition
- Disposition

Disposition Symbols
- Camp
- Disposition Unknown/Pending
- Freehold Patent Mining Rights Only
- Freehold Patent Surface Rights Only
- Freehold Patent Surface and Mining Rights
- Land Use Permit
- Leasehold Patent Mining Rights Only
- Leasehold Patent Surface Rights Only
- Leasehold Patent Surface and Mining Rights
- License of Occupation Mining Use Only
- License of Occupation Surface Use Only
- License of Occupation Surface and Mining Rights
- License of Occupation Uses Not Specified
- Order in Council
- Tower
- WPLA

Geology Layers
- AMIS Sites
- AMIS Features
- Drill Holes
- Mineral Occurrences

TROUT LAKE PIT

LEGEND

Licence Boundary –

30m Setback –

30m Tree Buffer –

15m Earth Berm –

Residential Dwelling –

Notes:
- All dimensions and locations of features are approximate

0 0.3 km

Projection: Web Mercator

N

APPENDIX B

Appendix B1: Bulk Material Handling Emissions Spreadsheet

Trout Lake Pit

Project #1800123

AGGREGATE HANDLING AND STORAGE PILES - AP-42 Section 13.2.4

Average recorded hourly wind speed (m/s): 3.7
(used for sample calculations & factor validation)

Silica Content of Material = 17%

Material handling emissions: $E = 0.0016\ k\ (U / 2.2)^{1.3} / (M / 2)^{1.4}$

E emission factor
k particle size multiplier (0.8, 0.35 and 0.053 for TSP, PM_{10} and $PM_{2.5}$) [3]
U mean wind speed, meters per second (m/s)
M material moisture content (%)

Source ID [1]	Description	Processing Rate			Site Data				Base AP-42 Emission Factor		Base Emission Rate			Additional	Final Controlled Emission Rate at 3.7 m/s					
		Hourly (Mg/h)	Daily (Mg/d)	Annual (Mg/y)	Site Specific Data? (y/n)	Silt Content (%)	Moisture Content (%)	Source Conditions Valid [2]	TSP (kg/Mg)	PM_{10} (kg/Mg)	TSP (g/s)	PM_{10} (g/s)	Silica (g/s)	Control Efficiency Applied (%)	TSP (g/s)	Data Quality Rating	PM_{10} (g/s)	Data Quality Rating	Silica (g/s)	Data Quality Rating
Load	Loader drop of material into haul truck	133	1,200	90,000	n	3.9%	2.1%	valid	2.3E-03	1.0E-03	8.7E-02	3.8E-02	6.5E-03		8.7E-02	B	3.8E-02	B	6.5E-03	B

[1] ID corresponds to process flow diagram for facility and / or material
[2] Relates to AP-42 Section 13.2.4-4
[3] k-factor for TSP (PM44) scaled up logarithmically to 0.8 from published k-factor of 0.74 which refers to PM30.
[4] Silica emissions are based on the PM10 emission rate and the silica content percentage in the material.

Peak extraction rate based on the daily extraction rate as provided by Silvio Di Gregorio, Aug. 10, 2017. The hourly extraction rate was calculated based on a 9 hour working day (7:30 am to 4:30 pm). All material assumed to be loaded into a shipping vehicle via loader and immediately hauled off-site.

Moisture and silt values reflect default values from AP-42 Chapter 13.2.4. The mean values for "Various Limestone Products" from this document were used.

Silica emissions based on "PM4 Crystalline Silica and PM10 Particulate Matter Emission Factors for Aggregate Producing Sources", Richards and Brozell, Air Control Techniques, July 31, 2007. Equivalent to 17% of PM10 emissions

It is assumed that all material is loaded directly into trucks and immediately shipped off-site. This is the worst-case scenario in terms of site-wide impacts, as it results in the greatest number of vehicles on-site per day.

Sample calculation for uncontrolled TSP emission factor for Source Load: Loader drop of material into haul truck, at a sample wind speed of 3.7 m/s

EF = 0.0016 x (0.74) x ((3.7 m/s) / 2.2)^1.3 / ((2.1%) / 2)^1.4 2.3E-03 kg TSP / Mg handled

Sample calculation for TSP emission rate for Source Load: Loader drop of material into haul truck, at a sample wind speed of 3.7 m/s

$$\frac{133\ Mg_{handled}}{1\ h} \left| \frac{2.3E\text{-}03\ kg_{TSP}}{1\ Mg_{handled}} \right| \frac{1\ h}{3600\ s} \left| \frac{1000\ g_{TSP}}{1\ kg_{TSP}} \right| \frac{1\ g_{TSP\ uncontrolled}}{1\ g_{TSP}} = 8.7E\text{-}02\ g_{TSP} / s$$

Appendix B2: On-Site Mobile Equipment Emissions Spreadsheet - Fugitive Dust

Trout Lake Pit

UNPAVED ROAD SECTIONS - AP-42 Section 13.2.2
PAVED ROAD SECTIONS - AP-42 Section 13.2.1

Silica Content of Material = 17%

Paved Roads:	$E = k\ (sL)^{0.91}\ (W)^{1.02}$
Unpaved Roads - Industrial:	$E = 281.9\ k\ (s / 12)^{a}\ (W / 3)^{b}$
Unpaved Roads - Public:	$E = 281.9\ k\ (s / 12)^{a}\ (S / 30)^{d} / (M / 0.5)^{c} - C$

E particulate emission factor (g/VKT) — **W** average weight of the vehicles traveling the road (US short tons)
k particle size multiplier (see below) — **s** surface material silt content (%)
sL road surface silt loading (g/m^2) — **C** emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear

Route ID [1]	Route Description	Traffic Passes [2] Hourly (#/h)	Daily (#/d)	Annual (#/a)	Segment Length [2] (m)	Road Surface [3]	Roadway Type [4]	Mean Vehicle Speed (km/h)	(mph)	Average Vehicle Weight [5] (tons)	Surface Material Moisture Content [6] (%)	Surface Silt Content [7] (%)	Road Surface Silt Loading [8] (g/m^2)	ase AP-42 Emission Fact TSP (g/VKT)	PM_{10} (g/VKT)	Base Emission Rate TSP (g/s)	PM_{10} (g/s)	Silica [9] (g/s)	Additional Control Efficiency Applied (%)	Final Controlled Emission Rate TSP (g/s)	Data Quality Rating	PM_{10} (g/s)	Data Quality Rating	Silica (g/s)	Data Quality Rating
On-Site Mobile Equipment																									
Loader	Movement of Loader at Extraction Face	38	334	25000	10	Unpaved	Industrial	20	12	31		4.8%		2.1E+03	5.3E+02	2.2E-01	5.6E-02	9.5E-03		2.2E-01		5.6E-02		9.5E-03	
Shipping	Unpaved haul route for shipping trucks	12	108	8,100	367	Unpaved	Industrial	20	12	27		4.8%		2.0E+03	5.0E+02	2.4E+00	6.1E-01	1.0E-01		######		6.1E-01		1.0E-01	

Constants for Mobile Emission Equations

Roadway Type	Contaminant	k	a	b	c	d	Quality
Paved Roads:	**$PM_{2.5}$**	0.15	-	-	-	-	-
	PM_{10}	0.62	-	-	-	-	-
	TSP	3.23	-	-	-	-	-
Unpaved Roads - Industrial:	**$PM_{2.5}$**	0.15	0.9	0.45	-	-	C
	PM_{10}	1.5	0.9	0.45	-	-	B
	TSP	4.9	0.7	0.45	-	-	B
Unpaved Roads - Public:	**$PM_{2.5}$**	0.18	1	-	0.2	0.5	C
	PM_{10}	1.8	1	-	0.2	0.5	B
	TSP	6	1	-	0.3	0.3	B

Comments

Shipping Trucks based on a total of 5 trucks (3 triaxle and 2 tractor-trailers) each making one round trip every 50 minutes over a 9 hour workday, as provided by Silvio Di Gregorio, Aug. 10, 2017.

Loader trips per hour from the extraction face to the haul truck based on a loader bucket capacity of 7.2 tonnes, based on a heaped bucket capacity of 3.6 m3 from manufacturer's specs for CAT 966H wheel loader (smaller capacity of the two loader types potentially used on site) and a material density of 2.0 tonnes / m3, based on wet gravel.

Silt values for unpaved roads reflect mean values from AP-42.

Silica emissions based on "PM4 Crystalline Silica and PM10 Particulate Matter Emission Factors for Aggregate Producing Sources", Richards and Brozell, Air Control Techniques, July 31, 2007. Equivalent to 17% of PM10 emissions

0% control applied to unpaved roads based on watering.

All material was assumed to be loaded directly into trucks and immeadiately shipped off-site. This is the worst-case scenario in terms of site-wide impacts, as it results in the greatest number of vehicles on-site per day.

[1] Route ID numbers provided on site plan.
[2] Length of a specific road segment. A separate segment should be used whenever one or more parameters change.
[3] Paved surfaces include asphalt, concrete, and recycled asphalt (if it forms a relatively consistent surface).
[4] Publicly accessible and dominated by light vehicles, or industrial, and dominated by heavy vehicles.
[5] The average vehicle weight reflects the average of the empty and loaded vehicle weight, for travel in both directions.
[6] Required only for publicly accessible unpaved roads.
[7] Required only for unpaved roads (public and industrial).
[8] Required only for industrial paved roads.
[9] Silica emissions are based on the PM10 emission rate and the silica content percentage in the material.

Sample calculation for uncontrolled TSP emission factor for Source Loader: Movement of Loader at Extraction Face

EF = 281.9 x (4.9) x [(4.8% / 12)]^(0.7) x [(31 tons) / 3]^(0.45) = 2080 g TSP / vehicle kilometer travelled (vkt)

Sample calculation for TSP emission rate for Source Loader: Movement of Loader at Extraction Face

$$\frac{38\ \text{vehicles}}{1\ \text{h}} \left| \frac{10\ \text{m}}{} \right| \frac{1\ \text{km}}{1000\ \text{m}} \left| \frac{2080\ g_{TSP}}{1\ \text{vehicle km}} \right| \frac{1\ \text{h}}{3600\ \text{s}} \left| \frac{1\ g_{TSP\ uncontrolled}}{1\ g_{TSP}} \right. = 2.2\text{E-}01\ g_{TSP} / \text{s}$$

Appendix B3: Summary of Combustion Exhaust Emissions (Mobile and Stationary Sources)

Project #1800123

Trout Lake Pit

Source ID	Description	Gross Power Rating (kW)	Number Of Units	Traffic Passes [2] Hourly (#/h)	Traffic Passes [2] Daily (#/d)	Segment Length [3] (m)	Mean Vehicle Speed (km/h)	Load Factor [4] (%)	Tailpipe Emission Factor [5] TSP (g/vkt)	TSP (g/kW-h)	PM10 (g/vkt)	PM10 (g/kW-h)	NOx (g/vkt)	NOx (g/kW-h)	Tailpipe Emission Rate TSP (g/s)	Tailpipe Emission Rate PM10 (g/s)	Tailpipe Emission Rate NOx (g/s)	Tailpipe + Fugitive Emission Rate [6] TSP (g/s)	Tailpipe + Fugitive Emission Rate [6] PM10 (g/s)	Tailpipe + Fugitive Emission Rate [6] NOx (g/s)
On-Site Mobile Equipment																				
Loader	Movement of Loader at Extraction Face	201.3	1	38	334	10	20	59%		0.54		0.54		9.2	1.8E-02	1.8E-02	3.0E-01	2.4E-01	7.4E-02	3.0E-01
Shipping	Unpaved haul route for shipping trucks	n/a	5	12	108	367	20		2.10		2.10		23.50		2.6E-03	2.6E-03	2.9E-02	2.4E+00	6.1E-01	2.9E-02

[1] ID should reflect Source ID or Route ID, as appropriate.
[2] Where applicable, this value reflects travel in both directions (e.g., 1 round-trip = 2 passes)
[3] Length of a specific road segment. A separate segment should be used whenever one or more parameters change.
[4] Load Factors from "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling", EPA-420-R-10-016, NR-005d, July 2010
[5] Emissions are input on either a vehicle distance or power rating basis. Load factor applies only to emissions based on power ratings.
[6] Applicable only for TSP, PM10 and PM2.5 emissions from mobile equipment. Emissions rates for NOx and stationary sources do not change.

Comments
Tailpipe emission factors for highway trucks is based on U.S. EPA MOVES output.
Loader assumed to be Tier 1 Compliant.
TSP and PM2.5 Emissions assumed to be equal to PM10 emissions unless otherwise noted.

Sample Calculations

Pit Loader Exhaust TSP Emissions: (Source: "Loader")

$$\frac{201.3\ \text{kW}}{1\ \text{kW h}} \times \frac{0.54\ \text{g}}{} \times \frac{59\%\ \text{Load}}{} \times \frac{1\ \text{h}}{3600\ \text{s}} = 1.8\text{E-}02\ g_{TSP}/\text{s}$$

Highway Truck Exhaust TSP Emissions: (Source: "Shipping")

$$\frac{12\ \text{Vehicles}}{1\ \text{h}} \times \frac{367\ \text{m}}{} \times \frac{2.10\ \text{g}}{1\ \text{Veh. Km}} \times \frac{1\ \text{km}}{1000\ \text{m}} \times \frac{1\ \text{h}}{3600\ \text{s}} = 2.6\text{E-}03\ g_{TSP}/\text{s}$$

Appendix B4: Dispersion Modelling Parameters for All Sources

Project #1800123

Trout Lake Pit

Suggested Volume and Line Source Model Parameters

ID	Description	Base Elevation	Release Height	Physical or Drop Height	Physical Width or Length of Side	Initial Lateral Dimension	Elevated or Surface Based	On or Adjacent to Building?	Vertical Dimension or Building Height	Initial Vertical Dimension	Comments
Material Handling Sources											
Load	Loader drop of material into haul truck	462.5	4	3	3.3	0.77	elevated	no	4	0.93	Bucket width = 3.3 m (average), drop height = 3m, release height = 4m, truck height = 3m
Mobile Sources											
Loader	Movement of Loader at Extraction Face	462.5	3.7	3.7	10	2.33	surface	yes	3.7	1.72	loader height = 3.7 m (average), single volume source encompassing activity at extraction face (assumed 10m square area)
Shipping	Unpaved haul route for shipping trucks	462.5	3	3	6	1.4	surface	yes	3	1.4	truck height assumed to be 3 m, road assumed to be 2 lanes, width of 6m

APPENDIX C

BRIAN SULLEY, B.A.SC., P.ENG.

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Brian is a Technical Director and Principal whose air quality emissions and dispersion modelling work, as well as his chemical process quantitative risk analysis work, has benefitted our clients in almost every industrial and institutional sector served by RWDI. Brian's experience includes heavy industry such as mining, aggregate extraction, hot mix asphalt production, cement plants, pulp and paper mills, petrochemical facilities, and automotive production, through to institutional facilities such as hospitals and universities. Brian's experience in chemical process quantitative risk analysis spans his work with his previous employer in the chemical process industry and with RWDI. His work in chemical process engineering provides a strong foundation for both his air quality and risk assessment work.

Brian sits on the Board of the Ontario Section of the Air & Waste Management Association and is an active member with the Ontario Environmental Industry Association. Brian also sits on the Environment Committee of the Ontario Stone Sand and Gravel Association, providing guidance and training to members on fugitive dust management and control and regulatory compliance requirements.

In addition to working directly with clients to meet air quality objectives and comply with regulations, Brian acts as a technical lead for our Air Quality modelling group, coaching and mentoring scientists and engineers across Canada at work on a range of emissions inventory, monitoring and modelling projects.

Employment History

2001 – Present
Technical Director – Air Quality, Principal, RWDI

2016 – Present
Instructor: Air and Water Quality Analysis, Environmental Building Science Program, Conestoga College

2003 – Present
Instructor: Introduction to Air Quality, Environmental Engineering Applications Program, Conestoga College

2011 – 2018
Instructor: Air Pollution Control, Environmental Control Program, Sheridan College

1999 – 2001
Process Engineering Associate, Huntsman Corporation Canada Inc.

Affiliations

A&WMA - Air & Waste Management Association

OSSGA – Ontario Stone Sand and Gravel Association

Ontario Air Practitioners Group.

Licensed Professional Engineer (P.Eng.) Professional Engineers of Ontario

Licensed Professional Engineer (P.Eng.) Association of Professional Engineers and Geoscientists of Saskatchewan

Licensed Professional Engineer (P.Eng.) Association of Professional Engineers of Nova Scotia

Education

Bachelor of Applied Science (Environmental [Chemical] Engineering), University of Waterloo, 2000

Courses

Controlling Dust from Process Equipment. Ontario Agri Business Association

Evolution of the Ontario Approvals Process. Ontario Association of Physical Plant Administrators

Emission Sources, From Boilers to Bulldozers. A&WMA Ontario Section

Emission Estimation & Data Quality, Good Emissions Data Makes for Good Decisions. A&WMA Ontario Section

Controlling Fugitive Dust. OSSGA Bi-Annual Environmental Management Workshop

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Selected Project Experience

Hearings

- Albion Hills Automotive, Palgrave, ON, (OMB File PL070637)
- Crestwood Subdivision OMB Appeal, London, ON (OMB File PL080059)
- SASE Aggregates Ltd., Uxbridge, ON (OMB File PL160852)
- Blythe Holsteins Ltd., Municipality of Thames Centre, ON (LPAT File PL161154)
- Atlantic Power Corporation, Williams Lake, BC (EAB file 2016-EMA-G05)
- Colacem Canada Inc., Township of Champlain, ON (LPAT File PL170756)
- James Dick Construction Limited, Township of Guelph-Eramosa, ON (LPAT File PL170688)
- C. H. Demill Holdings Inc., Township of Tyendinaga (LPAT File MM180027)
- Halton Crushed Stone, Town of Erin, ON (LPAT File MM190008)
- Zircon Design and Development Inc., Toronto, ON Hearing of Necessity under the Expropriations Act.
- MJJJ Developments Inc., Town of Caledon, ON (LPAT File PL190106, PL190107)
- RioTrin Properties (Burnhamthorpe) Inc., Mississauga, ON (LPAT File PL190221, PL190222)

Land-Use Planning Air Quality Assessments

- Dundas & Shorncliffe, Toronto, ON
- 328-374 Dupont Street, Toronto, ON
- 6 Lloyd Avenue, Toronto, ON
- Riverside Waste Transfer Facility, Centre, Wellington, ON
- Thorold Park Redevelopment, Thorold, ON
- Portage Rd. Development, Niagara Falls, ON
- Niagara Stone Rd. Development, Niagara-on-the-Lake, ON
- Hansler Rd. Development, Thorold, ON
- Active Wellness Products, London, ON
- Portuguese Cheese, Toronto, ON
- 250 Front Street East Redevelopment, Toronto, ON
- 771 Yonge Street Redevelopment, Toronto, ON
- 176-178 Front Street Redevelopment, Toronto, ON
- 225 Birmingham Street Redevelopment, Toronto, ON
- 933-935 Queensway Redevelopment, Toronto, ON
- 5507-5509 Dundas Street Redevelopment, Toronto, ON
- Xinyi Glass Canada, Guelph Eramosa Township, ON
- Xinyi Glass Canada, Stratford, ON

Federal Government

- Cliff Hill Central Heating Plant, Ottawa, ON
- Revision to NPRI Welding Emission Factors, Gatineau, PQ

Industrial Facilities

- Arcelor Mittal Hamilton East Works, Hamilton, ON
- Ar-Razi Methanol Plant, Jubail, Kingdom of Saudi Arabia
- Enbridge Gas Storage and Transfer Operations, ON
- Fiat Chrysler, Multiple Sites, ON
- General Motors of Canada Limited, Multiple Sites, ON
- NOVA Chemicals, Corunna, Sarnia & St. Clair, ON
- Resolute Iroquois Falls Mill, Iroquois Falls, ON
- Resolute Thunder Bay Mill, Thunder Bay, ON
- Sithe Energy, Mississauga and Brampton, ON
- Stelco, Hamilton & Nanticoke, ON

Transportation / Roadway Air Quality

- Widening of the QEW, Oakville, ON
- North Channel Seaway Bridge, Cornwall, ON
- Bluewater Bridge, Sarnia, ON
- Widening of Highway 417, Ottawa, ON
- Widening of Highway 69 North of Parry Sound, ON
- Jebel Ali Airport, Dubai, UAE
- GO Milton Expansion, ON
- Metrolinx Network Expansion, ON

Odour Assessments

- Trail Road Landfill, Ottawa, ON
- S.C. Johnson, Brantford, ON
- Parry Sound Sewage Treatment Plant, Parry Sound, ON
- Arnprior Sewage Treatment Plant, Arnprior, ON
- Kawartha Ethanol, Kawartha Lakes, ON
- IGPC Ethanol, Aylmer, ON
- Ravensview Water Pollution Control Plant, Kingston, ON
- Keswick Wastewater Treatment Plant, Keswick, ON
- Creemore Springs Brewery Peer Review, Creemore, ON
- Nitta Gelatin, Toronto, ON
- Elora Wastewater Treatment Plant, Elora, ON
- Colonial Sewage Pumping Station, Waterloo, ON

Institutional

- Women's College Hospital, Toronto, ON
- Trillium Health Care, Multiple Sites, ON
- St. Joseph's Health Centre, Hamilton, ON
- North Bay Regional Health Centre, North Bay, ON
- Joseph Brant Hospital, Burlington, ON
- St. Michael's Hospital, Toronto, ON
- Milton District Hospital, Milton, ON
- Mackenzie Health Care, Multiple Sites, ON
- North Bay Aquatic Centre, North Bay, ON
- Centre Wellington Sportsplex, Fergus, ON
- University of Guelph, Guelph, ON
- Carleton University, Ottawa, ON
- University of Ottawa, Ottawa, ON

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Fugitive Dust Studies

- 5W Farms, Victoria Road Quarry, Victoria Road, ON
- AECON Ottawa Quarry, Ottawa, ON
- Blythe Dale Agg. Leitch Gover Pit, Thames Centre, ON
- Brampton Brick Hillsdale Plant, Hillsdale, ON
- Brampton Brick Norval Quarry Review, Brampton, ON
- Bruno's Contracting, Trout Lake Pit, Thunder Bay, ON
- Capital Paving, Aikensville Pit, Puslinch, ON
- Capital Paving, West Montrose Pit, West Montrose, ON
- Capital Paving, Shantz Station Pit, Maryhill, ON
- CBM Sunderland Pit Dust Control, Sunderland, ON
- C.H. Demill Melrose Quarry, Shannonville, ON
- City of Ottawa Trail Road Landfill, Ottawa, ON
- Cressy Quarry Review, Cressy, ON
- D&J Lockhart Martin Pit Expansion, Woolwich, ON
- Dufferin Aggregates Aberfoyle Pit, Puslinch, ON
- Dufferin Aggregates Acton Quarry, Acton, ON
- Dufferin Aggregates Alps Pit, North Dumfries, ON
- Dufferin Aggregates Butler Pit, North Dumfries, ON
- Dufferin Aggregates Carden Quarry, Carden, ON
- Dufferin Aggregates Cayuga Quarry, Cayuga, ON
- Dufferin Aggregates Cedar Creek Pit, North Dumfries, ON
- Dufferin Aggregates Chudyk Pit, North Dumfries, ON
- Dufferin Aggregates Flamboro Quarry, Dundas, ON
- Dufferin Aggregates Maple Yard, Maple, ON
- Dufferin Aggregates Mill Creek Pit, Puslinch, ON
- Dufferin Aggregates Mosport Pit, Mosport, ON
- Dufferin Aggregates Mill Creek Pit, Puslinch, ON
- Dufferin Agg. Richmond Hill Yard, Richmond Hill, ON
- Dufferin Aggregates Pickering Yard, Pickering, ON
- Duncor Portable Plant, Barrie, ON
- Duncor Emulsions, Shanty Bay, ON
- E.C. King Transfer Yard, Owen Sound, ON
- Farrish Crushing Portable Plant, Listowel, ON
- Federal Marine Terminals, Hamilton, ON
- Halton Crushed Stone, Town of Erin, ON
- Hanson Brick Burlington Review, Burlington, ON
- Highlands Group Melancthon Quarry, Melancthon, ON
- Hillway Equipment Limited, Orillia, ON
- James Dick Rockfort Quarry, Rockfort, ON
- James Dick Erin Pit Extension, Erin, ON
- James Dick Hidden Quarry, Guelph Eramosa, ON
- James Dick Reid Road Reservoir Quarry, Campbellville, ON
- Jennison Construction Clinton Pit, Clinton, ON
- Johnson Brothers McGuigan Pit, Cedar Springs, ON
- Johnson Brothers Erwin South Pit, Putnam, ON
- Lafarge Cement, Bath, ON
- Lafarge Goodwood Pit, Goodwood, ON
- Lippa Quarry, Skeleton Lake, ON
- Livingston Excavating & Trucking Inc., Simcoe, ON
- Lower Mattagami River Project, Mattagami, ON
- Lowndes Holdings, Mountsberg Quarry, Mountsberg, ON
- McCann Redi-Mix Durst Pit, Benmiller, ON
- NJ Excavating Martin Pit, Woolwich, ON
- SASE Aggregates, Uxbridge, ON
- Thames Valley Agg., Banner Rd. Pit, Thamesford, ON
- Thames Valley Aggregates, Golding Pit, Putnam, ON
- The Murray Group, Cole Pit, Inverhaugh, ON
- The Murray Group, Devin Pit, Inverhaugh, ON
- Trent Valley Sand & Gravel Norfolk Quary, Norfolk, ON
- Try Aggregates Byron Pit Review, London, ON
- Preston Sand & Gravel Roszell Pit, Puslinch, ON
- Preston Sand & Gravel Henning Pit, North Dumfries, ON
- VicDom Sand and Gravel, Uxbridge, ON
- VicDom Sand and Gravel, Sunderland, ON
- VicDom Sand and Gravel, Utica, ON
- Walker Aggregates Walker Brothers Quarry, Thorold, ON
- Walker Aggregates Severn Pines Quarry, Orillia, ON
- Walker Aggregates Duntroon Quarry, Duntroon, ON
- Walker Aggregates Uppers Lane Quarry, Niagara Falls, ON
- Walker Aggregates Vineland Quarry, Vineland, ON
- Waterford Group Vinemount Quarry, Vinemount, ON
- Waterford Group Law Crushed Stone, Port Colborne, ON
- Wilson Quarry, Monck, ON

Fugitive Dust Monitoring Studies

- Summit Aggregates, Ayr Pit, Ayr, ON
- CBM Sunderland Pit, Sunderland, ON
- CBM Codrington Pit, Codrington, ON
- CBM Westwood Pit, Peterborough, ON
- CBM Thamesford Pit, Thamesford, ON
- CBM St. Mary's Quarry, St. Mary's ON
- CBM Osprey Quarry, Duntoon, ON
- CBM Hillsburgh Pit, Hillsburgh, ON
- CBM David Pit, North Dumfries, ON
- CBM Buckhorn Quarry, Buckhorn, ON
- CBM Bowmanville Quarry, Bowmanville, ON
- CBM Aberfoyle South Pit, Puslinch, ON
- CBM Aberfoyle North Pit, Puslinch, ON
- Waterford Group Dunnville Rock Products, Dunnville, ON
- Waterford Group Law Crushed Stone, Port Colborne, ON
- Waterford Group Norfolk Aggregates, Norfolk, ON
- Waterford Group Vinemount Quarry, Vinemount, ON
- Waterford Group Waterford Pit, Waterford, ON

Ready-Mix Concrete Facilities

- Dufferin Construction, Burlington, ON
- Dufferin Construction, Hamilton, ON
- Dufferin Construction, Bowmanville, ON
- Ontario Redi-Mix, Pickering, ON
- Ontario Redi-Mix, Toronto, ON

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Hot-Mix Asphalt Facilities

- AECON, Brampton, ON
- Walker Aggregates, Thorold, ON
- Ingram Asphalt, Toronto, ON
- Walker Aggregates, Vineland, ON
- Dufferin Aggregates, Mosport, ON
- Waterford Group, Port Colborne, ON
- Coco Paving, Windsor, ON

Mining

- Vale, Sudbury, ON
- Kirkland Lake Gold, Kirkland Lake, ON
- Treasury Metals Goliath Gold, Wabigoon, ON

Chemical Process Quantitative Risk Analysis

- Quantitative Hazard Assessment Sulphur Dioxide Storage and Transfer Systems, Huntsman Corporation Canada Inc., Guelph, ON
- Quantitative Hazard Assessment Hydrogen Chloride Storage and Transfer Systems, Huntsman Corporation Canada Inc., Guelph, ON
- Quantitative Hazard Assessment Ethylene Oxide Storage and Transfer Systems, Huntsman Corporation Canada Inc., Guelph, ON
- Peer Review of Cytec Canada Risk Assessment, Niagara Falls, ON
- Edmonton Air Quality Assessment, Edmonton, AB
- Madoc Co-Operative Association, Madoc, ON
- Screening Level Risk Assessment of a Propane Facility, St. George, ON
- RioTrin Grand Park Redevelopment Hazard Consequence Modelling, Mississauga, ON

Air Pollution Control Technologies

- Flue Gas Desulphurization Technology and Design Review, Moa Nickel, Cuba
- City of Guelph Waste Resource Innovation Centre Biofilter Replacement, Guelph, ON

Chemical Engineering Experience

- Process Design, Optimization and Control Relating to the Chemical Process Industry
- Two years in the process-engineering group of Huntsman Corporation Canada Inc.