DUST ASSESSMENT OF THE JIGS HOLLOW PIT

Prepared for:

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N0B 2N0

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Richmond Hill, Ontario
L4B 3N4

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March 2009

EXECUTIVE SUMMARY

An atmospheric dispersion modelling assessment was undertaken to determine the maximum impact of the proposed Jigs Hollow Sand & Gravel Pit on ambient particulate matter concentrations in the area. The Industrial Source Complex Short Term model Version 3 (ISCST3) was used to simulate the atmospheric spreading of emissions from all significant sources of particulate matter at the facility, in combination with emissions from surrounding public roads. The phase that could most significantly affect sensitive receptors in the vicinity of the proposed pit was analyzed, which was based on conservatively high activity levels occurring near sensitive receptor locations. The maximum 24-hour and annual average dust concentrations in three size ranges (TSP, PM_{10}, and $PM_{2.5}$) were evaluated specifically at the nine sensitive receptors located closest to the boundary of the proposed site.

The analysis illustrated that even using a conservative emission scenario (i.e., an overestimate), the applicable standards for TSP, PM_{10}, and $PM_{2.5}$ were not predicted to be exceeded during site operations at any off-site location, including the nine nearby sensitive receptors. In addition, due to the conservative modelling approach used in this study, and the presence of vegetation and berms around the site, the maximum concentrations will, in reality, be lower than predicted.

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1.0 INTRODUCTION

SENES Consultants Limited (SENES) was retained by Kuntz Topsoil, Sand and Gravel Ltd. to assess the potential dust impacts of a proposed sand and gravel extraction operation north of Waterloo, Ontario in the Township of Woolwich. The site is proposed to be located on the south side of Peel Street, approximately 1½ km west of the intersection of Katherine Street. The site surrounding area gently slopes towards the Grand River, which travels from east of the site winding around to south of the site. The surrounding land use is primarily agricultural with two built-up residential areas on the opposite side of the Grand River east and south of the site.

SENES developed an emissions inventory for particulate matter, based on a maximum annual extraction limit of 150,000 tonnes/year of gravel and related products. Particulate matter (PM) is a term used for both solid and liquid particles in the atmosphere. Particulate matter varies considerably in size. Total Suspended Particulate (TSP) describes all particles with aerodynamic diameters less than 30 µm[1]; PM_{10} describes all particles with aerodynamic diameters less than 10 µm; and $PM_{2.5}$ describes all particles with aerodynamic diameters less than 2.5 µm. The larger diameter fraction of PM is commonly made up of crustal material (for inland locations) and can be emitted to the atmosphere by erosion by the wind, or disturbance of soil due to anthropogenic activity. The smaller diameter fraction of PM is largely due to combustion sources. Whereas larger particulate matter tends to be deposited relatively close to the source of emission, fine particulate matter can stay airborne for days and can be transported significant distances from its source. Currently, there is a provincial ambient air quality criterion specified for TSP, but not for PM_{10} or $PM_{2.5}$. There is, however, a proposed (federal) Canada-Wide Standard for $PM_{2.5}$, and an Ontario Ministry of the Environment (MOE) interim guideline for PM_{10}.

The objective of this dust impact assessment was to predict the highest levels of airborne particulates (dust) that are likely to result from the added industrial activity at the proposed Jigs Hollow Pit. The predicted air quality impacts were compared to relevant criteria and guidelines. The potential impact of particulate matter emissions on air quality in the vicinity of the operation was evaluated using dispersion modelling to determine the maximum predicted ambient air concentrations of total suspended particulate matter (TSP), inhalable particulate matter (PM_{10}), and respirable particulate matter ($PM_{2.5}$). The modelling analysis focussed on potential impacts at nearby residential properties, since these will be most sensitive to any dust emissions originating from the proposed operation.

The Industrial Source Complex Short Term Version 3 (ISCST3) model was used with the projected emissions to predict ambient particulate matter concentrations, as well as dustfall, in the area surrounding the site. This model was developed for the U.S. Environmental Protection

[1] In Ontario, TSP is defined as all particles 44µm in diameter and less.

Agency (U.S. EPA) and was designed specifically to determine downwind air concentrations and deposition rates of various airborne pollutants from industrial sources. The ISCST3 simulates the dispersion of pollutants by advecting a plume of material with an assumed Gaussian profile. The dilution of the plume as it travels downstream is calculated based on wind speed and mixing caused by atmospheric conditions.

1.1 AIR QUALITY CRITERIA

1.1.1 Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP) is often used to characterize air quality near a dust source. TSP is measured with a high-volume (Hi-Vol) sampler over 24-hours and consists, in Ontario, of particles less than 44 μm in diameter. An annual average is calculated as the geometric mean of these samples measured every six days.

The Ontario Ministry of the Environment (MOE) Standards Development Branch released new Ambient Air Quality Criteria (AAQC) in February 2008 (PIBS #6570e). The AAQC for TSP is 120 $\mu g/m^3$ averaged over 24-hours, and the annual geometric mean of the 24-hour samples is 60 $\mu g/m^3$.

The ambient TSP standards and criteria were originally set to prevent a reduction in visibility. Particles suspended in the atmosphere reduce visibility or the visual range by reducing the contrast between an object being viewed and its background. This reduction is a result of particles scattering or absorbing light coming from both the object and its background, and from particles scattering light into the line of sight [Robinson, 1977]. Particles with a radius of 0.1 to 1.0 μm are most effective at reducing visibility. In a rural area where TSP levels are on the order of 30 $\mu g/m^3$, the visibility would be about 40 km. At 150 $\mu g/m^3$, a common urban concentration, the range would be reduced to about 8 km [Robinson, 1977]. The MOE 24-hour criterion for TSP of 120 $\mu g/m^3$ is based on a visual range of about 10 km.

1.1.2 Fine Particulate Matter (PM_{10} and $PM_{2.5}$)

Many studies over the past few years have indicated that fine particulate matter (PM_{10} and $PM_{2.5}$) in the air is associated with various adverse health effects in people who already have compromised respiratory systems such as asthma, chronic pneumonia and cardiovascular problems. However, the available studies have not been able to link the adverse health effects in such people to any one component of the pollution mix. PM_{10} is a mixture of chemically and physically diverse dusts and droplets, and some of these components may be important in determining the effects of PM_{10} on health.

Particulate Matter less than 2.5 µm – $PM_{2.5}$ is the “finer fraction” of fine particulate, and is also known as respirable particulate. It is referred to as “respirable” since the particles are generally small enough to be drawn in and deposited into the deepest portions of the lungs. Anthropogenic sources, such as combustion of fossil fuels, tend to be the largest contributor to $PM_{2.5}$ levels in the environment.

A summary of the applicable air quality objectives for this study is provided in Table 1.1.

TABLE 1.1
PARTICULATE MATTER AIR QUALITY CRITERIA

Pollutant	Averaging Period	Objective	Air Quality Standard (µg/m³)
TSP	24-hour	AAQC	120
TSP	Annual	AAQC	60
PM_{10}	24-hour	Ontario Interim Guideline	50
$PM_{2.5}$	24-hour	Canada-Wide Standard (CWS)	30*

*Compliance is measured as the 98th percentile of measured concentrations, averaged over 3 years.

1.2 DUSTFALL CRITERIA

Dustfall, or dust deposition, involves the settling of particles from the air due to gravitational force. It is a total amount of dust, inclusive of all particle size categories. Dustfall or dust deposition includes those particles of sufficient weight to settle from the air by gravity. These particles are generally larger than 20 µm in diameter. TSP deposition generally provides a good estimate of total dustfall. The AAQC for dustfall is 7.0 g/m^2/30 days for an averaging period of one month and 4.6 g/m^2/30 days for an averaging period of 1 year.

In developing an Ambient Air Quality Criterion for dustfall, the MOE used soiling data (i.e. surface build up of dust) from various Ontario towns between 1951 and 1955, which indicated areas of relatively low soiling (11 – 15 g/m^2/30 days), relatively moderate soiling (17 – 24 g/m^2/30 days) and relatively heavy soiling (26 – 34 g/m^2/30 days) (WHO, 1961).

1.3 OTHER CRITERIA AIR CONTAMINANTS

Criteria Air Contaminants (CACs) including nitrogen oxides, sulphur oxides and carbon monoxide are common pollutants released into the air by activities such as the combustion of fossil fuels.

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas that is formed in ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides (NO_x) is the term used to describe the sum of NO, NO_2 and other oxides of nitrogen, and plays a major role in the formation of ozone.

Sulphur dioxide (SO_2) is a colourless gas that smells like burnt matches. It can be oxidized to sulphur trioxide, which in the presence of water vapour, is readily transformed to sulphuric acid mist. SO_2 can be oxidized to form acid aerosols, and is a precursor of particulate sulphates, which are one of the main components of respirable particulates in the atmosphere (MOE, 2002).

Carbon monoxide (CO) is a colourless, odourless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 60 percent of all CO emissions nationwide. High concentrations of CO generally occur in areas with heavy traffic congestion.

There are some minor sources of CACs at the proposed Jigs Hollow pit. These sources include mobile equipment such as haul trucks and front end loaders, as well as stationary equipment such as diesel generators. These sources are not expected to be significant contributors to concentrations of these contaminants at nearby residential locations, due to the proximity of local public roads (which are larger sources of these contaminants). Thus CACs were not included in the dispersion modelling assessment.

2.0 BACKGROUND CONCENTRATIONS

Existing air quality in the area surrounding the proposed Jigs Hollow Pit, is a combination of emissions from sources in the area (other industry and traffic) plus a component that flows into the area from upwind sources (Toronto, the USA, etc.). When a modelling assessment is undertaken all of these other “background” sources must be included in order to get an accurate representation of the air quality after the proposed Jigs Hollow Pit is in operation. To account directly for some of the background levels of dust, traffic data along Peel Street and Jigs Hollow Road as estimated by IBI Group, was used to estimate emissions from these sources which was then included into the model. In addition, historical measured rural background concentrations for TSP, PM_{10} and $PM_{2.5}$ were added to model-predicted concentrations to capture the far upwind portions of background. Consequently, the concentrations presented in this report include potential effects from the background dust sources in the area as well as other upwind sources.

2.1 AIR CONCENTRATIONS

The proposed Jigs Hollow Pit site will be in a predominantly rural location, therefore TSP, PM_{10} and $PM_{2.5}$ monitoring data from the rural Point Petre station were used for developing background concentrations. Table 2.1 below presents five years of 90th percentile 24-hr measurements for TSP, PM_{10} and $PM_{2.5}$, along with five years of annual average TSP concentrations. The average of the five years of data is provided at the bottom of the table. The 90th percentile values are values that will only be exceeded 10% of the time under adverse meteorological conditions.

TABLE 2.1
TSP MEASUREMENTS FROM THE POINT PETRE STATION

Year	90th Percentile $PM_{2.5}$	90th Percentile PM_{10}	90th Percentile TSP	Annual Average TSP
2000	9	13	27	16
2001	10	15	30	17
2002	10	15	30	17
2003	11	15	30	18
2004	14	19	38	19
Average	**11**	**16**	**31**	**17**

TSP was not measured at the Point Petre Station, the value above was estimated using the observed average relationship TSP= PM_{10}x2

The proposed Jigs Hollow Pit is located near active farms, therefore the actual background concentrations in the vicinity of the proposed Jigs Hollow Pit will likely be greater than the typical rural background concentrations provided above. For this reason, more conservative background concentrations were selected for the proposed Jigs Hollow Pit as shown in Table 2.2 below.

TABLE 2.2
SELECTED BACKGROUND CONCENTRATIONS FOR TSP, PM_{10} AND $PM_{2.5}$

Averaging Time	Contaminant Background Concentration (µg/m^3)		
	TSP	PM_{10}	$PM_{2.5}$
24-hr	50	25	12.5
Annual	30	n/a	n/a

These numbers were generated as follows. Based on SENES' experience the maximum emissions scenario from an aggregate pit will result in an additional 0.5 µg/m^3 of $PM_{2.5}$ after 2 km of travel. Therefore, assuming that three upwind active farms could line up with the proposed Jigs Hollow Pit, 1.5 µg/m^3 was added to a background of 11 µg/m^3 for an overall $PM_{2.5}$ background concentration of 12.5 µg/m^3. The average factor of 2 rule was applied from $PM_{2.5}$ to PM_{10} and from PM_{10} to TSP to get the other numbers in the table. As $PM_{2.5}$ will travel longer distances this fraction is considered to be the worst case, and the PM_{10} and TSP values provided in Table 2.2 are likely to be very conservative.

2.2 DUSTFALL CONCENTRATIONS

A measured background dust deposition rate was not available. However, background values can be estimated from the selected conservative TSP background air concentration of 50 µg/m^3 for 24-hr concentrations, using an equation proposed by Beychok (Beychok, 2005) to convert between averaging periods ranging from 1 day and 365 days. The equation is as follows:

$$C_{long} = C_{short} * (t_{short} / t_{long})^{0.53}$$

The 24-hr TSP background air concentration of 50 µg/m^3 was converted to a 30 day mean concentration where: t_{short} = 1 day, t_{long} = 30 days and C_{short} = 50 µg/m^3

$$C_{30} = 50 * (1/30)^{0.53} = 8.2 \text{ µg/m}^3$$

This mean concentration, with an assumed deposition velocity of 10 cm/s (or 0.1 m/s, which is a conservatively high estimate based on an average particle size of 10 µm) yields a monthly background deposition rate of 2 g/m^2/30 days as shown in the following calculation:

8.2 µg/m^3 * 0.1 m/sec * 1 g/1,000,000 µg * 86,400 sec/day * 30 days/month = 2 g/m^2/30 days

This value was added to the model predicted monthly deposition rates for comparison to the monthly AAQC.

3.0 DISPERSION MODELLING PARAMETERS

3.1 INTRODUCTION

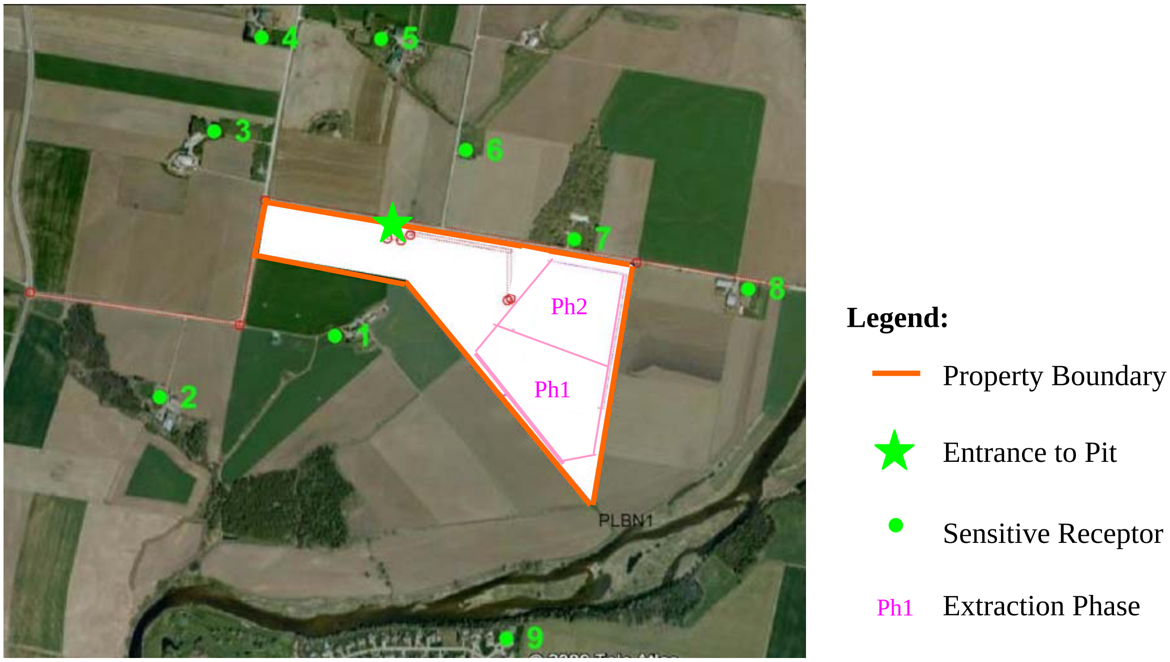
SENES used the 'Planning Summary Report' (dated December 10, 2008) provided by IBI Group to obtain the site characteristics needed for dispersion modelling. The Plan included the locations of the Processing Plant, where extraction activities will occur, the location of the on-site haul road and location of the adjacent public roads Peel Street and Jigs Hollow Road. Additional information was provided through personal communication with IBI Group staff.

Due to the different settling characteristics of TSP, PM_{10}, and $PM_{2.5,}$ these particulate fractions are modelled separately with ISCST3. An emission inventory was developed for each fraction, and ambient, off-site concentrations were modelled on a grid including the Jigs Hollow Pit.

Several residential homes and outbuildings were close to the site. For this reason, these locations were specifically used in the model as sensitive ('discrete') receptors.

During the lifetime of the undertaking, the working face will be located in different parts of the site. However, the processing plant site and the haul road will remain fixed in one location. Figure 3.1 shows the Jigs Hollow Pit, and the relative locations of roads and residential (discrete receptor) buildings. Berms will be constructed along the west, north and east extraction limits to reduce adverse noise and visual impacts. The berms will range from 2 - 10 m in height, depending on the location of nearby receptors. Berms and existing trees and shrubs surrounding the Pit will act to reduce horizontal dust transport from the Pit area, but these mitigating effects have not been taken into account when estimating off site impacts.

FIGURE 3.1
PIT OPERATIONAL LAYOUT WITH DISCRETE RECEPTOR LOCATIONS



During the lifetime of the Pit, there will be two different phases of operation. A basic description of each operating phase is provided in Table 3.1.

TABLE 3.1
OPERATING PHASES AT JIGS HOLLOW PIT

Operating Phase	Description of Activities
1	Phase 1 will occur on the southern half of the proposed extraction area. The direction of extraction will be generally southward, toward the nearest sensitive noise receiver. Pit activities will include all aspects of aggregate processing including extraction, crushing, screening blending, and asphalt and concrete recycling and topsoil screening. From this area, the material will be trucked to the west portion of the site and to the site entrance on Peel Street.
2	Phase 2 will occur on the northern half of the proposed extraction area. The direction of extraction will be generally northward, toward the nearest sensitive noise receiver. Pit activities will include extraction, screening and limited stockpiling. All other processing activities (crushing, screening blending, and asphalt and concrete recycling), will occur within the processing area of Phase 1. From this area, the material will be trucked to the west portion of the site and to the site entrance on Peel Street.

The processing plant will be permanently located in the Phase 1 area, and the haul road will travel northwest from the processing plant towards Peel Street (see Figure 3.1 above). The worst case operating scenario was determined to be when the haul trucks travel the greatest distance, which is during Phase 2, and when the extraction face is at the northern extent of the extraction limit. Haul trucks would be travelling from the extraction face south to the processing area, and also from the processing area northwest to the site entrance.

This worst case operating scenario will result in the highest off-site particulate matter concentrations and the highest concentrations at the closest sensitive receptor locations.

3.2 METEOROLOGY

The ISCST3 model uses hourly meteorological data records to define the conditions for plume rise, transport and dispersion. The model estimates the concentration or deposition value for each source-receptor combination, for each hour of input meteorology, and calculates short-term averages, such as one-hour, eight-hour and 24-hour averages. The hourly averages can also be combined into longer averages (1-month, seasonal, annual or period). The industry standard is to use five years of hourly meteorological data from a local meteorological station, therefore, five years of meteorological data was used for all model runs in this study.

The 5-year period 2001 – 2005 was used to develop a meteorological input file representative of all possible weather conditions that the proposed Jigs Hollow Pit would be subjected to during its operation. The ISCST3 model requires hourly values of wind speed, wind direction, ambient temperature, atmospheric stability class[2], and mixing height[3] to determine the air concentrations of particulate matter at sensitive receptors caused by dust emitted from the site. These meteorological variables are determined from hourly surface weather observations, and twice-daily upper air soundings. For the purpose of this study, surface observations were obtained from the Toronto Pearson International Airport (approximately 70 km east of the proposed Jigs Hollow Pit location) and upper air data was obtained from the National Weather Service station at Buffalo, N.Y (which is geographically the nearest upper-air station to the area being modelled).

[2] Relates to the ability of the atmosphere to resist or enhance vertical motion. Determined from cloud cover, wind speed and time of day.

[3] The maximum vertical distance through which a contaminant released at ground level is able to mix. Related to solar insolation (heating of the ground) and time of day.

3.2.1 Temperature

Generally, the near-surface temperature controls the reaction rates of contaminants, as well as how fast the surface dries. If the temperature is low, the moisture near the surface may remain or it may even freeze, sealing the surface from the effects of wind erosion thereby reducing dust emissions.

Temperature and precipitation normals for the Toronto Lester B. Pearson International Airport (1971-2000) are presented in Table 3.2. The annual mean temperature is 7.5°C at the Toronto Lester B. Pearson International Airport site. The daily mean minimum temperature is –10.5°C in January and daily mean maximum temperature is 26.8°C in July.

TABLE 3.2 - TORONTO LESTER B. PEARSON INTERNATIONAL AIRPORT CLIMATE NORMALS (1971-2000)

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-6.3	-5.4	-0.4	6.3	12.9	17.8	20.8	19.9	15.3	8.9	3.2	-2.9	7.5
Standard Deviation	3	2.7	2.3	1.7	2	1.5	1.3	1.3	1.2	1.6	1.5	2.7	0.9
Daily Maximum (°C)	-2.1	-1.1	4.1	11.5	18.8	23.7	26.8	25.6	21	13.9	7	0.9	12.5
Daily Minimum (°C)	-10.5	-9.7	-5	1	6.9	11.9	14.8	14	9.6	3.9	-0.7	-6.7	2.5
Precipitation													
Rainfall (mm)	24.9	22.3	36.7	62.4	72.4	74.2	74.4	79.6	77.5	63.4	62	34.7	684.6
Snowfall (cm)	31.1	22.1	19.2	5.7	0.1	0	0	0	0	0.5	7.6	29.2	115.4
Precipitation (mm)	52.2	42.6	57.1	68.4	72.5	74.2	74.4	79.6	77.5	64.1	69.3	60.9	792.7
Days with Rainfall													
>= 0.2 mm	5.1	4.6	8	10.7	11.9	11	10.1	10.8	10.7	11.5	10.6	6.7	111.8
Days With Snowfall													
>= 0.2 cm	12.6	9.4	7.1	2.6	0.07	0	0	0	0	0.4	4	10.3	46.5
Days with Precipitation													
>= 0.2 mm	14.9	11.6	13.1	12.1	11.9	11	10.1	10.8	10.7	11.5	13.2	14.6	145.5
Days with Wind													
Days with Winds >= 52 km/hr	3.4	2.2	3.4	3.2	1.5	0.7	0.6	0.7	0.7	1.8	2.4	3.1	23.8
Days with Winds >= 63 km/hr	1.1	0.8	1	1	0.5	0.2	0.2	0.2	0.3	0.4	0.9	0.6	7.2

Note: Source Environment Canada Website, www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm

3.2.2 Precipitation

Precipitation plays a role in emissions of pollutants from the ground and removal of pollutants from the air. For example, small amounts of precipitation will leave a soil surface mostly dry and available for wind erosion whereas a large amount of precipitation effectively seals the surface against erosion by the wind. Contaminants in the air may be washed out by precipitation; increased precipitation means more pollutant washout.

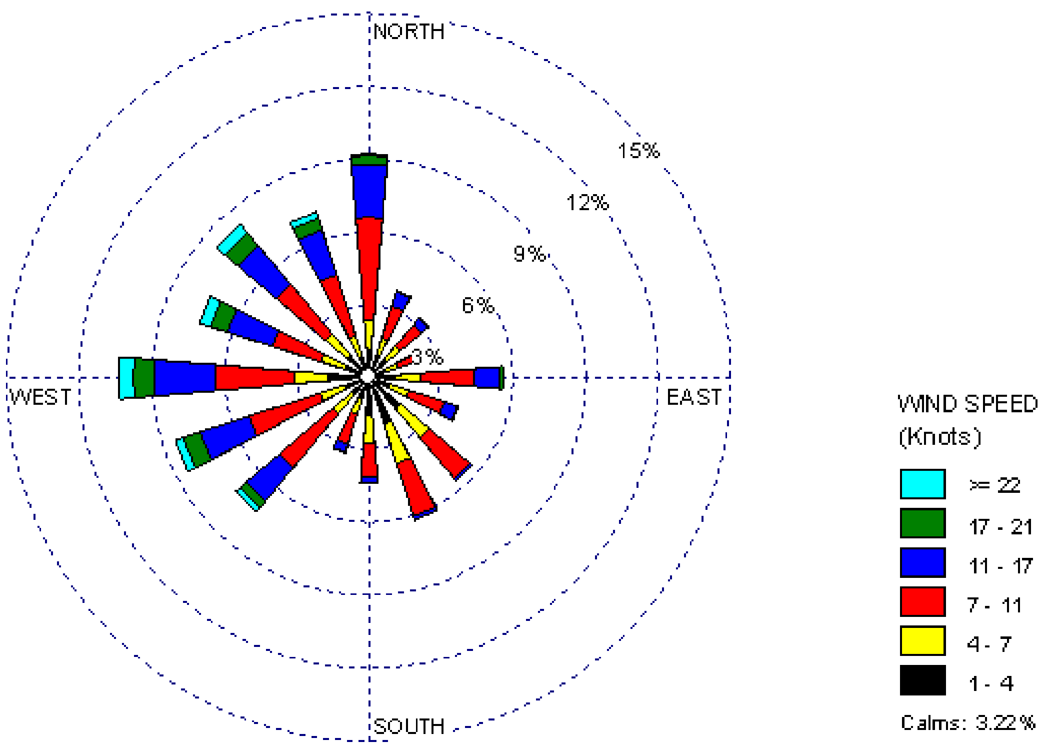
As shown in Table 3.2 above, the Toronto area receives a total of 792.7 mm of precipitation per year, including 684.6 mm of rainfall and 115.4 cm of snowfall. The maximum mean monthly rainfall is 79.6 mm, which occurs in August.

3.2.3 Wind

Wind is the primary driver that carries air pollutants away from a source. The direction and speed of the wind dictates the location and distance from the source that a pollutant may travel, and the receptors that may be impacted. High winds effectively disperse gases and particulates throughout the atmosphere. Concentrations generally decrease with increasing wind speed as a result of dilution. However, these conditions can lead to increased wind erosion and re-suspension of surface-based dust sources. Low wind speeds or no winds can lead to very high pollutant concentrations near the ground. Wind speed also induces mechanical turbulence (which affects dispersion) as a result of flows around obstacles on the surface (topography, buildings, etc.). The amount of mechanical turbulence created depends on the roughness of the surface and the wind speed.

At the Toronto Pearson International Airport meteorological station, calms were reported approximately 3.2% of the time during the 2001-2005 period. Figure 3.2 presents a wind rose for the Toronto Lester B. Pearson International Airport meteorological station for the 2001-2005 time period. A wind rose simply documents the frequency of occurrence of various wind directions and speeds over the period of interest. The figure shows that the prevailing winds are from the west and north and each occurs approximately 10% of the time. Winds from the NW sector occur over 42% of the year.

FIGURE 3.2
WIND ROSE DIAGRAM FOR PEARSON INTERNATIONAL AIRPORT (2001-1005)



3.2.4 Atmospheric Stability

Atmospheric stability is tied to vertical temperature structure, and is a measure of the amount of vertical motion in the atmosphere, and hence its ability to mix pollutants. A stable atmosphere has little vertical motion (is less turbulent) and cannot disperse pollutants as well as a more turbulent, unstable atmosphere. A number of classification schemes have been developed for describing stability classes. These classes reflect the ability of the atmosphere to disperse and dilute pollutants.

An atmospheric stability classification scheme, developed by Pasquill-Gifford and modified by Turner, is now widely used [Turner, 1964]. The atmosphere can have three general stability states – unstable, neutral, or stable. The stability class distribution for the Toronto Lester B. Pearson International Airport for the period 2001-2005 is presented in Table 3.3. At this station, neutral stability conditions {D (neutral) + C (near neutral)} occur approximately 69% of the time and stable conditions (E, F) about 27% of the time. Stable conditions are important because they can produce higher concentrations of contaminants because of reduced turbulent mixing.

TABLE 3.3
STABILITY CLASS DISTRIBUTION TORONTO LESTER B. PEARSON INTERNATIONAL AIRPORT (2001-2005)

Stability Class	Frequency (%)	Descriptor
A	0.30	Unstable
B	4.20	
C	10.48	Neutral
D	58.42	
E	13.23	Stable
F	13.39	

3.2.5 Mixing Height

The mixing height is a vertical measure for estimating the volume of air available for mixing between the ground and a trapping inversion layer. This is important to characterize because a low mixing height can trap ground-based emissions and cause elevated ground level pollutant concentrations. Mixing heights, which are a regional parameter, are typically estimated from upper air measurements; however there are few stations that measure these upper air data. Upper air data was obtained from the National Weather Service station at Buffalo, N.Y. (which is geographically the nearest upper-air station to the area being modelled) and was used to estimate mixing heights over the area around the proposed Jigs Hollow Pit.

3.3 SOURCES OF PARTICULATE MATTER

All significant sources of particulate matter were characterized and included in the emission inventories for this gravel pit. Many of the emissions are fugitive in nature. Fugitive dust involves the suspension of dust by material or machinery movement, or erosion. The source emissions are based on seasonal maximum daily extraction rates and include those due to operating machinery, road-based emissions due to the movement of gravel trucks on-site, and particulate emissions due to exhaust from internal combustion engines. Wind blown dust due to the erosion of exposed soil was also determined and included in the total emissions.

Extraction, processing and shipping were assumed to occur 12 hours per day (7 AM until 7 PM), 7 days per week. A summary of the individual sources included and the estimation method used in the dispersion modelling analysis is provided in Table 3.4. Specific individual parameters used in the dispersion model are detailed in Table A.1 in Appendix A.

3.3.1 On-site Emissions

In order to be conservative, a maximum emission scenario was developed to capture expected worst-case maximum daily particulate emissions from the proposed Jigs Hollow pit. The maximum operating scenario was based upon a maximum daily extraction rate of 792 tonnes/day and an hourly maximum extraction rate of 66 tonnes/hour. This scenario also incorporated an estimated maximum daily shipping rate of three 22 tonne trucks loads per hour and 36 trucks per day.

TABLE 3.4
SUMMARY OF EMISSION SOURCES USED IN THE DISPERSION MODEL

Activity	Emission Factor Equation	Units	Reference	Comments
Haul Road Truck Travel on Unpaved Roads	$E_{24hr} = 281.9 \times k \times (s/12)^{a} \times (W/3)^{b}$ $E_{annual} = 281.9 \times k \times (s/12)^{0.8} \times (W/3)^{0.4} \times ((365-P)/365)$	g/VKT	AP-42 13.2.2, November 2006	Unpaved Haul Roads
Primary and Secondary Crushing (Uncontrolled)	TSP = 0.0027, PM_{10} = 0.0012 $PM_{2.5}$ = 0.0006	kg/tonne	AP-42, Table 11.19.2-1, August 2004	Permanent Plant, Uncontrolled
Screening (Uncontrolled)	TSP = 0.0125, PM_{10} = 0.0043 $PM_{2.5}$ = 0.002	kg/tonne	AP-42, Table 11.19.2-1, August 2004	Permanent Plant, Uncontrolled
Material Drops loading Crusher and off-site haul trucks	$E = k \times (0.0016) \times (U/2.2)^{1.3} \times (M/2)^{-1.4}$	kg/tonne	AP-42 13.2.4, 1995	Based on Maximum Extraction Rate
Wind Erosion - Unvegetated Areas	E = 1.9*s/1.5	kg/ha/day	U.S. EPA	Applied at Wind Speeds Greater than 5.14 m/s
Tailpipe Emissions (excavators and loaders)	E_{10} = 0.724	g/hp-hr	U.S. EPA Non-Road, 2005	1 Excavator at Working Face, 1 Excavator at Central Plant and Haul Truck Tailpipe
Tailpipe Emissions (diesel generators for crushers, screeners and conveyors)	E_{10} = 0.000721 lb/hp-hr x 454 g/lb = 0.327	g/hp-hr	AP-42 3.3-1, October 1996	1 Small Generator for Screening at Working Face and 1 Large Generator at Central Processing Plant

Notes: AP-42 is a U.S. EPA compilation of air contaminant emissions due to various activities. See http://www.epa.gov/ttn/chief/ap42/index.html.
U.S. EPA Non-Road is a compilation of (industrial) emissions from non-road activities. (U.S. EPA, 2004).

The seasonal shipping and production factors assumed are presented in Table 3.5. Operations during the winter will be minimal due to freezing conditions, and thus the seasonal factor was set to 10%.

TABLE 3.5
MAXIMUM EMISSION FACTOR SEASONAL MULTIPLIERS

Season		Production/Shipping
Dec -Feb	Winter	0.10
Mar -May	Spring	1.00
June-Aug	Summer	1.00
Sept -Nov	Fall	1.00

On-Site Road Dust Emissions

Silt content and fleet average vehicle weight are the most important parameters needed for estimating fugitive roadway emissions in the Pit. All on-site haul roads will be unpaved. Site specific analysis of aggregate material within the proposed Jigs Hollow Pit indicated a maximum silt content of 2.3%, however, SENES conservatively assumed the silt content on the unpaved haul roads to be 2.4%, which is the low end of sampled silt contents at Stone Quarrying and Processing facilities on AP-42 Table 13.2.2-1 [U.S. EPA 2006].

Material was assumed to be transferred from the extraction face to the processing area and off-site by 15 tonne shipping trucks having a load capacity of 22 tonnes. To be conservative, dust reduction by precipitation was not factored into the annual TSP emission rates. However, for deposition estimations dust reduction by precipitation was considered.

On-Site Tailpipe Emissions

Tailpipe emissions for industrial machinery and heavy-duty vehicles were included in the fugitive emissions from the Jigs Hollow Pit. Appropriate emission factors were obtained for each vehicle type or piece of machinery from the U.S. EPA [U.S. EPA 2004, U.S. EPA 2006]. For roadworthy vehicles, the emissions estimates are proportional to the total vehicle kilometres travelled per day, which were calculated from the maximum daily number of loads shipped and the on-site road lengths. For loaders and diesel generators, the emission estimates are proportional to the equipment capacities and an estimate of the percentage of time equipment is operating at maximum capacity.

Material Handling and Processing Emissions

Fugitive dust emissions resulting from material handling, primarily from material drops to vehicles and off vehicles and equipment, have been estimated using U.S. EPA emission factors [U.S. EPA 2006] in conjunction with maximum hourly extraction rates.

The particulate emissions resulting from the screeners and crushers were estimated using U.S. EPA emission factors [U.S. EPA 2006] in conjunction with the maximum hourly extraction rate. Site specific analyses indicate that the moisture content of the raw material extracted from pits is greater than 2.5% (typically 3 to 4%). When this is the case, “controlled” emission factors may be used to estimate the emissions from screening and handling operations. However, for the worst case scenario extracted material is picked-up and dropped three times before crushing. Therefore, it was conservatively assumed that after handling of extracted material the moisture content decreased, therefore uncontrolled emission factors were used for crushing and screening activities in the processing area.

Wind Erosion

Wind eroded dust is typically an event-driven emission, since particles are not suspended unless a sufficient wind speed is reached. Typically, at wind speeds less than 5.14 m/s, there would be no emissions caused by wind erosion. For this assessment it was assumed there would be wind erosion from the on-site unpaved haul roads for all hours when wind speeds exceeded 5.14 m/s.

3.3.2 Local Area (Off-Site) Traffic Emissions

Public Roadway Emissions

The public roads in the vicinity of the Jigs Hollow Pit are Peel Street, which runs adjacent to the northern boundary of the Pit, and Jigs Hollow Road, which is west of the site approximately 600 m from the western limit of the extraction area. Both Peel Street and Jigs Hollow Road are unpaved. Haul truck traffic leaving the Pit will turn left (west) and continue along Peel Street to Jigs Hollow Road. Haul trucks will then turn south and continue on Jigs Hollow Road to Northfield Drive, which is more than 1 km west of the extraction limit.

IBI Group collected peak hour traffic volume information for Peel Street and Jigs Hollow Road, and then conservatively estimated 24-hr traffic volumes. SENES then estimated road dust and tailpipe emissions based on traffic volumes, which were input into the model. Shipping traffic resulting from the proposed Jigs Hollow Pit was added to the existing traffic, to estimate the total emissions resulting from vehicular traffic on Peel Street and Jigs Hollow Road during future operations of the proposed Jigs Hollow Pit.

For these public roads, the silt content of the parent soil in the area was used, which is the conservative method recommended in AP-42 Section 13.2.2-1. Tests suggest that road silt content is normally lower than in the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles.

As indicated above site specific analysis of aggregate material within the proposed Jigs Hollow Pit indicted a maximum silt content of 2.3%, however, SENES conservatively assumed the silt content of the unpaved public roads to be 2.4%.

Tailpipe Emissions

Tailpipe emissions from vehicle travel on Peel Street and Jigs Hollow Road were calculated by applying a fleet averaged emission factor from the Mobile 6C Emissions model for the year 2007. For the public roads, traffic data was used to determine Annual Average Daily Traffic (AADT) levels, as detailed above. The data and calculations used to determine the tailpipe emissions from public roads are shown in Table A.1 in Appendix A.

3.4 REDUCTION OF UNCONTROLLED FUGITIVE DUST

Reduction of uncontrolled industrial emissions is commonly achieved by applying a 'control mechanism'. An example of a control mechanism is simply applying water or another dust suppressant to an unpaved road, which dramatically reduces dust emissions. SENES estimated the emissions assuming that sufficient dust control measures will be applied that the control efficiencies indicated in Table 3.5 will be achieved on all roads. These efficiencies were used to reduce the uncontrolled emission rates estimated with the U.S. EPA emission equations.

TABLE 3.6
CONTROL EFFICIENCIES USED IN DISPERSION MODELLING

Process/Activity	Strategy	Control Efficiency Applied
Unpaved Roads in Pit	chemical suppressant and watering	90%
Unpaved Off-Site Roads	chemical suppressant	80% during winter, spring and fall 60% during summer

Kuntz Topsoil, Sand & Gravel has committed to controlling dust emissions from the off-site truck haul route. Currently, the Township of Woolwich applies a single coat of calcium chloride during the spring. The control efficiencies outlined in Table 3.6 above are based on Kuntz Topsoil, Sand & Gravel applying a second coat of calcium chloride during the late summer. This approach follows the best practices suggested by Environment Canada in their February 2007 document *"Best Practices for the Use and Storage of Chloride-Based Dust Suppressants."*

3.5 ISCST3 SETTINGS

Emissions from most sources were set to originate from approximately the pit floor, or ground level for above-pit sources (off-site road traffic and some on-site haul roads). For sources within the Pit, the 'OPENPIT' source designation was used, which applies the total emissions to the volume of air within the pit, and retains a fraction of the emissions within the pit, depending on the pit's depth. During Phase 2, it was assumed that the Pit would have an average depth of 4m. Berms were assumed to be placed along the north and east edges of the extraction limit. However, the effect of the berms cannot reliably be captured in the modelling and were not taken into account. As a result, expected concentrations will likely be less than those predicted in this assessment.

In previous studies of this nature, SENES has used the CAL3QHCR road emissions dispersion model to estimate concentrations due to fugitive dust and tailpipe emissions[4] near roads, in addition to the ISCST3 model used for other (area or volume) sources in the modelling domain. CAL3QHCR is also an approved U.S. EPA (and MOE) model for fugitive dust emissions from roads. The use of the model for roadway emissions is considered appropriate because the model incorporates the increased dispersion of air contaminants due to turbulence generated behind the moving vehicles. The ISCST3 model treats roads as elongated area sources and does not take this behind vehicle turbulence into consideration, thereby predicting air concentrations near roadways that are much higher than air quality monitoring has shown. Unfortunately, a drawback to using two separate models in an air quality study is that total, combined ground-level concentrations at individual locations are difficult to accurately determine.

Recently, SENES undertook a comprehensive study of the use of ISCST3 for modelling roadway emissions [SENES 2003]. The results of this study show that the ISCST3 model, representing roads as elongated area sources in 'RURAL' dispersion conditions, can reproduce CAL3QHCR estimates when modelled emission rates are reduced by a factor of 3.5. The net effect of applying this reduction factor accounts for the turbulent mixing that occurs behind a vehicle. This study was presented at an Air and Waste Management Association (AWMA) Conference. A detailed account of the study, with supporting figures, is presented in Appendix B. For the Jigs Hollow project, on-site and off-site public roads within the modelling domain were modelled as elongated area sources in ISCST3 using a reduction factor of 3.5. This reduction factor was not applied to roadway emissions in the Pit, since total emissions from the Pit were classified as an OPENPIT source.

[4] SENES Consultants Limited, 2002. *Benchmark Air Quality Assessment for Dust in the Caledon Area*.

Model ‘switches’ used were rural dispersion (as opposed to urban), dry deposition and plume depletion (due to settling of plume material). In addition, terrain was assumed to be flat. A sample ISCST3 input file is shown in Appendix C.

4.0 MODELLING RESULTS

Several dispersion model runs were undertaken to predict maximum 24-hour and annual average ground-level concentrations at sensitive receptor locations and at gridded receptor locations. A tiered receptor grid was set up including receptor locations at increasing spacing with increasing distance from the property line. Receptors within 500 m of the property centre were spaced at 50 m intervals, receptors within 1,000 m of the property centre were spaced at 100 m intervals, while receptors were spaced at 200 m intervals further away from the property. In addition, fence line locations at 10 m intervals along the Jigs Hollow Pit property line as well as nine residential (discrete) receptor locations were included in all model runs.

The pollutant concentrations presented here are the sum of modelled worst case concentrations and estimated background concentrations (as discussed in Chapter 2). This modelling enabled a determination of the number of exceedances of federal and provincial air quality standards/guidelines expected to occur over the span of five years at any off-site receptor locations, and a visualization of the maximum 'footprint' of the Pit's activity in the area. The dispersion modelling was undertaken for Phase 2. In addition, maximum monthly and annual deposition of dust (TSP) was determined.

4.1 TOTAL SUSPENDED PARTICULATE (TSP)

Table 4.1 presents the maximum predicted 24-hour and annual average TSP concentrations at the nine discrete receptors (shown previously on Figure 3.1). As indicated in Table 4.1, the maximum predicted concentrations at all nine discrete receptors are below the 24-hour MOE AAQC for TSP of 120 µg/m^3 and below the annual average MOE AAQC for TSP of 60 µg/m^3.

Figure 4.1 presents a visualization of the off-property predicted annual average TSP concentrations in the vicinity of the proposed Jigs Hollow Pit for Phase 2. For TSP, there are no off-site exceedances of model predicted annual average concentrations, including the nearby nine sensitive receptors.

TABLE 4.1
MODEL PREDICTED TSP CONCENTRATIONS –PHASE 2

Receptor	Annual Average Concentration (μg/m^3)	Maximum 24-hour Concentration (μg/m^3)
R1	31	59
R2	31	54
R3	31	57
R4	31	56
R5	31	57
R6	32	64
R7	35	82
R8	33	65
R9	30	55
Maximum	**35***	**82***
AAQC	**60**	**120**

*Values include background concentrations of 50μg/m^3 for 24-hr values and 30μg/m^3 for annual values.

FIGURE 4.1
PREDICTED ANNUAL AVERAGE TSP CONCENTRATIONS – PHASE 2

TSP Annual Average AAQC = 60 μg/m^3

Figure 4.2 presents an off-property visualization of the predicted maximum 24-hour TSP concentrations in the vicinity of the proposed Jigs Hollow Pit for Phases 2. The maximum predicted concentration is on the site property line immediately northwest of the extraction pit.

The site emission inventory and dispersion modelling was conducted on a "maximum effects" basis. Although seasonal variations in production were considered, the emissions were based on seasonal maximum activity, rather than seasonal average activity, which yield conservatively high results on an annual basis.

It is also important to note that the maximum 24-hour TSP concentrations at each location shown on Figure 4.2 represent a hypothetical worst case scenario, since the maximum at each receptor occurs during different meteorological conditions. As a result, the figure is only representative of the maximum concentrations that can occur at each location, rather than a snapshot of any actual 24-hour period, since the maximum concentrations at each location most likely occur on different days.

FIGURE 4.2
PREDICTED 24-HOUR AVERAGE TSP CONCENTRATIONS - PHASE 2

TSP 24-hr Average AAQC = 120 µg/m^3

Table 4.2 presents the maximum predicted monthly and annual average TSP deposition rates for each of the nine discrete receptors based on the full five years of meteorological data. The table shows no exceedances of the annual deposition standard at any of the sensitive receptors, however, receptor R7 shows a 4% exceedance of the monthly standard. To put this into perspective, model results for the top 10 predicted monthly depositions are presented in Table 4.3. This table shows that the predicted exceedance only occurs once every 5 years. It is unlikely that the worst case emissions that have caused this exceedance will occur at the same time as the poorest dispersion conditions. It is SENES's professional opinion that this predicted exceedance of the monthly deposition will not occur.

TABLE 4.2
MAXIMUM MONTHLY AND ANNUAL AVERAGE TSP DEPOSITION – PHASE 2

Receptor	Maximum Deposition Rate (g/m^2/30 days)	Annual Average Deposition Rate (g/m^2/30 days)
R1	4.0	1.9
R2	2.8	1.5
R3	2.7	1.5
R4	2.5	1.4
R5	2.7	1.5
R6	3.9	2.0
R7	7.2	4.0
R8	5.7	3.3
R9	2.7	1.5
Maximum	**7.2***	**4.0***
AAQC	**7**	**4.6**

Note: Deposition rates reflect loading rates that account for mitigation from precipitation scavenging.
*Values include background concentrations of 2g/m^2/30 days for monthly values and 1.2 g/m^2/30 days for annual values.

TABLE 4.3
MAXIMUM MONTHLY DEPOSITION VALUES AT R7

Rank	Deposition Rate (g/m^2/30 days)	Meteorological Data (month & year)
1st	7.2	September 2001
2nd	6.6	October 2001
3rd	6.6	June 2005
4th	6.5	August 2004
5th	6.2	August 2002
6th	6.2	September 2002
7th	5.9	August 2001
8th	5.9	April 2001
9th	5.9	September 2005
10th	5.8	August 2005
AAQC	**7.0**	-

4.2 PARTICULATE MATTER LESS THAN 10 MICRONS (PM_{10})

The model predicted results for PM_{10} at the nearby residential receptors are presented in Table 4.4. The table shows that the maximum 24-hour PM_{10} concentrations are below the 24-hr Ontario interim standard of 50 $\mu g/m^3$ at all sensitive receptor locations.

TABLE 4.4
MODEL PREDICTED PM_{10} CONCENTRATIONS – PHASE 2

Receptor	Maximum 24-hour Concentration ($\mu g/m^3$)
R1	30
R2	27
R3	28
R4	28
R5	29
R6	32
R7	40
R8	32
R9	28
Maximum	**40***
AAQC	**50**

*Values include background concentrations of 25$\mu g/m^3$

Figure 4.3 presents the 24-hour maximum PM_{10} off-property concentrations, over five years of meteorological data, in the vicinity of the proposed Jigs Hollow Pit for Phase 2. The figure illustrates that the PM_{10} 24-hr Ontario interim standard of 50 µg/m^3 will not be exceeded at any off-site location, including the nearby sensitive receptor locations even if the highest emission day corresponds with the worst dispersion conditions.

It should be noted that there are no provincial or federal air quality standards for annual average PM_{10} concentrations.

FIGURE 4.3
PREDICTED 24-HOUR AVERAGE PM_{10} CONCENTRATIONS – PHASE 2

PM_{10} 24-hr Average AAQC = 50 µg/m^3

4.3 PARTICULATE MATTER LESS THAN 2.5 MICRONS ($PM_{2.5}$)

Figure 4.4 presents the 24-hour maximum $PM_{2.5}$ off-property concentrations in the vicinity of the proposed Jigs Hollow Pit for Phase 2 using five years of meteorology. As can be seen in Figure 4.4, there are no predicted exceedances of the Canada Wide Standard (CWS) at any off-site location.

FIGURE 4.4
PREDICTED 24-HOUR AVERAGE $PM_{2.5}$ CONCENTRATIONS – PHASE 2

$PM_{2.5}$ 24-hr Average AAQC = 30 µg/m^3

The maximum predicted $PM_{2.5}$ concentrations at the nearby residential locations for Phase 2 are presented below in Table 4.5.

TABLE 4.5
MODEL PREDICTED $PM_{2.5}$ CONCENTRATIONS – PHASE 2

Receptor	Maximum 24-hour Concentration ($\mu g/m^3$)
R1	14
R2	13
R3	13
R4	13
R5	14
R6	16
R7	20
R8	15
R9	14
Maximum	**20***
AAQC	**30**

*Values include background concentrations of 12.5$\mu g/m^3$

It should be noted the CWS for $PM_{2.5}$ represents a target concentration in ambient air that is to be achieved by 2010. According to the guidance documents provided by the CCME, achievement of the CWS will be based on community-oriented monitoring sites i.e., sites located where people live, work and play rather than at the expected maximum impact point for specific emission sources (CCME, 2000).

4.4 PERSPECTIVE ON FUGITIVE DUST AND AIR DISPERSION MODELLING

In summary, the dispersion modelling results indicate that using the maximum expected activity at the proposed Jigs Hollow Pit will not result in any exceedances of the relevant Provincial or Federal standards for TSP, PM_{10}, or $PM_{2.5}$ at any off-site location including the nine nearby discrete residential receptor locations.

A comprehensive review of fugitive dust and air dispersion modelling was conducted in 1998 involving a panel of experts including several members of the U.S. EPA [Watson and Chow, 2000]. One of the statements the panel made was to indicate that particles that might be suspended by activities are not necessarily transportable particles, and that the majority (60-90%) of suspended TSP and PM_{10} remains within one to two metres above the ground. As a result, deposition to the ground or impaction on a vertical structure (fence, bush, etc.) occurs within less than 100 metres of its release point significantly reducing downwind concentrations.

Although the development of a vegetated barrier (berm and existing trees) along the north and east extraction limits would likely cause a significant reduction in ambient dust concentrations beyond the property fence line, models such as ISC3 currently are not able to parameterize such a feature. Indeed, one of the suggestions from the experts was to account for the fact that (AP-42) road emission factors can over-estimate effective emissions from these sources. In addition, the workshop concluded that

> *"there is insufficient accounting for deposition losses and horizontal impaction in dispersion models"*

Since up to 90% of the horizontal flux of suspended dust will remain within 2 m of the ground, it is probable that most, if not all of this amount will be prevented from being transported up and over a berm, particularly if there is sufficient vegetation to act as an impaction source. Therefore, any vegetation located along the property line is expected to significantly reduce the transport of fugitive dust from the pit area, which will result in actual dust concentrations being significantly lower than those predicted in this dust assessment.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The analysis completed here illustrates that even using a conservatively high emission scenario (e.g. an overestimate of the real situation), the applicable annual standard for TSP and 24-hour standards for TSP, PM_{10}, and $PM_{2.5}$ were not predicted to be exceeded at any off-site location including the nine nearby sensitive receptors.

Due to the conservatively high emissions used for the modelling used in this study, and the presence of vegetated berms around portions the site, the maximum concentrations are expected to be lower than predicted.

5.2 RECOMMENDATIONS

The analysis assumed a reasonable level of mitigation, including efficient dust control (e.g., watering) of site haul roads. The intent is to ensure that only limited amounts of dust are carried out from the site. In addition, good dust management practices will ensure that any effect associated with material handling and transportation of materials is minimized. These practices are outlined in the Dust Best Management Plan (BMP) that is presented in Appendix E.

In order to ensure that the conclusions of this study remain valid, the following recommendations are made:

- dust mitigation activities on site should meet or exceed those used in this Dust Impact Assessment;
- on-site haul roads should be watered and chemical suppressants applied, as appropriate to reduce dust emissions; and,
- a second coat of calcium chloride should be applied during the late summer on the off-site haul road, including Peel Street east of the site over to the Grand River.

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APPENDIX A

DETAILED EMISSIONS TABLES

Summary of Variables Used for Emission Estimates on Worksheets **34915 Jigs Hollow Pit**

Soil & Truck Volume Assumptions

Variable	Assumed Value	Units	Comments
Moisture Content of extracted material	4%	%	See also Material handling Below
Construction days per year	220	days per year	
Construction Days per week	5	days per week	
Construction Hours per Day	12.0	(hours)	
Haul Trucks per hour	3	units	one way only
Average Haul Truck Weight	26	tonnes	Average of 37 tonnes full and 15 tonnes empty
Therefore tonnes per hour processing rate	66	tonnes/hr	22 tonnes per load x three loads per hour

Material Handling Calculation Method: Drop Equation AP-42 13.2.4, November 2006

Variable	Assumed Value	Units	Comments
Moisture Content of extracted material	4%	%	Site specific information from hydrogeologists (see also Soil & Truck Volumes above)
Wind Speed	5	m/s	MOE Outdoor default wind speed - Guideline A-10: Procedure for Preparing an ESDM Re July 2005, Table C-2: Summary of Some Useful Equations and General Guidance
tonnes per hour for material handling activities	various	tonnes per hour	see Soil & Truck Volumes calculations worksheet
Control Efficiency	50%	%	50% Control Efficiencies applied for drops to hopper and trucks as walls reduce wind expo
Control Efficiency	0%	%	No Control Efficiencies for drops to haul trucks and drops to stockpile

Crushing and Screening Calculation Method: Crushed Stone Processing AP-42 11.19.2, August 2004

Variable	Assumed Value	Units	Comments
tonnes per hour	various	tonnes per hour	see Soil Volume and Truck Count calculations worksheet

Unpaved Haul Road Emissions Calculation Method: Unpaved Road Emissions, AP-42 13.2.2-4, November 2006

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	2.4%	(%)	Site Specific Analysis @ 2.3% however, used AP-42 Table 13.2.2-1 Typical Silt Contents - Stone Quarrying 2.4% as low end of sampled
On-site haul trucks - Fleet Average Weight	26	tonnes	Average of 37 tonnes full and 15 tonnes empty
Passes per day	various	tonnes per hour	see Soil Volume and Truck Count calculations worksheet
ISC Calibration Factor for Roads Emissions comparable to CAL3Q	3.5	unitless	SENES Study - see Report Appendix C
On-site haul roads - Control Efficiency	90%	(%)	Based on chemical suppressants and watering
Active Pit haul road - Control Efficiency	90%	(%)	Based on chemical suppressants and watering

Haul Truck Tailpipe Emissions Calculation Method: Mobile 6C (Haul Trucks)

Variable	Assumed Value	Units	Comments
Haul trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - EF depends on vehicle weight

Stationary Equipment Tailpipe Emissions Calculation Method: AP-42 Section 3.3 & 3.4 - Emissions from Large Diesel Generators (>600 hp) and Small Diesel Generators (<600 hp)

Variable	Assumed Value	Units	Comments
Equipment hp rating for crusher at processing plant	425	hp	Assumption based on SENES experience (Craig Pit)
Percent Operational Capacity of Generator	78%	%	From Urbemis Appendix G – Construction Equipment Emission Factors, Page G-2

NonRoad Equipment Tailpipe Emissions Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Percent of Time Excavator Equipment is Operating	57%	%	Assumption based on URBEMIS2007 Model Appendix G for each piece of Equipment
Equipment hp rating for loader	211	hp	Actual hp ratings from assumed equipment CAT962H Loader

Wind Erosion Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Silt (%)	2.4%	%	Site Specific Analysis Silt Content of 2.3%
Frequency Wind > 5.4 m/s (%)	23.4	%	Pearson Airport Climate Normals - Canadian Climate Normals Website

Off Site Roads Vehicle Counts

Variable	Assumed Value	Units	Comments
Avg Weight for Off-Site Road Light Duty Vehicles	3	tonnes	Considered conservative as mid-sized SUV's are approximately 2 tonnes
Avg Weight for Haul Trucks and Off-Site Heavy Duty Vehicles	26	tonnes	Conservative - Typical off-site truck weight is 12 tonnes, haul trucks are 26 tonnes

Off Site Unpaved Roads Calculation Method: Paved Road Emissions, AP-42 13.2.1, November 2006

Variable	Assumed Value	Units	Comments
ISC Calibration Factor for Roads Emissions comparable to CAL3Q	3.5	unitless	
Vehicle Speed	50	kph	
Road Moisture Content	4	%	Baseline moisture content, likely higher with the application of Calcium Chloride
Off Site Unpaved Roads Existing Conditions	80%	(%)	Based on Calcium Chloride application in Late Spring, on 40% control for fall months
Off Site Unpaved Roads Phase 2	80%	(%)	Based on Calcium Chloride application in Late Spring and Late Summer - Reference - *Recommended Preactices and Best Available Control Measures* - BACM, October 2004

Material Handling Particulate Matter Emissions **34915 Jigs Hollow Pit**

Material Handling Emissions	k			M (%)	U (m/s)	Emission Factor in kg/tonne			Tonnes Handled per Hour	Uncontrolled (g/s)			Assumed Control Efficiency (%)[1]	Controlled (g/s)		
	TSP	PM_{10}	$PM_{2.5}$			TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$
Phase 2																
Front End Loader drop to Haul Truck @Face	0.74	0.35	0.053	4%	5.00	0.00130	0.00062	0.00009	66	0.0239	0.0113	0.0017	50%	0.0120	0.0057	0.0009
Haul Truck Drop to Surge Pile @Processing Plant	0.74	0.35	0.053	4%	5.00	0.00130	0.00062	0.00009	66	0.0239	0.0113	0.0017	0%	0.0239	0.0113	0.0017
Front End Loader drop to Crusher Hopper @Processing Plant	0.74	0.35	0.053	4%	5.00	0.00130	0.00062	0.00009	66	0.0239	0.0113	0.0017	50%	0.0120	0.0057	0.0009
Drop from Stacker to Stockpile @Processing Plant	0.74	0.35	0.053	4%	5.00	0.00130	0.00062	0.00009	66	0.0239	0.0113	0.0017	0%	0.0239	0.0113	0.0017
Front End Loader drop to Haul Truck @Processing Plant	0.74	0.35	0.053	4%	5.00	0.00130	0.00062	0.00009	66	0.0239	0.0113	0.0017	50%	0.0120	0.0057	0.0009

(1) Control Efficiencies applied for drops to hopper and drops to trucks as

Emission Factor Equation	Reference
$E = k \times (0.0016) \times (U/2.2)^{1.3} / (M/2)^{1.4}$	AP-42 13.2.4
	November 2006

Parameter	TSP	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

E = emission factor in kg/megagram
k = particle size multiplier for particulate size range and units of interest
U = mean wind speed (m/s)
M = material moisture content (%)

Crushing and Screening Particulate Matter Emissions **34915 Jigs Hollow Pit**

Description	Emission Factor in kg/tonne			Tonnes Loaded per Hour	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$
Phase 2							
Primary Crushing @Processing Plant	0.0027	0.0012	0.0006	66	0.0495	0.0220	0.0110
Secondary Crushing @Processing Plant	0.0027	0.0012	0.0006	66	0.0495	0.0220	0.0110
Screening @Processing Plant	0.0125	0.0043	0.0020	66	0.2292	0.0788	0.0367

EMISSION FACTORS (kg/Mg of material throughput)[1]			
Source	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Primary Crushing	0.0027	0.0012	0.0006
Secondary Crushing	0.0027	0.0012	0.0006
Tertiary Crushing	0.0027	0.0012	0.00005
Screening	0.0125	0.0043	0.002

(1) All emission factors from AP-42 Table 11.19.2-1

[shaded cells] uses tertiary EF's as upper limits as No Data was available for Primary or Secondary Crushing

Note: AP-42 Section 11.19.2 describes the stages of the crushing process as follows:

Type of Crushing Activity
Primary Crushing - Jaw, Impact or Gyratory Crusher
Tertiary Crushing - Cone or Impact Crusher
Secondary Crushing - Cone Crusher

Crusher Output Sizing
7.5 to 30 cm (3 to 12 inches) diameter
0.5 to 2.5 cm (3/16th to 1 inch) diameter
2.5 to 10 cm (1 to 4 inches) diameter

SPM Emissions Sample Calculation for Uncontrolled Crushing Emissions:

$$\frac{g\,(TSP)}{\sec} = \frac{tonnes\,loaded}{per\,hour} \times \frac{0.0027\,kg\,TSP}{tonne\,loaded} \times \frac{1\,hour}{3600\,seconds} \times \frac{1000\,grams}{1\,kg}$$

On-Site Unpaved Haul Roads Particulate Matter Emissions **34915 Jigs Hollow Pit**

Unpaved Road Emissions (see description on Soil & Truck Volumes worksheet)	k (lb/VMT)			s (%)	Fleet Average Weight (tonnes)	Emission Factor in g/VKT			Total # vehicle passes per hour (in and out)	One way length (km)	ISC Calibration Factor for Roads	Uncontrolled (g/s)			Assumed Control Efficiency (%)	Controlled (g/s)		
	TSP	PM_{10}	$PM_{2.5}$			TSP	PM_{10}	$PM_{2.5}$				TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$
Phase 2																		
Haul Rd1 Entrance	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.04	3.5	0.023	0.005	0.001	90 %	0.002	0.001	0.000
Haul Rd2 Scale House	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.04	3.5	0.023	0.005	0.001	90 %	0.002	0.001	0.000
Haul Rd3	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.04	3.5	0.023	0.005	0.001	90 %	0.002	0.001	0.000
Haul Rd4	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.30	3.5	0.169	0.038	0.004	90 %	0.017	0.004	0.000
Haul Rd5	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.14	3.5	0.079	0.018	0.002	90 %	0.008	0.002	0.000
Haul Rd6	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.04	3.5	0.023	0.005	0.001	90 %	0.002	0.001	0.000
Haul Roads Within Pit	4.9	1.5	0.15	2.4	26.0	1183	263	26	6	0.70	1.0**	1.380	0.306	0.031	90 %	0.138	0.031	0.003

** ISC Calibration factor for roads is based on increased mixing from vehicle wakes, however, the OPENPIT algorithm accounts for mixing of all sources within a pit. Therefore, no calibration factor is applied to road sources within the pit.
** Annual rates were not used, to be conservative the 24-hr values were applied to annual meteorology.

Emission Factor Equation	Reference	
$E_{unpaved} = k \times (s/12)^a \times (W/3)^b$	AP-42 13.2.2-4, November 2006	industrial sites

Constant	Industrial Roads		
	TSP	PM_{10}	$PM_{2.5}$
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

E = size speific emission factor (lb/VMT)
s = surface materal silt content (%)
W = mean vehicle weight (tons)
1 lb/VMT = 281.9 g/VKT
$E_{ext} = E \times [(365-P)/365]$
E_{ext} = annual size-specific emission factor for natural mitigation, lb/VMT
P = number of days in a year with at least 0.254 mm of precipitation

Haul Truck Tailpipe Emissions **34915 Jigs Hollow Pit**

Vehicle Use (see description on Soil & Truck Volumes worksheet)	One-way road length (km)	Total Number of Haul Trucks per hour two-ways	TSP	PM_{10}	$PM_{2.5}$
Phase 2			**(g/s)**	**(g/s)**	**(g/s)**
Haul Rd1 Entrance	0.040	6	0.0000	0.0000	0.0000
Haul Rd2 Scale House	0.040	6	0.0000	0.0000	0.0000
Haul Rd3	0.040	6	0.0000	0.0000	0.0000
Haul Rd4	0.300	6	0.0001	0.0001	0.0001
Haul Rd5	0.140	6	0.0000	0.0000	0.0000
Haul Rd6	0.040	6	0.0000	0.0000	0.0000
Haul Roads Within Pit	0.700	6	0.0002	0.0002	0.0002

Mobile 6C Emission Factors - Year 2007

Vehicle Type	Average Vehicle Weight (tonnes)	TSP	PM_{10}	$PM_{2.5}$
Off-Site Haul Trucks	26	0.199	0.199	0.164

All Emission Factors are g/VKT

$$Emissions(g/s) = EF\left(\frac{g}{VKT}\right) \times Road\ Length\,(km) \times \left(\frac{\#of\ Trucks}{hour}\right) \times \left(\frac{1\,hour}{3{,}600\,\sec}\right)$$

Stationary Diesel Equipment Tailpipe Emissions **34915 Jigs Hollow Pit**

Vehicle Use	Power Rating (hp)[1]	Operational Percent Capacity (%)[2]	Uncontrolled (g/s)		
			TSP	PM_{10}	$PM_{2.5}$
Phase 2					
Diesel Generator for Primary and Secondary Crushers @Processing Plant	425	78%	0.0921	0.0921	0.0921

(1) hp rating based on SENES experience with aggregate pits

(2) Operational percent capacity from Urbemis Software Appendix G – Construction Equipment Emission Factors, Page G-2

AP-42 Emission Factors for Diesel Generators (lb/hp-hr)			
Vehicle Type	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Small Diesel Generators (less than 600 hp) Table 3.3-1 and Table 3.3-2	0.0022	0.0022	0.0022

PM Emissions Sample Calculation for diesel generator:

PM Emission =
$$power(hp) \times \frac{0.0022 lb}{hp - hr} \times 78\% \times \left(\frac{1\,hr}{3{,}600\sec}\right) \times \left(\frac{1kg}{2.2lb}\right) \times \left(\frac{1000g}{kg}\right)$$

Tailpipe Emissions - Working Face Excavators and Loaders **34915 Jigs Hollow Pit**

Vehicle Use	Power Rating (hp)	Emission Factor in g/hp-hr			Frequency of Operation (%)	Uncontrolled (g/s)		
		TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$
Phase 2								
10T Excavator (CAT 962H) @Face	211	0.402	0.402	0.402	57%	0.0134	0.0134	0.0134
10T Excavator (CAT 962H) @Processing Plant	211	0.402	0.402	0.402	57%	0.0134	0.0134	0.0134

Note: Emission Factor values are from US EPA Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling--Compression-Ignition, April 2004 (EPA420-P-04-009), Page A6 based on a Tier 0 175hp to 300hp Engine (built prior to 1996).
http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2004/420p04009.pdf

$$Emissions(g/s) = EF\,(g/hp-hr) \times hp \times Frequency\ of\ Operation(\%) \times \left(\frac{1\,hour}{3{,}600\,seconds}\right)$$

Wind Erosion Particulate Matter Emissions **34915 Jigs Hollow Pit**

Wind Erosion Source	s %	f (%)	Road Length (m)	Road Width (m)	Area (ha)	EF (kg/ha/day)			Emissions (g/s)		
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Phase 2											
Open Pit - Active Roads	2.4	23.4	700	10	0.7	4.742	2.371	0.948	0.03842	0.01921	0.00768

Equation				Reference
EF = k*1.9 *(s/1.5) *(f / 15)				AWMA - Air Pollution Engineering Manual, 1992, page 137
Parameter	**TSP**	**PM_{10}**	**$PM_{2.5}$**	
k	1.0	0.5	0.2	

EF = emission factor (kg/day)
k = particle size multilier for particulate size range of interest
f = Percentage of the time that the wind speed is > 5.4 m/s
s = Silt Content in %

Off Site Unpaved Roads Vehicle Counts **34915 Jigs Hollow Pit**

Description	Hour of Day																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	24hr Total	Maximum Ratio
Phase 2																										
Jigs Hollow Rd1	2	2	2	2	2	2	21	28	21	15	15	15	15	15	15	21	28	21	9	9	9	9	9	9	**298**	
Jigs Hollow Rd2	2	2	2	2	2	2	21	28	21	15	15	15	15	15	15	21	28	21	9	9	9	9	9	9	**298**	
Peel St to Entrance	2	2	2	2	2	2	21	28	21	15	15	15	15	15	15	21	28	21	9	9	9	9	9	9	**298**	
Peel St East of Site1	2	2	2	2	2	2	15	22	15	9	9	9	9	9	9	15	22	15	9	9	9	9	9	9	**220**	
Peel St East of Site2	2	2	2	2	2	2	15	22	15	9	9	9	9	9	9	15	22	15	9	9	9	9	9	9	**220**	
Calculated Hourly Profile for Haul Road	0.007	0.007	0.007	0.007	0.007	0.007	0.072	0.094	0.072	0.050	0.050	0.050	0.050	0.050	0.050	0.072	0.094	0.072	0.030	0.030	0.030	0.030	0.030	0.030	1.00	0.094
Assumed Hourly Profile for Peel St	0.009	0.009	0.009	0.009	0.009	0.009	0.070	0.100	0.070	0.041	0.041	0.041	0.041	0.041	0.041	0.070	0.100	0.070	0.041	0.041	0.041	0.041	0.041	0.041	1.03 *	0.100

* values should sum to 1.00, exceeding this total results in a conservative assessment

Assumptions: IBI Group provided existing 24hr AADT values and hourly traffic ratios for Jigs Hollow Rd and Peel St.
IBI Group assumed:
- 24hr AADT values were 10 times the hourly peak of 22 vehicles
- Shoulder hours were approximately 2/3rd's the peak hours (i.e, 15 vehicles per hour)
- Minimal traffic during first six hours of the day (i.e., 2 vehicles per hour)
- Remaining daily traffic is approximately equal for 12 hour balance (i.e., 9 vehicles per hour)

Off Site Unpaved Roads Particulate Matter Emissions

34915 Jigs Hollow Pit

Road Emissions - TSP	24 hr AADT	k (lb/VMT)	s (%)	Speed (mph)	Road Moisture Content (%)	Road Dust Emission Factor in g/VKT SPM	One way length (km)	ISC Calibration Factor for Roads	Control (%)	Maximum Hourly TSP Emission Rate Hour 8 (g/s)
Phase 2										
Jigs Hollow Rd1	298	6	2.4	31	4	183.1	0.620	3.5	80%	5.04E-02
Jigs Hollow Rd2	298	6	2.4	31	4	183.1	0.380	3.5	80%	3.09E-02
Peel St to Entrance	298	6	2.4	31	4	183.1	0.380	3.5	80%	3.09E-02
Peel St East of Site1	220	6	2.4	31	4	183.1	0.720	3.5	80%	4.60E-02
Peel St East of Site2	220	6	2.4	31	4	183.1	0.450	3.5	80%	2.88E-02

Road Emissions - PM_{10}	24 hr AADT	k (lb/VMT)	s (%)	Speed (mph)	Road Moisture Content (%)	Road Dust Emission Factor in g/VKT PM_{10}	One way length (km)	ISC Calibration Factor for Roads	Control (%)	Maximum Hourly PM_{10} Emission Rate Hour 8 (g/s)
Phase 2										
Jigs Hollow Rd1	298	1.8	2.4	31	4	68.0	0.620	3.5	80%	1.87E-02
Jigs Hollow Rd2	298	1.8	2.4	31	4	68.0	0.380	3.5	80%	1.15E-02
Peel St to Entrance	298	1.8	2.4	31	4	68.0	0.380	3.5	80%	1.15E-02
Peel St East of Site1	220	1.8	2.4	31	4	68.0	0.720	3.5	80%	1.71E-02
Peel St East of Site2	220	1.8	2.4	31	4	68.0	0.450	3.5	80%	1.07E-02

Road Emissions - $PM_{2.5}$	24 hr AADT	k (lb/VMT)	s (%)	Speed (mph)	Road Moisture Content (%)	Road Dust Emission Factor in g/VKT $PM_{2.5}$	One way length (km)	ISC Calibration Factor for Roads	Control (%)	Maximum Hourly $PM_{2.5}$ Emission Rate Hour 8 (g/s)
Phase 2										
Jigs Hollow Rd1	298	0.18	2.4	31	4	6.7	0.620	3.5	80%	1.85E-03
Jigs Hollow Rd2	298	0.18	2.4	31	4	6.7	0.380	3.5	80%	1.13E-03
Peel St to Entrance	298	0.18	2.4	31	4	6.7	0.380	3.5	80%	1.13E-03
Peel St East of Site1	220	0.18	2.4	31	4	6.7	0.720	3.5	80%	1.69E-03
Peel St East of Site2	220	0.18	2.4	31	4	6.7	0.450	3.5	80%	1.05E-03

Assumption: Average vehicle weight for off-site roads based on the assumption that 95% of vehicles are light duty (3 tonnes) and 5% are heavy duty (37.5 tonnes). Therefore, 0.95*3+0.05*37.5=4.73 tonnes

Emission Factor Equation	Reference	
$E_{unpaved} = k \times (s/12)^a \times (S/30)^d / (M/0.5)^c - C$	AP-42 13.2.2-4, November 2006	Public Roads

Constant	Industrial Roads TSP	PM_{10}	$PM_{2.5}$
k (lb/VMT)	6.0	1.8	0.18
a	1	1	1
c	0.3	0.2	0.2
d	0.3	0.5	0.5
C (lb/VMT)	0.00047	0.00047	0.00036

E = size speific emission factor (lb/VMT)
s = surface materal silt content (%)
S = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear
1 lb/VMT = 281.9 g/VKT

Phase 2 Off Site Tailpipe Emissions

Road Emissions - TSP	One way length (km)	ISC Calibration Factor for Roads	Emission Rate (g/s) TSP																								Maximum Hourly Emission Rate (g/s)
Phase 2			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
Jigs Hollow Rd1	0.620	3.5	2.92E-06	2.92E-06	2.92E-06	2.92E-06	2.92E-06	2.92E-06	8.12E-05	9.08E-05	8.12E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	8.12E-05	9.08E-05	8.12E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	9.08E-05
Jigs Hollow Rd2	0.380	3.5	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	4.98E-05	5.57E-05	4.98E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.98E-05	5.57E-05	4.98E-05	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	5.57E-05
Peel St to Entrance	0.380	3.5	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	4.98E-05	5.57E-05	4.98E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.98E-05	5.57E-05	4.98E-05	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	5.57E-05
Peel St East of Site1	0.720	3.5	3.39E-06	3.39E-06	3.39E-06	3.39E-06	3.39E-06	3.39E-06	2.60E-05	3.72E-05	2.60E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	2.60E-05	3.72E-05	2.60E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	3.72E-05
Peel St East of Site2	0.450	3.5	2.12E-06	2.12E-06	2.12E-06	2.12E-06	2.12E-06	2.12E-06	1.63E-05	2.33E-05	1.63E-05	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	1.63E-05	2.33E-05	1.63E-05	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	2.33E-05

Road Emissions - PM_{10}	One way length (km)	ISC Calibration Factor for Roads	PM_{10} - Emission Rate (g/s) Hour of the Day																								Maximum Hourly Emission Rate (g/s)
Phase 2			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
Jigs Hollow Rd1	0.620	3.5	2.92E-06	2.92E-06	2.92E-06	2.92E-06	2.92E-06	2.92E-06	8.12E-05	9.08E-05	8.12E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	7.19E-05	8.12E-05	9.08E-05	8.12E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	9.08E-05
Jigs Hollow Rd2	0.380	3.5	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	4.98E-05	5.57E-05	4.98E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.98E-05	5.57E-05	4.98E-05	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	5.57E-05
Peel St to Entrance	0.380	3.5	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	1.79E-06	4.98E-05	5.57E-05	4.98E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.41E-05	4.98E-05	5.57E-05	4.98E-05	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	8.03E-06	5.57E-05
Peel St East of Site1	0.720	3.5	3.39E-06	3.39E-06	3.39E-06	3.39E-06	3.39E-06	3.39E-06	2.60E-05	3.72E-05	2.60E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	2.60E-05	3.72E-05	2.60E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	3.72E-05
Peel St East of Site2	0.450	3.5	2.12E-06	2.12E-06	2.12E-06	2.12E-06	2.12E-06	2.12E-06	1.63E-05	2.33E-05	1.63E-05	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	1.63E-05	2.33E-05	1.63E-05	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	9.51E-06	2.33E-05

Road Emissions - $PM_{2.5}$	One way length (km)	ISC Calibration Factor for Roads	$PM_{2.5}$ - Emission Rate (g/s) Hour of the Day																								Maximum Hourly Emission Rate (g/s)
Phase 2			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
Jigs Hollow Rd1	0.620	3.5	1.91E-06	1.91E-06	1.91E-06	1.91E-06	1.91E-06	1.91E-06	6.32E-05	6.95E-05	6.32E-05	5.71E-05	5.71E-05	5.71E-05	5.71E-05	5.71E-05	5.71E-05	6.32E-05	6.95E-05	6.32E-05	8.59E-06	8.59E-06	8.59E-06	8.59E-06	8.59E-06	8.59E-06	6.95E-05
Jigs Hollow Rd2	0.380	3.5	1.17E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06	3.87E-05	4.26E-05	3.87E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.87E-05	4.26E-05	3.87E-05	5.26E-06	5.26E-06	5.26E-06	5.26E-06	5.26E-06	5.26E-06	4.26E-05
Peel St to Entrance	0.380	3.5	1.17E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06	3.87E-05	4.26E-05	3.87E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.50E-05	3.87E-05	4.26E-05	3.87E-05	5.26E-06	5.26E-06	5.26E-06	5.26E-06	5.26E-06	5.26E-06	4.26E-05
Peel St East of Site1	0.720	3.5	2.22E-06	2.22E-06	2.22E-06	2.22E-06	2.22E-06	2.22E-06	1.71E-05	2.44E-05	1.71E-05	9.97E-06	9.97E-06	9.97E-06	9.97E-06	9.97E-06	9.97E-06	1.71E-05	2.44E-05	1.71E-05	9.97E-06	9.97E-06	9.97E-06	9.97E-06	9.97E-06	9.97E-06	2.44E-05
Peel St East of Site2	0.450	3.5	1.39E-06	1.39E-06	1.39E-06	1.39E-06	1.39E-06	1.39E-06	1.07E-05	1.52E-05	1.07E-05	6.23E-06	6.23E-06	6.23E-06	6.23E-06	6.23E-06	6.23E-06	1.07E-05	1.52E-05	1.07E-05	6.23E-06	6.23E-06	6.23E-06	6.23E-06	6.23E-06	6.23E-06	1.52E-05

Mobile 6C Emission Factors - Year 2007			
Vehicle Type	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Haul Trucks and Off-Site Heavy Duty Vehicles	0.199	0.199	0.164
Off-Site Light Duty Vehicles	0.0296	0.0296	0.0194

All Emission Factors are g/VKT

$$Emissions(g/s) = EF\left(\frac{g}{VKT}\right) \times Road\ Length\,(km) \times \left(\frac{vehicles}{hour}\right) \times \left(\frac{1\,hour}{3{,}600\sec}\right)$$

APPENDIX B

SENES ISC3 vs. CAL3QHCR STUDY

Modelling Line Sources

An air dispersion model is a mathematical model that simulates how pollutant emissions to the air from specified sources are dispersed in the environment. There are a number of MOE-approved models that can be used to predict concentrations resulting from the landfill operations. These are the Fugitive Dust Model (FDM), CAL3QHCR and the Industrial Source Complex Version 3 (ISCST3) Model. SENES' initial evaluation of the models identified a combination of ISCST3 and CAL3QHCR as the most appropriate model selection.

This combination approach was chosen to account for the ISC3 model's limitations with respect to line sources (such as roads) and the initial dispersion from vehicle movements along these line sources. More specifically, the US EPA suggests that for their sources, a 1:10 aspect ratio be used. For long roads, this results in the development of a significant number of small sources, which then leads to excessive model run times.

SENES completed the initial baseline modelling using the combined approach. During this complex and time consuming exercise, SENES became aware of recent publications which suggested the ISC3 model could be run with significantly larger aspect ratios than 1:10 for their sources. SENES subsequently contacted the ISC3 model developer, Roger Brode of MACTEC Federal Programs to confirm the literature. The model developer agreed that ISC3 can be used to model roads but observed that it tended to over-predict concentrations close to the line sources.

As a result of this new information, SENES revised their model selection to use an adjusted ISC3 model for all sources including roads. The ISC model adjustment for roads is described below, from a previous study completed by SENES.

Case Study – ISC3 Model Adjustment for Line Sources (Roads)

Three different road links covering the entire modelling domain were examined. The links modelled were: a part of Highway 401, 6619 m in length; Side Road 10 (SR10), 1100m in length; and the Entrance Ramp to Westbound Highway 401, 280m in length.

The modelling exercise indicated good agreement between the ISC3 and CAL3QHCR models could be achieved if the ISC3 emission rates are reduced by a factor of 3.5. This emission reduction is required when the ISC3 is used in the RURAL mode. It is well known that the CAL3QHC dispersion coefficients had been increased to capture the mechanical mixing caused by traffic movements. For the ISC3 model running in the URBAN mode, the adjustment factor is different but that factor was not determined for this study. Examination of the figures presented below indicates that the ISC3 Model, with a correction of 3.5, under-predicts beyond 500 m from the edge of the roads. What was not clear was, on the whole modelling domain, what was happening close to the road.

In order to clarify this situation, detailed modelling was undertaken for two links 1 km in length, oriented North-South with the traffic volume of 1621 vehicles northbound and 1275 vehicles southbound with an emission factor of 0.117 g/mi/vehicle (PM_{10} tailpipe emissions). The meteorology used for these runs was Toronto Pearson International Airport for 2001. Predictions downwind of two different locations on these links were used in order to assess the impact of the length of a road segment. Those two locations were (1) the end of a link and (2) the middle of a link.

PM_{10} was modelled perpendicular to the link end and the results of predictions with the distance are presented in Figures B.1, B.2 and B.3, for a 1-hour, 24-hour and annual prediction, respectively. It is clear that close to the road the ISC3 Model still over predicts but after a few hundred metres it is only under-predicting by about 10-15%. In order to ensure that the impact of road sources was properly modelled at the houses very close to the road, SENES Consultants calculated an appropriate reduction factor of 3.5 for this study. This slight under-prediction at distances of about 500 m was not considered to be significant because the concentrations at these distances are very small. Figures B.2 and B.3 show some under-prediction using this method for the 24-hour and annual averaging periods.

Figures B.4, B.5 and B.6 present the same concentration curves for a location near the middle of a link for the 1-hour, 24-hour and annual averaging times, respectively. For almost all distances and averaging times, the ISC3 Model over-predicts the concentrations.

FIGURE B.1
CAL3QHC VS. ISC3 – CONCENTRATIONS WITH DISTANCE
1 HOUR – LINK END

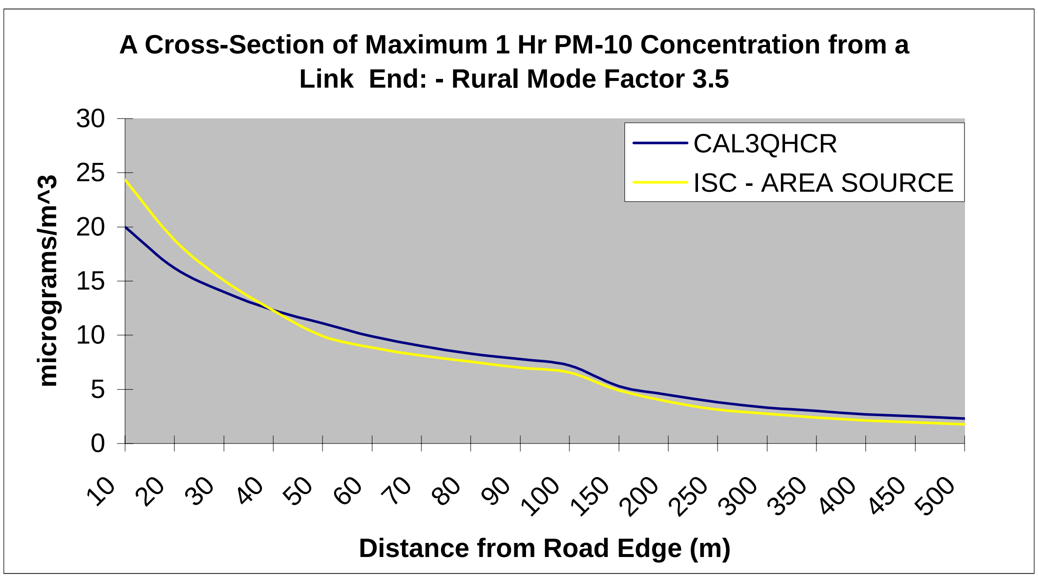


FIGURE B.2
CAL3QHC VS. ISC3 – CONCENTRATIONS WITH DISTANCE
24 HOUR – LINK END

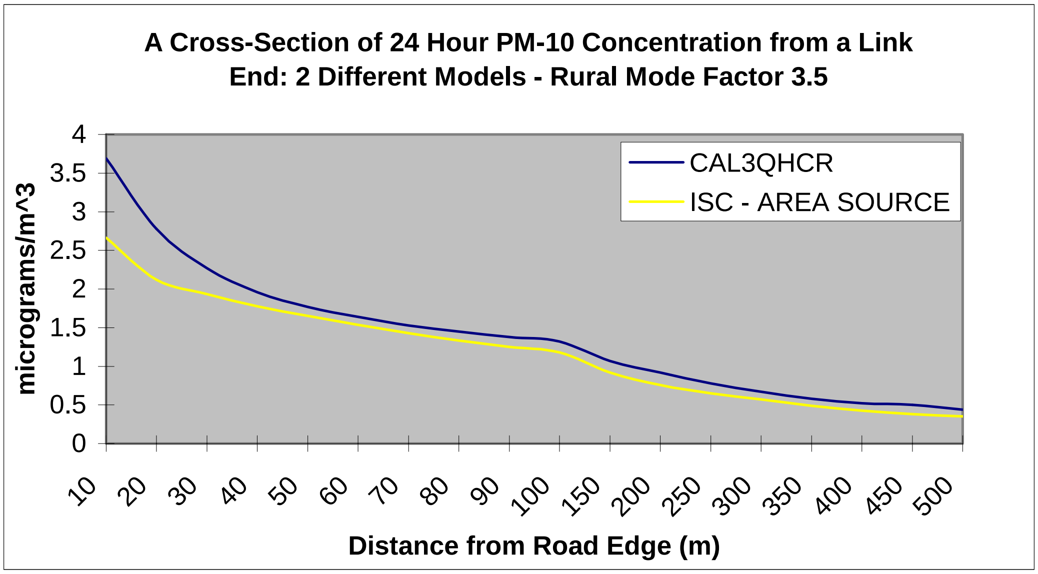


FIGURE B.3
CAL3QHC VS. ISC3 – CONCENTRATIONS WITH DISTANCE
ANNUAL AVG. – LINK END

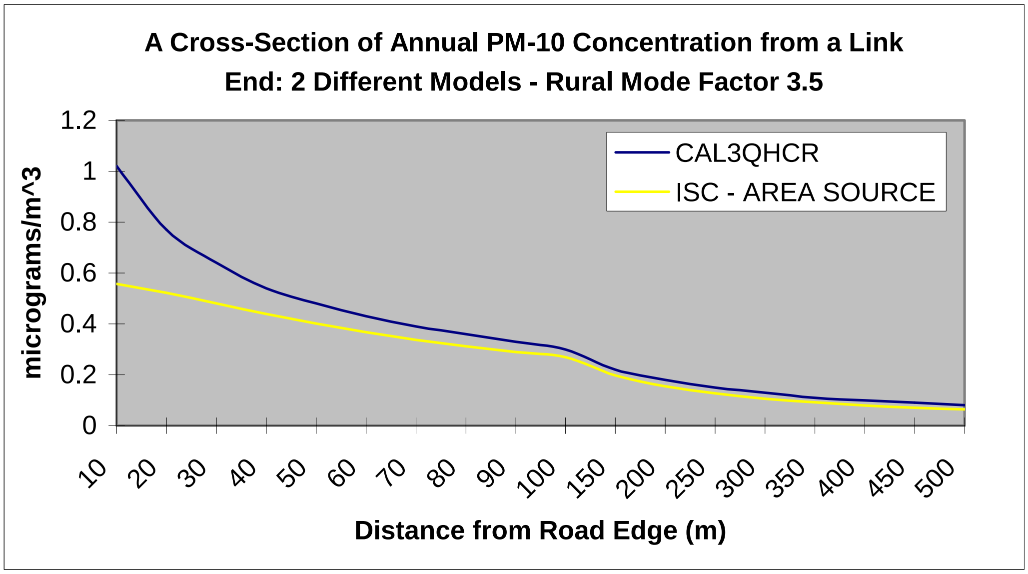


FIGURE B.4
CAL3QHC VS. ISCST3 – CONCENTRATIONS WITH DISTANCE
1 HOUR –LINK MIDDLE

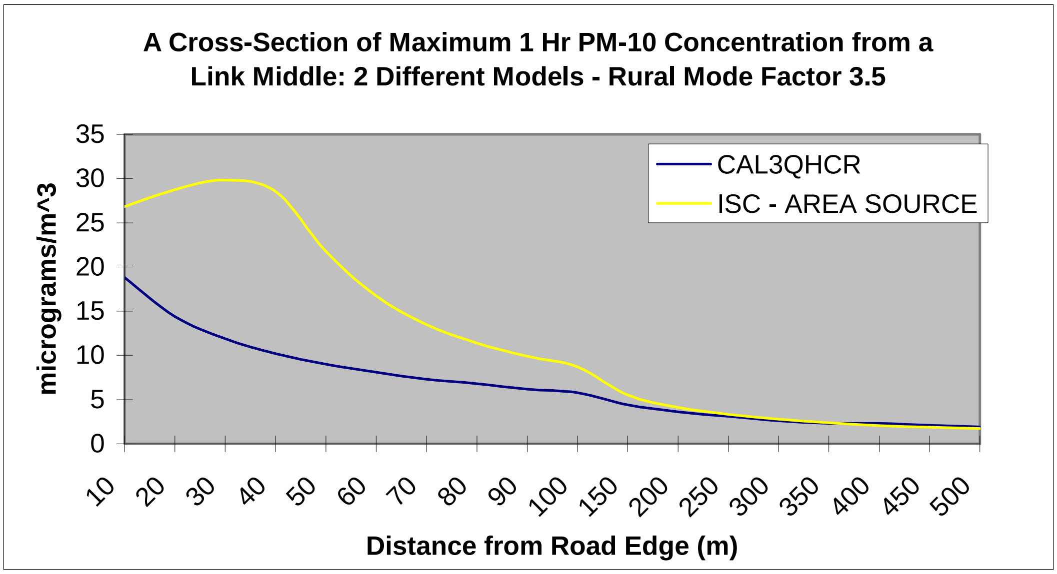


FIGURE B.5
CAL3QHC VS. ISCST3 – CONCENTRATIONS WITH DISTANCE
24 HOUR –LINK MIDDLE

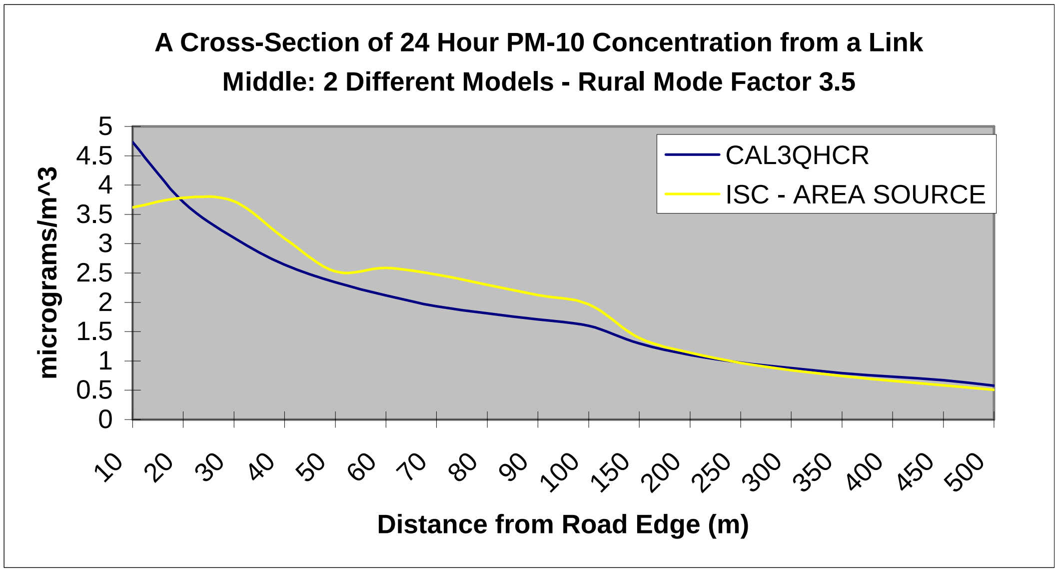
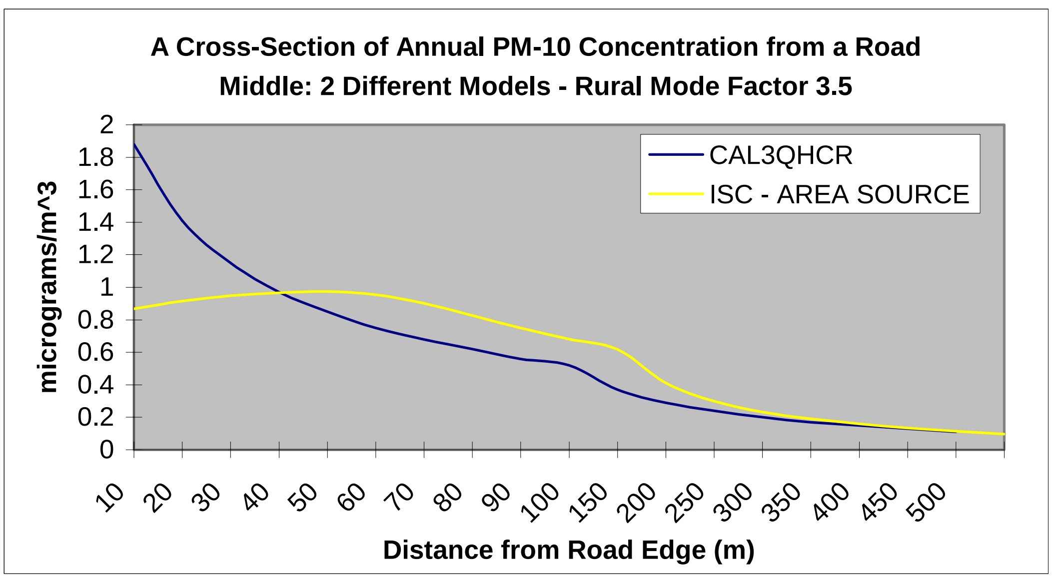


FIGURE B.6
CAL3QHC VS. ISCST3 – CONCENTRATIONS WITH DISTANCE
ANNUAL AVG.–LINK MIDDLE



Based on the results presented here, it is clear that the concentrations vary significantly with distance from the road. For the application to the Study Site, the comparison of the performance of the two models was based on looking at all discrete receptors and modelling all on-site and off-site roads for the base case scenario. The CALINE3 Model (the foundation of the CAL3QHCR) over predicts the hourly concentrations for E and F stability by about 40 – 60% and at close receptors it can over predict by more than 80% (CALINE 3 – Interim Report, 1979).

Also all of the CALINE3 validation runs were based on hourly concentrations. In summary, based on the validation studies, CALINE3 tends to over-predict concentrations. In the approach that SENES used, the comparison between the ISC3 and CAL3QHCR at discrete receptors shows good agreement at critical receptors and under-predictions of up to 30% further from the landfill. Since CALINE3 over-predicts, it is concluded that the agreement between the ISC3 and CALINE3 is a reasonable representation of the reality around the Study Site.

In summary, the links and discrete receptors were all tested because they had different lengths, angle orientation and distances from the road as well as different emission levels. Based on this sensitivity test, it is concluded that ISC3 with an adjusted emission factor of 3.5 can be used for road modelling for majority of the receptors, especially those within about 100 m of roads. Receptors further from a road, where the contribution is small, may be under-predicted. (in the range of 15 –30 %).

It is important to note that the observed concentrations at the background monitoring station, located just downwind of a road, for the baseline study were in the range of 30 – 40 $\mu g/m^3$. The ISC3 model predicted concentrations, using this approach, were also in the same range.

APPENDIX C

SAMPLE ISC INPUT FILE

```
****************************************
** ISCST3 Input Produced by:
** AERMOD View Ver. 6.1.0
** Lakes Environmental Software Inc.
** Date: 3/19/2009
** File: D:\30000 - Projects\34915 Jiggs Hollow Pit\Modelling\PM10Ph2\PM10Ph2.INP
****************************************
** ISCST3 Control Pathway
****************************************
CO STARTING
   TITLEONE D:\30000 - Projects\34915 Jiggs Hollow Pit\Modelling\PM\PM\PM.isc
   MODELOPT CONC DDEP  RURAL TOXICS
   AVERTIME 24 ANNUAL
   POLLUTID TSP
   TERRHGTS FLAT
   RUNORNOT RUN
CO FINISHED
****************************************
** ISCST3 Source Pathway
****************************************
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION AREA1 AREA 539906.646 4823115.697
** DESCRSRC Jigs Road Seg1 Tailpipe
   LOCATION AREA2 AREA 540519.725 4823019.567
** DESCRSRC Jigs Road Seg2 Tailpipe
   LOCATION AREA4 AREA 540960.203 4823322.620
** DESCRSRC Entrance Rd1
   LOCATION AREA5 AREA 540952.311 4823272.405
** DESCRSRC Entrance Rd2
   LOCATION AREA6 AREA 540993.007 4823267.236
** DESCRSRC Entrance Rd3
   LOCATION AREA7 AREA 541020.962 4823282.875
** DESCRSRC Entrance Rd4
   LOCATION OPIT1 OPENPIT 541290.000 4822825.500
** DESCRSRC Open Pit Source Extraction Face
   LOCATION AREA9 AREA 541305.840 4823091.367
** DESCRSRC Pit Haul Rd1
   LOCATION AREA10 AREA 541314.641 4823097.419
** DESCRSRC Pit Haul Rd2
   LOCATION PAREA1 AREAPOLY 540970.448 4823321.083
** DESCRSRC Peel St East of Site1 Tailpipe
   LOCATION PAREA2 AREAPOLY 540594.399 4823384.175
** DESCRSRC Peel St Haul Road Tailpipe
   LOCATION PAREA3 AREAPOLY 541682.915 4823202.038
** DESCRSRC Peel St East of Site2 Tailpipe
   LOCATION OPIT2 OPENPIT 541290.000 4822825.500
```

```
** DESCRSRC Open Pit Source Wind Erosion
   LOCATION AREA11 AREA 539906.646 4823115.697
** DESCRSRC Jigs Road Seg1 Road Dust
   LOCATION AREA12 AREA 540519.725 4823019.567
** DESCRSRC Jigs Road Seg2 Road Dust
   LOCATION PAREA4 AREAPOLY 540594.399 4823384.175
** DESCRSRC Peel St Haul Road Road Dust
   LOCATION PAREA5 AREAPOLY 540970.448 4823321.083
** DESCRSRC Peel St East of Site1 Road Dust
   LOCATION PAREA6 AREAPOLY 541682.915 4823202.038
** DESCRSRC Peel St East of Site2 Road Dust
** Source Parameters **
   SRCPARAM AREA1 1.465E-08 1.000 10.000 620.000 98.160
   SRCPARAM AREA2 1.466E-08 1.000 10.000 380.000 9.780
   SRCPARAM AREA4 2.525E-06 1.000 40.000 10.000 98.630
   SRCPARAM AREA5 2.525E-06 1.000 40.000 10.000 8.010 0.000
   SRCPARAM AREA6 2.525E-06 1.000 40.000 10.000 -28.070 0.000
   SRCPARAM AREA7 2.533E-06 1.000 300.000 10.000 9.620
   SRCPARAM OPIT1 2.602E-06 2.000 300.000 400.000 480000.000 10.330
   SRCPARAM AREA9 2.536E-06 1.000 10.000 140.000 0.000
   SRCPARAM AREA10 1.283E-06 1.000 10.000 40.000 130.000 0.000
   SRCPARAM PAREA1 5.478E-09 1.000 4
   AREAVERT PAREA1 540970.448 4823321.083 540972.476 4823331.066
   AREAVERT PAREA1 541682.748 4823211.436 541682.546 4823202.695
   SRCPARAM PAREA2 1.371E-08 1.000 4
   AREAVERT PAREA2 540594.399 4823384.175 540596.559 4823395.190
   AREAVERT PAREA2 540971.929 4823331.044 540969.985 4823321.109
   SRCPARAM PAREA3 5.58E-09 1.000 4 0.000
   AREAVERT PAREA3 541682.915 4823202.038 541684.943 4823212.021
   AREAVERT PAREA3 542126.619 4823137.575 542125.203 4823129.236
   SRCPARAM OPIT2 1.601E-07 2.000 300.000 400.000 480000.000 10.330
   SRCPARAM AREA11 3.016E-06 1.000 10.000 620.000 98.160 0.000
   SRCPARAM AREA12 3.026E-06 1.000 10.000 380.000 9.780 0.000
   SRCPARAM PAREA4 4.208E-06 1.000 4 0.000
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   AREAVERT PAREA4 540971.929 4823331.044 540969.985 4823321.109
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   AREAVERT PAREA5 541682.748 4823211.436 541682.546 4823202.695
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   AREAVERT PAREA6 541682.915 4823202.038 541684.943 4823212.021
   AREAVERT PAREA6 542126.619 4823137.575 542125.203 4823129.236
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** Variable Emission Scenario: "Scenario 1"
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   EMISFACT AREA10 SEASHR 0.1 0.1 0.1 0.1 0.1 0.1
```

```
  EMISFACT AREA10 SEASHR 0.1 0 0 0 0 0
** Spring
  EMISFACT AREA10 SEASHR 0 0 0 0 0 0
  EMISFACT AREA10 SEASHR 0 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 0 0 0 0 0
** Summer
  EMISFACT AREA10 SEASHR 0 0 0 0 0 0
  EMISFACT AREA10 SEASHR 0 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 0 0 0 0 0
** Fall
  EMISFACT AREA10 SEASHR 0 0 0 0 0 0
  EMISFACT AREA10 SEASHR 0 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 1 1 1 1 1
  EMISFACT AREA10 SEASHR 1 0 0 0 0 0
** Winter
  EMISFACT AREA4 SEASHR 0 0 0 0 0 0
  EMISFACT AREA4 SEASHR 0 0.1 0.1 0.1 0.1 0.1
  EMISFACT AREA4 SEASHR 0.1 0.1 0.1 0.1 0.1 0.1
  EMISFACT AREA4 SEASHR 0.1 0 0 0 0 0
** Spring
  EMISFACT AREA4 SEASHR 0 0 0 0 0 0
  EMISFACT AREA4 SEASHR 0 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 0 0 0 0 0
** Summer
  EMISFACT AREA4 SEASHR 0 0 0 0 0 0
  EMISFACT AREA4 SEASHR 0 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 0 0 0 0 0
** Fall
  EMISFACT AREA4 SEASHR 0 0 0 0 0 0
  EMISFACT AREA4 SEASHR 0 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 1 1 1 1 1
  EMISFACT AREA4 SEASHR 1 0 0 0 0 0
** Winter
  EMISFACT AREA5 SEASHR 0 0 0 0 0 0
  EMISFACT AREA5 SEASHR 0 0.1 0.1 0.1 0.1 0.1
  EMISFACT AREA5 SEASHR 0.1 0.1 0.1 0.1 0.1 0.1
  EMISFACT AREA5 SEASHR 0.1 0 0 0 0 0
** Spring
  EMISFACT AREA5 SEASHR 0 0 0 0 0 0
  EMISFACT AREA5 SEASHR 0 1 1 1 1 1
  EMISFACT AREA5 SEASHR 1 1 1 1 1 1
  EMISFACT AREA5 SEASHR 1 0 0 0 0 0
** Summer
  EMISFACT AREA5 SEASHR 0 0 0 0 0 0
```

```
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   EMISFACT AREA5 SEASHR 1 1 1 1 1 1
   EMISFACT AREA5 SEASHR 1 0 0 0 0 0
** Fall
   EMISFACT AREA5 SEASHR 0 0 0 0 0 0
   EMISFACT AREA5 SEASHR 0 1 1 1 1 1
   EMISFACT AREA5 SEASHR 1 1 1 1 1 1
   EMISFACT AREA5 SEASHR 1 0 0 0 0 0
** Winter
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   EMISFACT AREA6 SEASHR 0.1 0.1 0.1 0.1 0.1 0.1
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** Spring
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   EMISFACT AREA6 SEASHR 0 1 1 1 1 1
   EMISFACT AREA6 SEASHR 1 1 1 1 1 1
   EMISFACT AREA6 SEASHR 1 0 0 0 0 0
** Summer
   EMISFACT AREA6 SEASHR 0 0 0 0 0 0
   EMISFACT AREA6 SEASHR 0 1 1 1 1 1
   EMISFACT AREA6 SEASHR 1 1 1 1 1 1
   EMISFACT AREA6 SEASHR 1 0 0 0 0 0
** Fall
   EMISFACT AREA6 SEASHR 0 0 0 0 0 0
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** Winter
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   EMISFACT AREA7 SEASHR 1 1 1 1 1 1
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** Fall
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   EMISFACT AREA7 SEASHR 0 1 1 1 1 1
   EMISFACT AREA7 SEASHR 1 1 1 1 1 1
   EMISFACT AREA7 SEASHR 1 0 0 0 0 0
```

```
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   EMISFACT AREA9 SEASHR 0.1 0 0 0 0 0
** Spring
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   EMISFACT AREA9 SEASHR 1 1 1 1 1 1
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** Summer
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** Fall
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   EMISFACT AREA9 SEASHR 1 0 0 0 0 0
** Winter
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   EMISFACT OPIT1 SEASHR 0.1 0 0 0 0 0
** Spring
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   EMISFACT OPIT1 SEASHR 0 1 1 1 1 1
   EMISFACT OPIT1 SEASHR 1 1 1 1 1 1
   EMISFACT OPIT1 SEASHR 1 0 0 0 0 0
** Summer
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   EMISFACT OPIT1 SEASHR 0 1 1 1 1 1
   EMISFACT OPIT1 SEASHR 1 1 1 1 1 1
   EMISFACT OPIT1 SEASHR 1 0 0 0 0 0
** Fall
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   EMISFACT OPIT1 SEASHR 0 1 1 1 1 1
   EMISFACT OPIT1 SEASHR 1 1 1 1 1 1
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** Variable Emission Scenario: "Existing Roads"
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   EMISFACT PAREA1 HROFDY 0.091 0.091 0.091 0.091 0.091 0.091
   EMISFACT PAREA1 HROFDY 0.7 1 0.7 0.409 0.409 0.409
```

```
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   EMISFACT PAREA1 HROFDY 0.409 0.409 0.409 0.409 0.409 0.409
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** Variable Emission Scenario: "Ph2 OffSite Rds"
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   EMISFACT AREA1 HROFDY 0.764 1 0.764 0.536 0.536 0.536
   EMISFACT AREA1 HROFDY 0.536 0.536 0.536 0.764 1 0.764
   EMISFACT AREA1 HROFDY 0.321 0.321 0.321 0.321 0.321 0.321
   EMISFACT AREA2 HROFDY 0.072 0.072 0.072 0.072 0.072 0.072
   EMISFACT AREA2 HROFDY 0.764 1 0.764 0.536 0.536 0.536
   EMISFACT AREA2 HROFDY 0.536 0.536 0.536 0.764 1 0.764
   EMISFACT AREA2 HROFDY 0.321 0.321 0.321 0.321 0.321 0.321
   EMISFACT PAREA2 HROFDY 0.072 0.072 0.072 0.072 0.072 0.072
   EMISFACT PAREA2 HROFDY 0.764 1 0.764 0.536 0.536 0.536
   EMISFACT PAREA2 HROFDY 0.536 0.536 0.536 0.764 1 0.764
   EMISFACT PAREA2 HROFDY 0.321 0.321 0.321 0.321 0.321 0.321
** Variable Emissions Type: "By Wind Speed / Stability"
** Variable Emission Scenario: "Scenario 4"
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   EMISFACT OPIT2 STAR 0 0 1 1 1 1
   EMISFACT OPIT2 STAR 0 0 1 1 1 1
   EMISFACT OPIT2 STAR 0 0 1 1 1 1
   EMISFACT OPIT2 STAR 0 0 1 1 1 1
   EMISFACT OPIT2 STAR 0 0 1 1 1 1
** Variable Emissions Type: "By Season / Hour"
** Variable Emission Scenario: "Ph2OffRoad"
** Winter
   EMISFACT PAREA5 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
   EMISFACT PAREA5 SEASHR 0.7 1 0.7 0.409 0.409 0.409
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.7 1 0.7
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Spring
   EMISFACT PAREA5 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
   EMISFACT PAREA5 SEASHR 0.7 1 0.7 0.409 0.409 0.409
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.7 1 0.7
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Summer
   EMISFACT PAREA5 SEASHR 0.182 0.182 0.182 0.182 0.182 0.182
   EMISFACT PAREA5 SEASHR 1.4 2 1.4 0.818 0.818 0.818
   EMISFACT PAREA5 SEASHR 0.818 0.818 0.818 1.4 2 1.4
   EMISFACT PAREA5 SEASHR 0.818 0.818 0.818 0.818 0.818 0.818
** Fall
   EMISFACT PAREA5 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
   EMISFACT PAREA5 SEASHR 0.7 1 0.7 0.409 0.409 0.409
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.7 1 0.7
   EMISFACT PAREA5 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Winter
   EMISFACT PAREA6 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
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EMISFACT PAREA6 SEASHR 0.7 1 0.7 0.409 0.409 0.409
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.7 1 0.7
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Spring
EMISFACT PAREA6 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
EMISFACT PAREA6 SEASHR 0.7 1 0.7 0.409 0.409 0.409
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.7 1 0.7
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Summer
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EMISFACT PAREA6 SEASHR 0.818 0.818 0.818 0.818 0.818 0.818
** Fall
EMISFACT PAREA6 SEASHR 0.091 0.091 0.091 0.091 0.091 0.091
EMISFACT PAREA6 SEASHR 0.7 1 0.7 0.409 0.409 0.409
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.7 1 0.7
EMISFACT PAREA6 SEASHR 0.409 0.409 0.409 0.409 0.409 0.409
** Variable Emissions Type: "By Season / Hour"
** Variable Emission Scenario: "Scenario 6"
** Winter
EMISFACT PAREA4 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
EMISFACT PAREA4 SEASHR 0.764 1 0.764 0.536 0.536 0.536
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.764 1 0.764
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Spring
EMISFACT PAREA4 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
EMISFACT PAREA4 SEASHR 0.764 1 0.764 0.536 0.536 0.536
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.764 1 0.764
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Summer
EMISFACT PAREA4 SEASHR 0.143 0.143 0.143 0.143 0.143 0.143
EMISFACT PAREA4 SEASHR 1.529 2 1.529 1.071 1.071 1.071
EMISFACT PAREA4 SEASHR 1.071 1.071 1.071 1.529 2 1.529
EMISFACT PAREA4 SEASHR 1.071 1.071 1.071 1.071 1.071 1.071
** Fall
EMISFACT PAREA4 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
EMISFACT PAREA4 SEASHR 0.764 1 0.764 0.536 0.536 0.536
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.764 1 0.764
EMISFACT PAREA4 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Winter
EMISFACT AREA12 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
EMISFACT AREA12 SEASHR 0.764 1 0.764 0.536 0.536 0.536
EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.764 1 0.764
EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Spring
EMISFACT AREA12 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
EMISFACT AREA12 SEASHR 0.764 1 0.764 0.536 0.536 0.536

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  EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.764 1 0.764
  EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Summer
  EMISFACT AREA12 SEASHR 0.143 0.143 0.143 0.143 0.143 0.143
  EMISFACT AREA12 SEASHR 1.529 2 1.529 1.071 1.071 1.071
  EMISFACT AREA12 SEASHR 1.071 1.071 1.071 1.529 2 1.529
  EMISFACT AREA12 SEASHR 1.071 1.071 1.071 1.071 1.071 1.071
** Fall
  EMISFACT AREA12 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
  EMISFACT AREA12 SEASHR 0.764 1 0.764 0.536 0.536 0.536
  EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.764 1 0.764
  EMISFACT AREA12 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Winter
  EMISFACT AREA11 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
  EMISFACT AREA11 SEASHR 0.764 1 0.764 0.536 0.536 0.536
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.764 1 0.764
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Spring
  EMISFACT AREA11 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
  EMISFACT AREA11 SEASHR 0.764 1 0.764 0.536 0.536 0.536
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.764 1 0.764
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
** Summer
  EMISFACT AREA11 SEASHR 0.143 0.143 0.143 0.143 0.143 0.143
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  EMISFACT AREA11 SEASHR 1.071 1.071 1.071 1.529 2 1.529
  EMISFACT AREA11 SEASHR 1.071 1.071 1.071 1.071 1.071 1.071
** Fall
  EMISFACT AREA11 SEASHR 0.072 0.072 0.072 0.072 0.072 0.072
  EMISFACT AREA11 SEASHR 0.764 1 0.764 0.536 0.536 0.536
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.764 1 0.764
  EMISFACT AREA11 SEASHR 0.536 0.536 0.536 0.536 0.536 0.536
  PARTDIAM AREA2 1.6 3.9 7.8
  PARTDIAM AREA1 1.6 3.9 7.8
  PARTDIAM AREA10 1.6 3.9 7.8
  PARTDIAM AREA4 1.6 3.9 7.8
  PARTDIAM AREA5 1.6 3.9 7.8
  PARTDIAM AREA6 1.6 3.9 7.8
  PARTDIAM AREA7 1.6 3.9 7.8
  PARTDIAM AREA9 1.6 3.9 7.8
  PARTDIAM OPIT1 1.6 3.9 7.8
  PARTDIAM PAREA1 1.6 3.9 7.8
  PARTDIAM PAREA2 1.6 3.9 7.8
  PARTDIAM PAREA3 1.6 3.9 7.8
  PARTDIAM OPIT2 1.6 3.9 7.8
  PARTDIAM PAREA4 1.6 3.9 7.8
  PARTDIAM PAREA5 1.6 3.9 7.8
  PARTDIAM PAREA6 1.6 3.9 7.8
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   PARTDIAM AREA12 1.6 3.9 7.8
   PARTDIAM AREA11 1.6 3.9 7.8
   MASSFRAX AREA2 0.363 0.225 0.411
   MASSFRAX AREA1 0.363 0.225 0.411
   MASSFRAX AREA10 0.363 0.225 0.411
   MASSFRAX AREA4 0.363 0.225 0.411
   MASSFRAX AREA5 0.363 0.225 0.411
   MASSFRAX AREA6 0.363 0.225 0.411
   MASSFRAX AREA7 0.363 0.225 0.411
   MASSFRAX AREA9 0.363 0.225 0.411
   MASSFRAX OPIT1 0.363 0.225 0.411
   MASSFRAX PAREA1 0.363 0.225 0.411
   MASSFRAX PAREA2 0.363 0.225 0.411
   MASSFRAX PAREA3 0.363 0.225 0.411
   MASSFRAX OPIT2 0.363 0.225 0.411
   MASSFRAX PAREA4 0.363 0.225 0.411
   MASSFRAX PAREA5 0.363 0.225 0.411
   MASSFRAX PAREA6 0.363 0.225 0.411
   MASSFRAX AREA12 0.363 0.225 0.411
   MASSFRAX AREA11 0.363 0.225 0.411
   PARTDENS AREA2 2 2 2
   PARTDENS AREA1 2 2 2
   PARTDENS AREA10 2 2 2
   PARTDENS AREA4 2 2 2
   PARTDENS AREA5 2 2 2
   PARTDENS AREA6 2 2 2
   PARTDENS AREA7 2 2 2
   PARTDENS AREA9 2 2 2
   PARTDENS OPIT1 2 2 2
   PARTDENS PAREA1 2 2 2
   PARTDENS PAREA2 2 2 2
   PARTDENS PAREA3 2 2 2
   PARTDENS OPIT2 2 2 2
   PARTDENS PAREA4 2 2 2
   PARTDENS PAREA5 2 2 2
   PARTDENS PAREA6 2 2 2
   PARTDENS AREA12 2 2 2
   PARTDENS AREA11 2 2 2
   SRCGROUP OFFHAUL( AREA1 AREA2 PAREA2 AREA11 AREA12 PAREA4
   SRCGROUP SITEHAUL AREA4 AREA5 AREA6 AREA7 AREA9 AREA10
   SRCGROUP EXTRACTI OPIT1 OPIT2
   SRCGROUP OFFROADS PAREA1 PAREA3 PAREA5 PAREA6
   SRCGROUP ALL
SO FINISHED
****************************************
** ISCST3 Receptor Pathway
****************************************
RE STARTING
```

```
** DESCRRECC "" ""
   DISCCART    540800.02   4822987.99
   DISCCART    540286.41   4822808.85
   DISCCART    540445.53   4823587.12
   DISCCART    540584.21   4823860.63
   DISCCART    540935.50   4823857.39
   DISCCART    541183.05   4823531.88
   DISCCART    541500.83   4823271.37
   DISCCART    542010.80   4823125.00
   DISCCART    541302.64   4822102.39
   ….
RE FINISHED
****************************************
** ISCST3 Meteorology Pathway
****************************************
ME STARTING
   INPUTFIL D:\30000-~1\34915J~1\MODELL~1\pe0105df.met
   ANEMHGHT 10 METERS
   SURFDATA 61444 2001 LONDON
   UAIRDATA 72632 2001
ME FINISHED
****************************************
** ISCST3 Output Pathway
****************************************
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 24 1ST
   MAXTABLE ALLAVE 100
   MAXIFILE 24 ALL 25 PM10PH2.IS\PM10.MAX
** Auto-Generated Plotfiles
   PLOTFILE 24 ALL 1ST PM10PH2.IS\24H1GALL.PLT
   PLOTFILE ANNUAL ALL PM10PH2.IS\AN00GALL.PLT
   PLOTFILE 24 OffHaul( 1ST PM10PH2.IS\24H1G001.PLT
   PLOTFILE ANNUAL OffHaul( PM10PH2.IS\AN00G001.PLT
   PLOTFILE 24 SiteHaul 1ST PM10PH2.IS\24H1G002.PLT
   PLOTFILE ANNUAL SiteHaul PM10PH2.IS\AN00G002.PLT
   PLOTFILE 24 Extracti 1ST PM10PH2.IS\24H1G003.PLT
   PLOTFILE ANNUAL Extracti PM10PH2.IS\AN00G003.PLT
   PLOTFILE 24 OffRoads 1ST PM10PH2.IS\24H1G004.PLT
   PLOTFILE ANNUAL OffRoads PM10PH2.IS\AN00G004.PLT
OU FINISHED
****************************************
** Project Parameters
****************************************
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse Mercator
** DATUM    Unknown (WGS-84 will be used)
** ZONE     17
```

APPENDIX D

PROPOSED BEST MANAGEMENT PLAN FOR FUGITVE DUST

D.0 BEST MANAGEMENT PLAN

The following presents potential sources of fugitive dust at the Jigs Hollow Pit as well as actions to control and mitigate these sources.

D.1 POTENTIAL SOURCES OF FUGITIVE DUST

Due to the nature of activities at a sand and gravel operation, there are several on-site sources at the Jigs Hollow Pit that could potentially contribute to fugitive dust emissions. These are as follows:

- truck travel on site entrance road;
- loader travel on unpaved roads;
- material processing and handling (conveying, loading, crushing and screening of aggregate); and
- stockpiling (raw and processed materials).

The fugitive dust generated by these sources and activities arises from processing or pulverizing crustal materials, and thus generally does not have significant amounts of other contaminants associated with it. Also, a significant portion of the fugitive dust from these sources is in the coarse fraction which tends to result in nuisance effects; only a small fraction of the dust is in the respirable range, which is of most concern from a health perspective.

In many instances, fugitive dust emissions depend on the wind speed at any given time as well as the activity rates. Thus the amount of effort necessary to control such emissions is greater during windy conditions than during calm conditions.

D.2 REQUIRED CONTROL ACTIONS

In general, most approaches for controlling fugitive dust involve the application of water to prevent the fugitive emissions from being generated. Depending on the source, there are other measures that are used to remove the source of the dust, and/or reduce the impact of the emissions when they occur. These are discussed in the following sections.

D.2.1 Application of Water to the Site Entrance Road and Internal Haul Route

The Ministry of Natural Resources (MNR) requires that dust be mitigated on site and therefore, water will be applied to the site entrance road and internal loader routes to mitigate fugitive dust. In the assessment, sufficient calcium chloride application and watering was assumed to be applied to achieve a control efficiency of 90% on all unpaved site roads travelled by non-road equipment (loaders, etc) and by product trucks that will be used to ship finished materials off site. These levels of control are reasonably achievable, and necessary to prevent excessive off-site emissions.

In order to achieve the level of control that is required to meet the levels that were used in the completion of this study, the following actions are recommended:

- the Township of Woolwich currently applies a single coat of calcium chloride to the off-site haul road on Peel Street and Jigs Hollow Road during the spring, in addition Kuntz Topsoil, Sand & Gravel should apply a second coat of calcium chloride during the late summer;
- all unpaved site haul roads should receive a coat of calcium chloride during the spring, and a second coat of calcium chloride during the late summer;
- all unpaved site haul roads should be watered at a sufficient frequency to control dust generation due to vehicle travel; and,
- vehicle speeds on unpaved haul roads should remain at 20 km/h or less.

An operational watering scheme that is based on the activity levels and meteorological conditions will be developed and followed by trained site personnel, to ensure that watering is completed frequently enough to adequately control fugitive dust emissions. For the purpose of illustration, the following scheme is included as an example of the type of system that could be developed at the Jigs Hollow Pit.

D.2.2 Example Operational Watering Scheme

Internal haul routes (both within the pit and at grade) will be treated with water as necessary for dust control. The capability for main internal haul truck watering will provide for the required number of passes per hour, as needed to achieve the recommended dust control efficiency.

For operational purposes, a scheme based on the type of day (hot/dry/windy, warm/overcast, cool/overcast, rainy) that prescribes the recommended watering frequency based on the number of truck passes and the length of road, is suggested, as presented below:

- During very hot, dry and sunny conditions (typical of July or August) or windy days (i.e. greater than 20 km/h), sufficient water will be applied to all in-pit roads for these conditions, depending on the traffic level;

- During moderately warm, dry conditions (late spring & fall), sufficient water will be applied to in-pit unpaved roads for these conditions, depending on the traffic level; and

- During wet or rainy periods, the roads generally will not be watered.

The scheme presented above will be adjusted as conditions dictate. For example, roads will definitely be watered regardless of the "rules" if there is visible, or blowing dust. A site specific watering table will be produced as part of the dust management plan following approval of the final site design.

D.2.3 Application of Water to Material Handling and Processing

This assessment was completed assuming that crushing and screening equipment will not have any water sprays to reduce dust emissions. The assessment assumed that no controls will be used on material drops from loaders, excavators and stackers. However, should problems with fugitive dust arise, installation of spray bars on processing equipment will be considered.

D.2.4 Application of Water to Material Storage Piles

Depending on the amount of "fines" present in the material, windblown dust from material storage piles can occur. The assessment was completed with the conservative assumption that wind erosion will occur at all wind speeds. In addition, it was assumed that no controls will be specifically employed to mitigate this source. Should emissions from storage piles become a problem, the piles will be sprayed with water or another approved dust suppressant as necessary to reduce windblown dust.

D.2.5 Record Keeping

A daily log of water applications and other dust control procedures and observations should be kept at the site to demonstrate, if necessary, that dust control actions are being taken.

D.2.6 Control of On-site Contractors

On-site contractors will be required to meet the same requirements as set out in this Best Management Plan at all times that they are on-site.

D.3 RECOMMENDED ACTIONS FOR IMPROVED CONTROL

In addition to the procedures outlined above, SENES recommends that the following options also be considered to further reduce the potential for off-site dust emissions:

- Apply calcium chloride or other chemical dust suppressants annually or semi-annually, if permitted by the ARA license; and
- Ensure that the site perimeter berms and surrounding area be sufficiently vegetated.
    - It is important to note that as trees and shrubs grow, some will become tall, while others will remain short; some will spread, while others will remain columnar. The mature plant characteristics of the selected species should be examined to determine the appropriate plant spacing and placement, such that a good screen is produced once all plants reach their ultimate height and spread.
    - The plantings should contain a mix of coniferous and deciduous species, such that some screening potential remains after the leaves have fallen off of the deciduous plants.

D.4 ENVIRONMENTAL COMPLAINT DOCUMENTATION AND RESPONSE PROCEDURE

SENES recommends that a complaint documentation and response procedure be established for the Jigs Hollow Pit, such that standardized procedures are followed in the event that a complaint is made by a member of the public. The documentation should include the date and time of the complaint, the nature of the problem, and whether any follow-up action was taken. The complaint information should be maintained in an on-site log that is available for review by the MOE, if requested.

A sample form is included on the following page.

RECORD OF ENVIRONMENTAL COMPLAINT AND RESPONSE

1. Location: ____

2. Date and Time Complaint Received: ______________________________

3. Name of Complainant: ____

   Address: ____

   Telephone Number: ____

4. Form of Complaint and Summary: Visit:[ ] Telephone Call:[ ] Letter:[ ] Attach Copy
   Other ____

5. Complaint Referred to Technical Services: No [ ] Yes [ ] and provide details:
   ____

6. Contact Made With Government Official(s): No [ ] Yes [ ]
   If Yes, Complete and Attach Record of Government Environmental Official Contact Form -- Yes [ ]

7. Details Concerning Investigation Made by Company Concerning Complaint:
   ____
   ____

8. Response to Complainant:
   Letter [ ] Date ______________________ Attach copy of letter to this form.

   Telephone Call [ ] Date ____________________ Time __________________

   Summary of Telephone Call:
   ____
   ____

9. Follow-up Action Required and/or Taken by Company: None [ ] Details:
   ____
   ____
   ____

10. Filed Original Form in the Plant Environmental Manual: Yes [ ]

    Date ______________________ ________________________________
    Employee Signature, Name & Position

APPENDIX E

AUTHOR'S QUALIFICATIONS

MALCOLM A. SMITH, P.ENG.

Environmental Engineer

EDUCATION

B.Sc., Mechanical Engineering, 1995, Queen's University, Kingston, Ontario.

Physical Hydrogeology Course, 1998, Waterloo University, Waterloo, Ontario.

PROFESSIONAL AFFILIATIONS

Professional Engineers of Ontario (PEO)

EXPERIENCE

Mr. Smith has over ten years' experience in the environmental consulting industry focusing primarily on Air Quality Impact Assessments, Certificate of Approval (Air) permitting applications and groundwater and soil remediation system projects.

2004 to date – SENES Consultants Limited
Environmental Engineer - Air Resources

Environmental Impact Assessments – Air Quality Managed and completed air quality assessments for the expansion or development of various undertakings such as aggregate operations (pits & quarries), and transportation corridors. Emissions of dust (TSP, PM_{10}, $PM_{2.5}$), NO_x, SO_2, CO and organics were estimated and dispersion modelling performed to determine the air quality conditions in the vicinity of a site. These studies typically involved the assessment of baseline conditions, post-construction conditions, and future "no build" scenarios.

Air Dispersion Modelling - Managed and/or completed numerous projects to model various pollutants such as particulate matter (PM, PM_{10}, $PM_{2.5}$), NO_x, SO_2, CO and VOCs originating from industrial facilities and regional sources. Also conducted several studies that predicted concentrations of multiple pollutants in urban areas due to changes in major urban roadways or industries. Responsible for conducting emissions inventories, preparing model inputs, conducting model runs and data/results interpretation. Models used to date include the Industrial Source Complex (ISC3) Model, CAL3QHC, and AERMOD.

Air Emission Inventories – Prepared air emission inventories for a variety of industrial clients ranging from manufacturing to recycling industries. Emissions were calculated from client supported data, equipment manufacturer data and accepted emission factors. The inventories include estimating emissions of particulate matter, various components of combustion gases, metals, and volatile organic compounds.

Certificates of Approval (Air) – Prepared Certificates of Approval (Air) for Power Generation facilities, Chroming and De-Chroming facilities, Asphalt and Wax Emulsion facilities, Hot Mix Asphalt plants, Pre-Mix Concrete Batching facilities, Aggregate Pits, a Printing facility, an Electronics Manufacturing facility, a Tobacco Manufacturing facility, and a Scrap Metal Recycling facility. Atmospheric emissions were modelled using the Ontario MOE (Ministry of the Environment) Reg. 346 Model and Aermod Model.

NPRI and O.Reg. 127 – Estimated emissions based on production and/or test data. Prepared detailed reports and submitted the NPRI (National Pollutant Release Inventory) and O.Reg. 127/01 information.

Air Emission Reduction Strategies/Policies – Project manager and principal author on a project for Environment Canada to develop emission profiles and weighted emission factors for the Hot Mix Asphalt industry in Canada. Production and operation information was collected from facilities across Canada, emission estimates were completed and profiles for Criteria Air Contaminants and Heavy Metals were developed.

Literature Study and Review – Reviewed air emission permits from various jurisdictions in support of an Ontario Ministry of Environment project to evaluate options for air pollution control of volatile organic compounds from the automobile and light truck original equipment manufacturing sub-sector.

2001 to 2004 – AMEC Earth & Environmental
Project Engineer – Decommissioning Group

Air Emission Inventories – Prepared site-wide air emission inventories for a variety of industrial clients ranging from manufacturing to mining industries. Emissions were calculated from client supported data, equipment manufacturer data and accepted emission factors. The inventories include estimating emissions of particulate matter, various components of combustion gases, metals, and volatile organic compounds.

Certificates of Approval (Air) – Prepared Certificates of Approval (Air) for Gold Mining Operations, Personal Hygiene Products Manufacturing facilities, Coating and Paint Booth operations, an Air Bag Manufacturing facility, and Soil and Groundwater Remediation Systems.

Comprehensive Certificate of Approval (Air) - Prepared an application for a Comprehensive Certificate of Approval for a Personal Hygiene Products Manufacturing facility.

NPRI and O.Reg. 127 – Estimated emissions based on production and/or test data. Prepared detailed reports and submitted the NPRI and O.Reg. 127 information.

In-Situ Soil and Groundwater Remediation Systems – Managed a wide range of projects involving soils and groundwater remediation systems including pilot testing, design, installation, commissioning, operation, and maintenance of large scale dual phase extraction and pump and treat projects for various manufacturing facilities.

Completed the pilot testing, design, and installation of a dual phase vacuum extraction soil and groundwater remediation system at an active aluminum manufacturing facility. Managed all facets of the project including pilot test reporting, preparation of equipment specifications, and preparation of system piping and electrical tender documents.

Health and Safety Coordinator – Responsible for administrating and implementing company health and safety programs.

2000 to 2001 – Doctors Without Borders
Logistics Manager – Feeding Program

Project Management – Worked as logistics manager for an international aid organization on a $2 million a year feeding program for malnourished children. Directly responsible for the daily activities of a staff of 75 people who coordinated food and medical supplies, water and sanitation facilities, construction of the feeding centres, and maintenance of all technical equipment (vehicles, radios, generators, etc).

1998 to 2000 – Morrow Environmental
Environmental Engineer – Systems Group

In-Situ Soil and Groundwater Remediation Systems – Participated in a wide range of projects involving soils and groundwater remediation systems including pilot testing, design, installation, commissioning, operation, and maintenance of large scale dual phase extraction, pump and treat, soil vapour extraction, and air sparging projects for retail gasoline service station, petrochemical refineries, rail yards, and manufacturing facilities.

Completed the pilot testing and design of a soil vapour extraction and air sparging soil and groundwater remediation system at a gasoline service station. Participated in all facets of the project including pilot test reporting, preparation of equipment specifications, and preparation of system piping and electrical tender documents.

Coordinated the pilot testing and installation of a large 52-extraction well dual phase vacuum extraction soil and groundwater remediation system at a gasoline service station.

James W.S. Young, Ph.D.

Manager SENES Kincardine

Education

Ph.D. Fluid Mechanics, University of Waterloo, 1973
M.Sc. Mech. Eng., Queen's University, 1969
B.Sc. Mech. Eng., Queen's University, 1967

Professional Affiliations

Director Air and Waste Management Association (Ontario Section, 1988 – 1990)
Past President of Canadian Meteorological and Oceanographic Society (1988)
Co-founder of the Canadian Institute for Research in Atmospheric Chemistry
Canadian Co-Chairman International Joint Commission Air Quality Advisory Board (1985 – 1996)

Association of Professional Engineers of Ontario

Awards

1984 Government of Canada Merit Award
1989 Environment Canada Citation of Excellence
1991 Citation of Appreciation - Acid Rain

Languages

English (good); French (fair); Spanish (some)

Experience

2005 – date: Jim Young Atmospheric Services Inc.

President. Responsibilities include delivering specialized air quality and weather services.

2005 – date: Manager SENES Kincardine Office and Senior Air Quality Advisor

1990 – 2005: SENES Consultants Limited

Vice President and Senior Air Quality Specialist (2003 – 2005)

Responsibilities included being part of Executive Committee, business development, mentoring and senior level advice and guidance in air quality.

Director, Atmospheric Environmental Services (1990 – 2003) - Responsibilities include environmental studies, climate change analyses, air quality, noise, expert review, hearing testimony, and research and development.

Experience at SENES included the **aggregate industry** (Certificates of Approval, air quality studies, advice & guidance, expert testimony), **air quality advice and training** (Colombia, Peru, Environment Canada, World Bank (Mexico), International Joint Commission, UNDP (Viet Nam), CIRAC Newsletter, Toyota, Chihuahua, Juárez); **air quality assessments** (Gardiner Expressway Revitalization, Voisey's Bay Nickel Smelter/Refinery, City of Windsor Waterfront, Chrysler Canada, GO Transit, Innisfil Landfill, Keele Valley Landfill, Leslie Street Extension, Peel Landfill Search, Richmond Landfill Expansion, Jordan - Petcoke); **air quality standards** (Chile, Viet Nam, British Columbia); **certificates of approval** (automotive, manufacturing); **climate change** (climate variability impact on air quality issues, GhG Inventories, International Guidelines and Workbooks, capacity building); **control technology** (AERCo$t, equipment options, costing, databases, advice/guidance, mercury control); **criteria development** (GTA Candidate Site Selection, Sustainability Index); **environmental management** (SIMON, Irving Oil Refinery Co-Gen Project, City of Toronto); **emission inventories** (direct, fugitive, Colombia, Mexico); **expert reviews or testimony** (impact of aggregate processing, U.S. and Canada response on Toxic Chemicals, OWMC Air and Dust, Niagara Falls Upgrade, Woburn Superfund Site, Swan Hills Incinerator, Mountain Road Landfill Site); **meteorology** (weather model for Macedonia, FReSH Air, FReSH-4 concept, mixing height climatology, building design criteria); **mining** (Slovakia, Chile); **modelling** (CALMET/CALPUFF, ISC3, FDM, SDM, Reg. 346); **monitoring** (network design, analysis, model calibration, dust and gases, Trinidad); **municipalities** (water supply pipeline, sludge management, zoning, developments); **noise assessments** (Honda Alliston, TransCanada Pipelines, City of Toronto Material Recovery Facility, IWA Landfill Search); **odour** (impacts, health assessment); **project management** (Lennox TGS Dual Fuel Assessment, Electrotechnology Energy Use Assessment, GhG Inventory for the Province of Ontario, Acid Rain Strategy for Ontario, Air Quality Compliance Plan); and **R&D** (FReSH-4, Continental Pollutant Pathways in North America, Acid Rain Modelling, Development of a Sustainability Index, Technology & Economics of Control Strategies).

1978-1990: Atmospheric Environment Service

Acting Director General Research (1989-1990) - Managed a staff of 180 people (70 research scientists) with an annual budget of $14 million and a facility worth $20 million; responsible for the health of the atmospheric sciences community in Canada; prepared Research Strategic Plan; member Steering Committee for Crombie Commission on the Toronto Waterfront; member Joint Working Group Canada-

PRC, member Senior Management Committee; successfully negotiated a doubling (to $1.6 million) of the Grants in Aid of Atmospheric Research with NSERC; Delegate to the WMO Commission on Atmospheric Sciences (CAS); lecturer at course on Atmospheric Chemistry (CIRAC) and meteorologist training course (AES).

Director, Air Quality and Inter-environmental Research Branch (1983-1989) - Advised senior service and departmental managers on viability of research programs or related policy; managed a staff of 86 people (40 research scientists, 17 other professionals and 29 technical and administrative support staff) and research facility worth $11.5 million with an annual budget of $8 million; liaised with other government departments, other levels of government, other nations, international organizations as well as university and private sector scientific community; developed an optimized science-based acid rain control strategy; encouraged development of a heavy gas dispersion model in the private sector; advisor to Canadian Electrical Association to ensure development of acid rain modelling expertise in the Canadian private sector; delivered York Chair in Atmospheric Chemistry with spin-off benefits of the creation of the Canadian Institute for Research in Atmospheric Chemistry and the donation of a privately funded second chair; successfully replaced the Station for Atmospheric Experiments with a new research facility and headquarters expansion with a net decrease of resources; prepared strategic plan for Air Quality Services area; tripled research output (Journal publications); improved monitoring data quality from 67 to 94% and served on international science and technology committees. Revitalized International Air Quality Advisory Board of the International Joint Commission, as Canadian Co-Chairman, by broadening their thinking about today's issues to the right time/space scales.

Chief, Air Quality Monitoring and Assessment Division (1981-1983) - Successfully defended the atmospheric sector during Royal Society of Canada review of acid rain program; developed first strategy for acid rain abatement; maintained responsibility for six bilateral MOI documents (successfully completed); established and upgraded Canadian Air and Precipitation Network (CAPMoN) to state of the art and made the Environmental Emergency Modelling Package operational.

Senior Scientist (1978-1981) - Chaired NRC Panel on Particulate Matter in the Canadian Atmosphere; developed a methodology for Criteria Digests; developed effects diagrams for nitrogen oxides which for the first time clearly outlined for decision makers health and ecosystem effects of options for standards; carried out research in air pollution, fugitive dust and acid rain modelling; Technical Co-ordinator for Work Group 2 (Modelling) under Canada/USA Memorandum of Intent (MOI) and during 1981 was Atmospheric Sector Co-ordinator for Acid Rain (with a budget of about $2M).

1989: Canadian Institute for Research in Atmospheric Chemistry (CIRAC)

Executive Director – **Six-month development leave. Responsible for the day-to-day activities including 4 major multi-partner research projects; planned for a $7 million Endowment Fund for CIRAC's on-going support.**

1977-1978: Beak Consultants

Director of Air Quality Engineering, Eastern Operations - Overall project manager for environmental impact of the Teller Scrubber installation, including liaison with Federal, Provincial and Mill officials as well as a full technical evaluation; responsible for atmospheric impact assessment of a uranium refinery, an iron ore mine, various pulp and paper mills, an iron and titanium mill, a thermal power station, a uranium mine and preconcentrator, and climate impact on uranium tailings disposal over 100,000 years; and expert testimony to the Ontario Municipal Board and expert review of guidelines for impact assessment.

1975-1977: Environment New Brunswick

Chief of the Air Quality Section, Pollution Control Branch - Responsible for policy direction, long-term planning and management of air quality for Province of New Brunswick; procured/installed a multiple use air pollution monitoring system and telemetry package for City of St. John; initiated joint research studies in acid rain effects on forests with the University of New Brunswick; developed provincial air quality standards and specific emission standards for asphalt paving plants, pulp and paper industry and the Irving Oil refinery; negotiated first Canadian operational installation of a Teller Scrubber for odour removal from a pulp and paper plant; and was responsible for development of Canadian short- and long-term Air Quality Indices (in use in five provinces today).

1973-1975: Atmospheric Environment Service

Research Scientist, in Air Pollution Meteorology - Planned, organized and co-ordinated field studies; carried out basic research in atmospheric science; delivered a real time pollution abatement model for the City of St. John and the Electric Power Commission; and lectured in Air Pollution Meteorology.

PAPERS AND PRESENTATIONS

Author or co-author of over 100 technical papers and presentations. (List available upon request).