



SENE Consultants Limited

Specialists in Energy, Nuclear and Environmental Sciences

**EKATI DIAMOND MINE
REVIEW OF 2008 AIR QUALITY MONITORING
PROGRAM REPORT**

Prepared for:

Independent Environmental Monitoring Agency

203-5006 Franklin Ave
P.O. Box 1192
Yellowknife, NWT
X1A 2N8

Prepared by:

SENE Consultants Limited

121 Granton Drive, Unit 12
Richmond Hill, Ontario
L4B 3N4

March 2010

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A handwritten signature in black ink that reads "John Peters".

Reviewed by:
John Peters, M.Eng., P.Eng.
Director, Atmospheric Sciences

A handwritten signature in black ink that reads "N. Shinbin".

Prepared by:
Nick Shinbin, P.Eng.
Environmental Engineer

March 2010

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1.0 INTRODUCTION

As requested by the Independent Environmental Monitoring Agency (IEMA), SENES Consultants Limited (SENES) undertook a peer review of the *2008 Air Quality Monitoring Program* (AQMP) report [Rescan, 2008] prepared by Rescan Environmental Services Ltd. (Rescan) for the EKATI diamond mine. The report summarizes the air quality monitoring activities conducted at the EKATI diamond mine for the years 2006 through 2008, and summarizes the results of this program. The aspects of the AQMP report included within SENES' scope of work included:

- The High Volume Air Sampling (HVAS or Hi-Vol) and dustfall particulate matter monitoring programs;
- The continuous air monitoring program;
- The snow core sampling program; and,
- The common air contaminant and greenhouse gas emission inventories.

SENES completed a review of each of the above components of the air monitoring program in place at the EKATI mine, as described in the Rescan report. The following sections outline the findings of the review. The report concludes with a brief summary of key conclusions and recommendations.

2.0 DISCUSSION

2.1 HIGH VOLUME AIR SAMPLING PROGRAM

1. There is a general lack of detail in the sections of the report discussing the High Volume Air Sampling (HVAS) program making it difficult to draw conclusions as to whether the program has been executed in accordance with generally accepted HVAS sampling practices. According to the 2008 AQMP report, sampling was conducted in accordance with an in-house (ENVR-SOP-AIR-01) Standard Operating Procedure (SOP). This SOP was not provided with the AQMP report. It is important to note that SENES identified concerns with this SOP in 2003 [SENES, 2003], and without an up-to-date copy of this SOP (perhaps, attached as an Appendix to the AQMP report), we cannot verify if our concerns have been adequately addressed. For example, with regard to sample start times, SENES identified that the 2003 version of the SOP allowed for mid-day start times as opposed to the generally accepted practice of midnight-to-midnight sampling. By starting a sample in mid-day, a significant portion of a non-daily dust event such as blasting may be missed, resulting in a lower TSP concentration associated with the event.
2. The 2008 AQMP report states that sampling was not conducted in the winter months, noting “that the electric motors ... do not function properly in winter conditions”. SENES has commented on this position previously in response to the *2003 Air Quality Management and Monitoring Plan* [BHPB, 2003], noting that SENES personnel have operated Hi-Vols successfully in sub-arctic environments with temperatures as low as -30°C. Other mining operations (e.g., Northern Saskatchewan, Nunavut) and Environment Canada) also operate Hi-Vols in winter conditions. While SENES agreed that it was not feasible to consistently operate the Hi-Vols on the typical 6-day schedule during the winter months due to blowing snow, it was our opinion that samples could still be collected through the winter months when meteorological conditions permitted.
3. There is a significant gap in the HVAS monitoring data in that no data were collected under the HVAS program in 2006, with some statements implying sampling was completed in 2006. For example, Section 2.3 of the 2008 AQMP report correctly states that monitoring station TSP-1 was decommissioned prior to 2006 (in 2003, with TSP-3 being added to the program in 2007), but implies that TSP-2 was fully operational over this time, “HVAS station TSP-2, located on the roof of the pump house at Grizzly Lake has operated annually since 1997, and continued to operate from 2006 to 2008.” Section 3.4.1 of the AQMP report notes that TSP-2 was out of commission in 2006, with similar information conveyed in Table 3.4-1 of the AQMP report. As with Section 2.3, the Executive Summary implies the HVAS program was fully operational in 2006 in that it states “the two stations were well below the annual Canadian Ambient Air Quality

Objective (CAAQO) of 60 µg/m³ for the *three monitoring years* of this current AQMP. *During the monitoring period (2006-2008) only two exceedances of the CAAQO daily ambient Total Suspended Particulate (TSP) standard (120 µg/m³) occurred ... (italics added).*” The report should be revised to accurately reflect the actual status of the HVAS program over the review period.

4. The AQMP report is silent of the reason why TSP-2 in particular, and the HVAS monitoring program in general, was not operational for all of 2006 (e.g., equipment failure, power supply issue).
5. It is not clear why geometric means, which are typically used to report annual average TSP concentrations were not calculated for 2008, as this calculation was completed for all previous monitoring periods.
6. The AQMP states “The average TSP was considerably less in 2007 than previously measured and that measured in 2008 (Table 3.4-1)” (p. 3-10); however, in reviewing data, the arithmetic average for 2007 at TSP-2 is similar to TSP-2 results for 2 of the 6 previous years and TSP-2 data for 2008 is similar to TSP-2 results for 3 of the 6 years over the 1999 to 2005 period, suggesting that TSP-2 data over this monitoring review period are generally consistent with historical data.
7. In a discussion of ambient monitoring results it is generally prudent to include a brief discussion of the quality assurance/quality control (QA/QC) measures taken to ensure that the reported data are of acceptable quality. For instance, regular calibrations of Hi-Vols are vital to accurate data reporting. There should be some discussion with regard to calibration intervals, and any other measures of note that were taken to improve data quality or issues with data quality. In particular, some discussion would assist the reader in understanding the QA/QC issues associated with why over 10% of the 2008 filters returned a negative value and whether this was indicative of a generally low bias in sample weights. Unless Hi-Vol units were not turned on, negative values are not expected for Hi-Vol filters collecting TSP samples.
8. While potential causes of the two TSP exceedances at TSP-3 in 2008 are provided in the AQMP report, there is no correlation made to meteorological parameters or to site activities, with exceedances attributable to “natural” sources. For instance, strong winds from an easterly or south-easterly direction on these dates may also be a cause for elevated values attributable to mine activities. Further comment on site activities and prevailing winds for these exceedances would provide additional context to these exceedances.

9. The AQMP reports states that TSP-3 “sited to be downwind of main camp area (based on the predominant easterly wind direction...)”, with this station located *northwest* of the main sources. Other monitoring stations (e.g., CMP, Fox Haul Road and Sable Haul Road dustfall jars) are sited *southwest* of the main sources being monitored. The reason for the discrepancy is not clear.
10. As a side note regarding Table 3.4-1, it does not appear as though the footnote reference numbers are included in the table body in super-script formatting, making them appear as though they are an additional significant digit on the reported number.

2.2 DUSTFALL MONITORING PROGRAM

The dustfall monitoring program was implemented in 2006 as a means of collecting information on dust deposition with distance from the haul roads. The AQMP report provides useful graphs indicating how the dustfall level changes with distance from the haul roads being monitored (including upwind samples based on the predominant wind direction in the area). With no guidance in the Northwest Territories with regard to dustfall standards/objectives, the AQMP report compares EKATI dustfall levels to objectives used by the Province of British Columbia (B.C.) for the mining industry (1.7 to 2.9 mg/dm²/day).

1. The AQMP report notes the following with regard to the B.C. objective level: “that for some months, reference concentrations at AQ-49 and AQ-54 exceeded these guidelines, suggesting that these guidelines may not be appropriate for the EKATI area” A review of analytical data in Appendix 2 indicates that this assertion overstates the issue, with only one reference sample (AQ-49 for June 2008) being above the B.C. objective. With this data point removed, all reference levels were below the B.C. standard. While the report states that monthly samples were collected, Figure 3.5-1 shows only a single entry for each control site in each year, with this value appearing to be the average at each reference site for each sampling year. If the June 2008 data point is removed, the average reference concentration at AQ-49 for 2008 (0.76 mg/dm²/day) is close to the 2007 average (0.66 mg/dm²/day).
2. The report identifies that easterly winds are predominant in this area, which means that the reference stations (AQ-49 and AQ-54) are located downwind of the site (based on the reported easterly predominant winds), albeit 21.5 and 36 km away respectively. These locations therefore may not be a true representation of background conditions.
3. There appears to be no discussion regarding outliers, such as the above elevated concentration at one of the reference locations for one sample event. There are also two instances in which the maximum dustfall levels occur at the furthest measured distance

from the haul road. This situation occurs at the Fox Haul Road in 2007 and 2008, and both times were in the month of July. It does not appear as though any investigation into the rationale for these outliers took place. For example, in the discussion of exceedances in the HVAS program it was noted that there were forest fires in July 2008. The preceding information raises questions such as whether it is possible that these fires may have contributed in some way to elevated dustfall in this area, or whether there is some other event that would affect July results in this area. Field notes describing the condition of the sample jar upon receipt by the technician, as well as records of any other local occurrences are useful in assessing potential rationale for such outliers.

4. Section 3.5 of the AQMP report states “The 2006 and 2007 results show that dust deposition was highest at the Fox haul road, followed by Misery and then Sable roads. This result is commensurate with the level of activity experienced on each road during those years.” Data does not support this generalization, with higher dustfall concentrations noted near field for Misery Road in 2007 than for Fox Road in either 2007 or 2008.
5. The “downwind” Misery Haul Road dustfall monitors are located south of the haul road, while the prevailing winds are reported to be from the east. The Fox Haul Road and Sable Haul Road dustfall monitors are arranged suitably given the prevailing wind direction.
6. In the description of the snow core sampling program in the AQMP report, it is noted that nitrate and sulphate are substances of concern as they are known to be harmful to terrestrial and aquatic ecosystems. According to the chain of custody reports for the dustfall samples, concentrations of these parameters were specifically requested however there is no discussion of the results in the report. A cursory review of the lab reports indicates that the concentrations near the haul roads are higher than those at the control location. It is unclear whether there has been any investigation into the measured nitrate and sulphate levels in dustfall, and whether there is any literature which suggests levels at which they may be of concern. Given that these parameters have been identified elsewhere in the AQMP report as being of concern, and the fact that they appear on the dustfall laboratory reports, it is recommended that these also be addressed to some extent when discussing the dustfall results.
7. In addition to nitrates and sulphates, dustfall samples were also analysed for soluble particulate and total metals (Section 2.5 and Appendix 2). There is no discussion or interpretation of monitoring results for these analytes.

8. There is a discrepancy in the sampling dates between what is written in the AQMP report and what appears in the figures and Appendix 2. Section 2.5 of the AQMP report states that monitoring in 2006 to 2007 took place in July and August, while June was added for the 2008 monitoring period. Figure 3.5-1 indicates that 2007 monitoring was in July, August and September while 2006 monitoring was in August and September.

2.3 CONTINUOUS AIR MONITORING PROGRAM

The Continuous Air Monitoring (CAM) station was commissioned in January 2008 at the Grizzly Lake location, and moved to an improved location in August 2008 near the Polar Explosives site. The improved location at the Polar Explosives site places the monitor at a downwind location with regard to the mine site activities (consistent with the siting of downwind dustfall monitors in a south-westerly direction from major sources). The parameters measured at the CAM station include TSP, particulate matter less than 2.5 μm (PM_{2.5}, or respirable particulate matter), sulphur dioxide (SO₂), and oxides of nitrogen (NO_x).

1. The only data for the Continuous Air Monitoring (CAM) program presented in the 2008 AQMP report, tabular or otherwise, is a summary of monthly averages of the parameters being measured (Table 3.4-2). There is a statement preceding Table 3.4-2 noting that all of the monthly average concentrations shown are within the Northwest Territories Ambient Air Quality Standards (NTAAQS) and the Canadian Ambient Air Quality Objectives (CAAQO), which are presented as Table 3.2-1 and Table 3.2-2 of the AQMP, respectively. It should be noted that *none* of the NTAAQSs or CAAQOs are intended for comparison to monthly averages for *any* of the parameters measured. Table 3.2-1 and Table 3.2-2 each show clearly that the standards/objectives are intended for comparison to either 1-hour average concentrations, 24-hour average concentrations or annual average concentrations. The measured maximum 1-hour and 24-hour average concentrations would be expected to be much higher than the monthly averages presented.

In short, the data provided in Section 3.4.2 of the AQMS report provides no useful information to assess performance relative to the NTAAQS standards and the CAAQO operational targets.

2. It should also be noted that the CAAQOs include maximum desirable, acceptable and tolerable concentrations for TSP, NO_x and SO₂ for various averaging periods. There is no comparison of the measured data to these objectives included in the AQMP report.

3. While Section 2.4 of the AQMP report indicated that the CAM building was installed at Grizzly Lake in May 2007, there are no data provided in Section 3.4.2 for 2007 nor any explanation for the absence of these data.
4. Similar to a previous comment on the HVAS program, it would be prudent to include a brief description of the QA/QC measures taken in the CAM program. As continuous NO_x and SO₂ analyzers need to be re-zeroed and re-spanned frequently in order to maintain accuracy, it should be noted how regularly analyzers were calibrated and their proper operation assured. Of note, significant operational issues appear to have been associated with the analyzers, with over 15% of SO₂ data (analyzer malfunction) and 4% of PM_{2.5} data (negative concentrations less than -3 µg/m³) invalidated over the sampling period. These operational issues only appear as footnotes to Table 3.4-2.

2.4 SNOW CORE SAMPLING PROGRAM

The snow sampling program was implemented in order to determine whether there is a decreasing trend in the presence of various parameters in snow with increasing distance from the mine operations. In 2008, snow core samples were collected at a total of 33 sites between April 9th and April 21st, 2008.

1. In Section 2.6.2 of the AQMP report, it is stated that analysis of the results was not completed on the basis of concentration (mg/L) as there can be variability depending on the depth of the snow pack. Instead, analysis was based on the surface loading rate (mg/m²/day). There is a statistical summary of selected parameters included in the analysis in Table 3.6-1. The statistics in the table for most parameters are based upon concentrations in units of mg/L (where applicable to the parameter). This seems to contradict the previous statement that indicated that the surface loading rate was to be used in the analysis of the results. For example, if the concentration of a certain parameter is low because it was collected in a deep snow pack, but its surface loading rate is comparable to other locations at a similar distance then there is some question as to how useful these summary statistics are when calculated on a concentration basis.
2. Snow samples are allowed to melt prior to analysis. Potential issues with this practice have been previously raised by SENES. In particular, nitrates and sulphates may be subject to reaction resulting in degradation of samples. SENES had previously recommended that split frozen and unfrozen samples be analyzed to validate the method used by the site. There is no indication that this recommendation was followed. Likewise, there is no evidence to suggest that melted snow samples are preserved or stored (e.g., maximum storage times) in accordance with generally accepted practice for water samples.

3. The AQMP states that “The higher concentrations of volatile compounds observed at reference sites is likely to be attributed to external sources such as arctic haze or long range transport.” This assertion is unsupported. Further, it is unclear why arctic haze and/or long range transport, being air shed issues, would not equally affect the EKATI site. Lower loadings noted in site monitoring data may be due to improper sampling /melting of snow cores resulting in nitrate and sulphate losses (see also comment 2 in this section).
4. Section 2.6 states that “spatial patterns in snow chemistry data were analysed based on the distance from the sampling site to the nearest centre of activity (Main Camp or Fox Pit).” Figures 3.6-2 and 3.6-3 are graphed relative to the distance from the mining source. It is not clear what was used as the point of origin of “the mining source” for each sample. Further, there is no differentiation between upwind and downwind samples which would add useful information to the analysis.
5. The AQMP report states “the effects of volatile compounds (S and N) are limited to the active mining areas surrounding EKATI.” Figure 3.6-2 does not appear to support this conclusion, with no clear discernable trends apparent for 2008 data. Given the significant scatter in data, regression analysis would provide further insight into the interpretation of these data.
6. There appears to be some inconsistency between Figures 3.6.1 and 3.6.3 for aluminum data. While the size of dots on Figure 3.6.1 are difficult to judge, it appears that eight aluminum samples exceed $0.5 \text{ mg/m}^2/\text{day}$, while Figure 3.6.3 suggests only 2 samples exceeded this value.
7. With regard to QA/QC measures, there is mention that duplicate samples were collected at three locations, however there is no further discussion regarding comparison between the duplicates. A cursory review of the laboratory data revealed that there were some notable differences in the two samples collected at location AQ-C4. For example, total suspended solids at this location for the two samples were 5.9 mg/L and 15.9 mg/L . It should also be noted that only two duplicates were found in the chain of custody forms (locations AQ-C4 and AQ-114).
8. The snow sampling program and dustfall monitoring program both monitor deposition rates ($\text{mg/m}^2/\text{d}$). As dustfall sampling is limited to summer months, some comparison of results between the two programs may provide insight into, or validation of, monitoring programs.

9. Lastly, the AQMP states that background concentrations are based upon 20 years of precipitation monitoring data at Snare Rapids, but refers to a 10 year period (1998 to 2008).

2.5 GREENHOUSE GAS EMISSIONS INVENTORY

The review of the greenhouse gas (GHG) emission inventory began by undertaking to review the applicability of the emission factors being used to calculate the total emissions. The GHG emissions are discussed in Section 3.3 of the AQMP report. This section does not include a cross-reference to the emission factor source document. While the source document does appear in the reference list, it would be useful to have a cross-reference in the chapter and additional information on the source reference itself such as chapter/table identifiers for the information used. The emission factors applied in the calculations were found in *Appendix A* of the AQMP report (GHG Management Plan), and most were traced back to the source document (blasting and biomass emission factors not found).

1. There is a discrepancy between the information in Table 3.3-1 of the AQMP report and the GHG Management Plan. The report identifies blasting emissions as being calculated using diesel consumption, while the GHG Management Plan identifies ANFO as the basis of the blasting emissions calculation. When using the emission factors appearing in *Appendix A* with the associated fuel volumes in Table 3.3-1, the resulting GHG emissions do not match with the annual emissions in Table 3.3-2 of the AQMP report. Interestingly, when the diesel fuel volume assigned to blasting in Table 3.3-1 is removed from the calculation, the resulting GHG emissions do match. This raises a concern that the GHG emissions totals in Table 3.3-2 are not complete as they appear to only include diesel fuel used as a fuel source, Jet A1 fuel and Waste Oil. *Appendix A* identifies other sources of GHGs, such as blasting, gasoline and biomass consumption in the waste incinerator which do not appear to be accounted for in Table 3.3-2.
2. The source document for the emission factors – Environment Canada’s *National Inventory Report 1990 – 2005: Greenhouse Gas Sources and Sinks in Canada*, Annex 12 [EC, 2005], was reviewed in order to ensure that the factors being applied were appropriate. The emission factors for diesel fuel were found in Table A12-7 of the reference document, under the entry for Heavy-Duty Diesel Vehicles with Advance Control. The information in Table 3.3-1 of the AQMP report identifies that only approximately 27% of the diesel fuel consumed at the site is consumed by motive sources, while over 50% is consumed by power generators. It is incorrect to apply emission factors for mobile equipment to stationary sources such as generators. Considering that diesel fuel consumption is already tracked by the type of equipment it is consumed by, it is recommended that emission factors suitable to each equipment

grouping be applied. While it is not anticipated that this will make a significant difference to the overall CO₂e emissions estimates, it would be a more technically sound approach. This practice has been previously questioned by SENES.

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3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

There were a number of deficiencies noted in the review of the *2008 Air Quality Monitoring Program* report and some generalizations and comments made that are not supported by the data. The main points of concern, some of which have been raised in the past but have not been addressed, are summarized below:

General Comments

- The application of “downwind” direction is not consistently applied. The CMS and Fox Road dustfall monitoring programs infer “downwind” as being *southwest* of sources. The Misery Road dustfall monitoring program is aligned as if “downwind” is in a *southerly* direction. The new Hi-Vol, TSP-3, was “...sited to be downwind of main camp area (based on the predominant easterly wind direction...)”, with this station located *northwest* of the main sources.
- Potential quality assurance/quality control issues are evident in the Hi-Vol and CAM programs, with significant data being lost or discarded as invalid.

HVAS Program

- The AQMP report lacks sufficient detail to draw any conclusions on the adequacy of the sampling program itself (i.e., sampling procedures). SENES has expressed concern in the past with regard to HVAS standard operating procedures, and there is no information in this report to dispel these concerns;
- The rationale for not running the HVAS program in the winter is not consistent with experience and practices in northern climates. This concern has been previously raised by SENES.
- There was no sampling conducted under the HVAS program at all in 2006. The AQMP report provides no rationale for missing an entire year of sampling and in parts (e.g., Executive Summary) infers HVAS monitoring was completed in 2006;
- There is no discussion of QA/QC practices. SENES has concerns with these practices. For example, over 10% of samples were discarded in 2008 due to negative weights. It is unusual to record negative weights on Hi-Vol filters used to collect TSP samples.

Dustfall Monitoring Program

- The AQMP report states that the guideline levels were exceeded for some months at each of the reference sites, however according to data within the AQMP report it appears that

this is true of only one site for one year. Inclusion of this apparent outlier significantly impacts the reference concentration for AQ-49 in 2008;

- There are several outliers for which it does not appear as though there was investigation into their respective causes;
- Analysis was requested for sulphate and nitrate, which were identified as being of particular concern elsewhere in the AQMP report; however, these are not discussed as they pertain to dustfall, nor is there any discussion on metals concentrations.

Continuous Air Monitoring Program

- The measured data is presented as monthly average concentrations, and compared to standards and objectives that are intended for comparison to 1-hour and 24-hour average concentrations. It is anticipated that the maximum measured 1-hour and 24-hour average concentrations will be significantly higher than the monthly averages. There is no useful analysis provided on the CAM to allow for an objective assessment of performance relative to regulatory standards and operational objectives;
- There is no notable discussion of QA/QC practices, other than to state that equipment is regularly calibrated. Data suggests that there are operational issues with the equipment (e.g., for SO₂ and PM_{2.5}).

Snow Core Sampling

- There is a statement that analysis of results was completed on the basis of loading rate rather than concentration; however, the summary statistics are presented on a concentration basis;
- Snow samples are allowed to melt, with no evidence to suggest that melted snow samples are preserved or stored (e.g., maximum storage times) in accordance with generally accepted practice for water samples. In particular, data suggests that nitrates and sulphated may be degrading after sample collection, with results biased low for these parameters. This issue was previously raised by SENES, with no indication that recommendations were followed;
- It is stated that duplicate samples were collected as a QA/QC measure, but there is no discussion of how the duplicate results compare, with some discrepancies noted on initial review.

Greenhouse Gas Emissions Inventory

- The GHG emissions summary table in the AQMP report only appears to consider diesel fuel as an equipment fuel source, Jet A1 fuel and waste oil whereas the GHG

Management Plan identifies other fuel sources such as ANFO, biomass and gasoline which do not appear to be included in GHG emission calculations;

- The fuel consumption summary table in the AQMP report lists diesel as the fuel type consumed in blasting whereas the GHG Management Plan states that blasting emissions are calculated based on ANFO usage;
- When applying the emission factors from the GHG Management Plan to the fuel consumption amounts in the body of the AQMP report, the resulting GHG emissions do not match unless the diesel amount applied to blasting is removed;
- The diesel emission factors applied for site-wide diesel consumption appear to be those for Heavy Duty Diesel Vehicles – Advance Control, where only approximately 27% of diesel is consumed by motive sources. The majority of diesel fuel is used in power generators and therefore the application of factors for mobile sources to the entire site. While it is not anticipated that this will make a significant difference to the overall CO₂e emissions estimates, use of applicable emission factors would be a more technically sound approach. This practice has been previously questioned by SENES.

3.2 RECOMMENDATIONS

Based on the above conclusions of the review, SENES has the following recommendations for future Air Quality Monitoring Program reports:

- A summary of QA/QC practices should be provided for each aspect of the monitoring program;
- Monitoring protocols should be provided as appendices to the report;
- Clarification and consistent application of “downwind” is required for placement of monitoring stations;
- Calculation methods for the measured data from the CAM program should be adjusted such that measured concentrations are presented appropriately for comparison to the respective standards and objectives;
- Investigate appropriate levels of nitrate and sulphate in dustfall, as these are highlighted in the AQMP snow core discussion as being of concern but not discussed in the dustfall section despite being included in the analysis;
- Refine the emission factors being used to estimate GHGs from diesel fuel. Currently it appears as though emission factors for mobile equipment are being applied to all sources that are consuming diesel fuel at the site;
- Ensure that the information presented in the AQMP report regarding fuels and GHG emissions are consistent with the GHG Management Plan.

4.0 REFERENCES

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