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ENVIRONMENTAL MONITORING ADVISORY BOARD

PEER REVIEW OF THE 2018 ENVIRONMENTAL AIR QUALITY MONITORING REPORT

DIAVIK DIAMOND MINES (2012) INC.

October 2019

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PEER REVIEW OF THE 2018 ENVIRONMENTAL AIR QUALITY MONITORING REPORT DIAVIK DIAMOND MINES (2012) INC.

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1 INTRODUCTION

As requested by the Environmental Monitoring Advisory Board (EMAB), Arcadis Canada Inc. (Arcadis) undertook a review of the *2018 Environmental Air Quality Monitoring Report* (AQMR) [ERM 2019] prepared by ERM Consultants Canada Ltd. (ERM) for Diavik Diamond Mines (2012) Inc. (DDMI). The report summarizes the air quality monitoring activities conducted at the DDMI diamond mine during 2018. The components of DDMI's AQMR include the following:

- total suspended particulate (TSP) monitoring;
- dustfall monitoring;
- snow core sampling program;
- National Pollutant Release Inventory (NPRI) reporting; and
- Greenhouse Gas (GHG) reporting.

The aspects of the AQMR contained within Arcadis' scope of review specifically included:

- Implications resulting from A21 Kimberlite Pipe and associated construction and operational activities;
- Adequacy of monitoring locations;
- Effectiveness of dust suppression techniques;
- Quality Assurance/Quality Control (QA/QC) practices and Standard Operating Procedures (SOPs);
- Integration of meteorological data and operational information;
- Modelled versus monitored TSP and dustfall;
- Adequacy and effectiveness of TSP samplers used;
- How well DDMI addressed comments and recommendations on the 2017 AQMR; and
- Any implications of Arcadis' review of the EAQMP program (May 6'19 draft memo).

Arcadis completed a review of each of the above components of the air quality monitoring program in place at the DDMI diamond mine, as described in the 2018 AQMR. The following sections outline the findings of the review. The report concludes with a summary of key findings and recommendations.

2 DISCUSSION

2.1 Continuous TSP Monitoring

Continuous air monitoring (CAM) was commissioned in April 2013 at two sampling locations: 1) the communications building adjacent to the accommodations complex; and 2) the A154 dike along the southeast corner of the A154 pit. The locations were selected based on the results of an updated air dispersion modelling analysis (completed in 2012), the proximity to the Project footprint, and power requirements. A beta attenuation monitor (BAM) is used to measure TSP at the CAM stations. The A154 Dike monitor was not operational in 2018 due to technical issues with flow and ambient relative humidity of the sampler. Therefore, the continuous monitoring data presented was only from the CB station.

Our comments with respect to the 2018 continuous TSP monitoring program are presented in Table 1.

Table 1. Review of Continuous TSP Monitoring

No.	Comment
1.	**AQMR, Page 2-1: "***Two TSP monitors were installed at the Mine in April 2013. The locations of the monitors were selected based on proximity to the Mine boundary, with careful consideration of the TSP results form the updated air dispersion modelling assessment and in consideration of the availability of power (Figure 2.1-1; DDMI 2013)"* Arcadis acknowledges that the TSP Sampler Assessment Memorandum (ERM, January 26, 2018) includes a discussion with respect to the TSP monitoring locations. The memorandum indicates that the updated dispersion modelling assessment, completed by Golder in 2012, was based on a maximum operating scenario for the mine and therefore captured the worst-case predicted impact of the Mine operations. It is also acknowledged that there are year to year variations in wind and there does tend to be wind in all directions, with some years having a more southeasterly or northwesterly dominance. However, in order to illustrate the efforts made to comply with the intent of the Environmental Agreement and the objectives of the established CAM Program, it is recommended that Diavik include information such as changes to mining activities for the reporting year (i.e. new mining areas, new or different road routes, suspended activities, etc) and wind rose data as compared to what was included in the updated air dispersion modelling assessment. Based on this information, Diavik then would be able to illustrate and confirm that the locations of the existing monitoring stations are sufficient, and the data captured is representative for the annual operations. Additionally, Arcadis recommends that an updated air dispersion modelling assessment be completed during review of the EAQMP to evaluate the current Site-wide operations (i.e. inclusion of operations at A21 and updated meteorological data and reassess the monitoring locations as needed.
2.	**AQMR, Page 2-1:** *"The DDMI TSP Monitoring Standard Operating Procedure (SOP) ENVI-801-0613 R4 (DDMI 2016) was in place and includes information about monthly, quarterly and*

	annual servicing requirements for samplers. The 2018 sampler maintenance and calibration records provided by DDMI are included in Appendix B." Arcadis notes that in Appendix A of the 2018 AQMR, ERM Response to Comment no. 2 identified that SOPs relevant to the AQMR would be included in the 2018 Report. Upon review of the AQMR it was determined that the TSP Monitoring SOP ENVI-801-0613 R4 was not included in the Report. Therefore, compliance with the SOP and procedures therein was not possible to review. An incomplete set of calibration records are included within Appendix B for the CB station including two (2) quarterly calibration records completed in March and June, and four (4) monthly calibration records from January, June, July, and September 2018. Based on the review of the provided records, it appears that the CB station was consistently failing multiple parameters when the calibrations were being completed. Arcadis recommends that compliance with DDMI SOP ENVR-801-0613 R4 be clearly demonstrated and reported within the AQMR to ensure that the monitors are operating correctly and to demonstrate due diligence is being taken to remedy any issues. This would also provide confidence in the data provided by the monitors and conclusions derived within the AQMR.
3.	**AQMR, Appendix B:** *TSP Monitoring Station Calibration and Maintenance Records* As noted in Comment no. 2, an incomplete set of calibration records have been provided for the CB monitor and it is not possible to determine whether all maintenance, audits, and calibrations have been completed in accordance with DDMI SOP ENVR-801-0613 R4. Arcadis recommends that validation of compliance with all maintenance and calibrations in accordance with the SOP be provided within the AQMR.
4.	**AQMR, Appendix C:** *Daily TSP Data 2018* Based on the review of the daily data provided in Appendix C, there appears to be a consistent pattern of invalid data (i.e. too many negative or missing values) occurring during the summer months (June – August). As noted within the AQMR, the period for greatest dust generation is when the site is free from snow, particularly during the period of May – September. While Diavik did achieve a reasonable data capture of 86% from the CB monitor in 2018, it appears the monitor had data capture issues during the highest months for dust generation at the site. Due to the continued issue with data completeness, Arcadis recommends that in addition to documentation of annual mining activities, Diavik document visual dust observations and the mitigation measures applied so that these records can be used within the AQMR to validate the results obtained from the monitors. The observations and mitigations measures could be presented within a format, such as an Observation Log, that would document the date, observation and corrective action/mitigation applied in response to the observation which could then correlate to the data from the monitor(s).

2.2 Dustfall and Snow Core Sampling

The dustfall monitoring and snow core sampling programs were implemented in 2001 under the Aquatic Effects Monitoring Program (AEMP) as a means of collecting information on dust deposition with distance from mining activities. A summary of the 2018 AEMP results is provided in the AQMR, while details are provided in Appendix D, *Diavik Diamond Mine: 2018 Dust Deposition Report* (DDMDDR) prepared by ERM [2019]. With no local guidance for dustfall, the AQMR compares DDMI dustfall levels to former objectives used by the Province of British Columbia (B.C.) for the mining industry (1.7 to 2.9 mg/dm^2/day, based on a 30-day average). This is consistent with the assessments completed for the previous AQMRs.

Our comments with respect to dustfall and snow core sampling are presented in Table 2.

Table 2. Review of Dustfall and Snow Core Sampling

No.	Comment
5.	**AQMR, Page 3-4:** *"To supress fugitive dust generation, roads, parking areas and laydown areas were watered during the summer as needed. Between May and September 2018, approximately 1,006 m^3 of water was applied on the Mine site and 66,472 m^3 of water was applied on haul roads. The exact impact of dust suppression could not be determined from the data collected in 2018; however, it is expected that road watering reduced the amount of dust generated at the Mine in 2018."* Results from the dust monitoring program can be a useful tool to evaluate the effectiveness of current Fugitive Dust Management programs and can provide opportunities for improvement to existing programs to ensure fugitive dust is effectively controlled at the site. Based on the identification of the quantity of water used for dust suppression, it is assumed that Diavik is already maintaining records/logs pertaining to visual dust observations at the site and implemented mitigation measures in response. Arcadis recommends, as noted in Comment no. 4, that Diavik utilize observed fugitive dust events and watering logs to correlate with observed events from the TSP Monitoring and Dustfall data as well as to confirm the effectiveness of the mitigation efforts implemented at the site and make modifications as necessary to limit the fugitive dust impacts.
6.	**AQMR, Page 3-5:** *"The greatest estimated dustfall rate measured using gauges occurred at Dust 3 (25 m from the Mine). The Dust 3 measured dustfall rate in 2018 was 796 mg/dm^2/y. Dust 7 (667 mg/dm^2/y) and Dust 10 (645 mg/dm^2/y) recorded the second and third highest dustfall rates measured using gauges, respectively. Both sites are located on the south side of the Mine. Dust 7 is located 1,147 m from the Mine but very close to the winter road (figure 3.1-1), and Dust 10 is located 46 m from the Mine adjacent to the A21 open pit."* TSP is strongly correlated to dustfall with the ability to correlate TSP concentrations in air from dustfall data. Considering this correlation between the two data sets, and as noted within the AQMR, the high concentrations of dustfall observed at the Dust 3 and 10 monitors appear to indicate that the operations in the vicinity of the backfill plant (north of Dust 3) and the operations at the A21 pit are having an impact on the dust levels from the Mine. Since there are increased dust observations in the vicinity of A21, Arcadis recommends relocating the A154 station to an area near A21 where access to power is available.

	Arcadis also recommends that the 2012 modelling assessment be updated during the review of the EAQMP to reflect current operations, confirm the most appropriate locations for TSP monitors, and assess the observed dustfall observations with predicted concentrations within the updated assessment.
7.	**AQMR, Page 3-6:** *"Dustfall rates at stations SS1-1, SS1-2, SS5-3, and Dust 7 were greater than the upper limit of the 95% confidence interval for their respective zones in 2018. These high dustfall rates, compared to the overall distribution of dustfall rates within each zone, indicated that higher dustfall rates were observed in the vicinity of the A21 open pit, the airstrip, and the winter road southeast of the Mine."* The 2018 dustfall and snow core sampling program has demonstrated that A21 open pit operations are impacting the dustfall in areas south of the site. In addition, the airstrip and winter road areas are seeing increased impacts with historical comparisons identifying a year to year variability at stations due to shifting or changes in mining activities. Given the observed impacts due to the open pit operations, as well as the observed high dustfall rates in the vicinity of the airstrip and winter road south of the Mine, it is recommended that the 2012 modelling assessment be updated during the review of the EAQMP to reflect current operations, and assess the observed dustfall observations with predicted concentrations within the updated assessment. This reassessment would provide confidence that the observed concentrations are within or below those of the conservatively model predicted concentrations and therefore confirm that the implemented mitigation measures employed at the Mine are effective. Arcadis also recommends that Diavik identify the changes to general mining activities (i.e. increase use of certain roadways, new mining areas, suspended activities, etc.), as well as visual dust observation and mitigation application logs, or similar, which would allow for the correlation of observed visual dust and changes in operations to the dustfall results as well as the demonstration that mitigation measures are having a positive impact on the dustfall results.

2.3 NPRI and GHG Emission Inventories

Emissions for CO, SO_2, NO_X, VOC, Ammonia (NH_3), TSP, PM, PM_{10} and $PM_{2.5}$ were estimated for 2018 and reported to Environment and Climate Change Canada (ECCC) under the NPRI reporting system. In addition, GHG emissions were calculated and reported to the federal system through ECCC.

Our comments with respect to NPRI and GHG emission inventories are presented in Table 3.

Table 3. Review of NPRI and GHG Inventories

No.	Comment
8.	**AQMR, Section 4 and Section 5** The results of the NPRI and GHG emissions inventories are discussed in Sections 4 and 5 of the AQMR, respectively. As indicated in Arcadis' previous reviews, the AQMR does not include any detailed information about the emission factors or calculation methodologies used for either of the inventories however, Arcadis does note that in the Response to Comments on the 2017

	AQMR ERM noted that published ECCC emission factors and estimation calculators were used. Based on the limited information presented within the AQMR regarding operating conditions at the Mine for 2018 Arcadis considers the values reported by DDMI to be reasonable by comparison to previous years. Although a review of the methods/calculations specifically used to derive these estimates would be required to confirm their appropriateness.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

There are several improvements that could be made in monitoring procedures and analysis noted in the review of the DDMI *2018 Environmental Air Quality Monitoring Report* and some generalizations and comments made that are not supported by the data. The main points of concern are summarized below:

General Comments

- Many of the comments provided in the previous reviews of the 2014-2015 Air Quality Monitoring Report, and the 2016 and 2017 Air Quality Monitoring Reports were not specifically addressed in the 2018 report, particularly with respect to the TSP Continuous Monitoring Program, SOPs and Calibration Records.
- There was not enough information provided in the AQMR to validate the statements made with respect to the revised dispersion modelling, the effectiveness of dust suppression activities, or the implications of A21 operations. However, based on dustfall data it appears as though A21 operations are increasing the observed dustfall.
- Even though there were some attempts to include QA/QC protocols and SOPs for some aspects of monitoring, based on information provided, it appears that adherence to the SOPs, particularly the TSP Monitoring SOP, remains an issue and with the lack of complete calibration and maintenance records as well.

Continuous TSP Monitoring Program

- The 2018 TSP Monitoring program consisted only of data from the CB station as the A154 Dike station was non-operational. As a result, QA/QC issues remain evident with the program as well as adherence to calibration, preventative maintenance and auditing schedules for the monitors. The CB station monitor also appeared to have the majority of invalid data (negative or missing values) occur during the summer months, when dust generation at the Mine is expected to be greater. Overall the CB station did have a reasonable completeness of 86% for the year.
- The location of the CB TSP monitoring station may not be adequately placed as dustfall monitoring suggested moderate to high values observed in the north and southwest. It is expected that TSP would follow the same pattern, however the lack of information with respect to the 2012 modelling assessment does not allow for correlation of monitored values against the predicted modelled concentrations.

Dustfall Monitoring Program

- The results of the Dustfall and Snow core sampling program strongly indicates that the A21 Open Pit operations have impacted the dust seen off-site from the Mine.
- There was no attempt to evaluate or use the dustfall results to evaluate the effectiveness of the dust suppression efforts or correlate to mining activities, other than to state that it is expected that road watering reduced the amount of dust generated and that the higher overall dust rates were likely a result of surface activity, particularly at A21.

NPRI and GHG

- There was not enough information provided within the AQMR to validate the reported values to NPRI or GHG.

3.2 Recommendations

Based on the above conclusions of the review, Arcadis has the following recommendations for future EAQMP activities and reporting:

- It is recommended that DDMI include (and adhere to) a detailed summary of QA/QC practices in the AQMR for each aspect of the monitoring program, particularly the CAM Program.
- Complete and finalized calibration records be provided for all equipment (i.e. continuous monitoring equipment, etc.).
- The current and historical dustfall monitoring results be used to evaluate the effectiveness of dust suppression efforts.
- Available meteorological data and records of on-site activity, including visual dust observation and mitigation logs, be used to document the cause/rationale for events of high TSP concentration measured by the monitors (including dustfall monitoring results).
- A detailed comparison of monitored and modelled TSP/dustfall be included within the AQMR.
- Details of the NPRI and GHG calculations be included, or a reference to an external document containing such details, to allow for validation of methods and quantities reported.

Arcadis recommends that the following items be considered during the re-evaluation of the EAQMP for the site:

- The TSP monitor locations be re-evaluated using historical meteorology and updated particle size distributions for dustfall, as the TSP monitor results do not appear to be correlated with the 2018 dustfall monitoring results and operations at A21 Open Pit.
- The 2012 dispersion modelling assessment be updated to reflect current operations and be used to evaluate the appropriate locations for TSP monitors and assess the observed dustfall observations with predicted concentrations within the updated assessment.

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