Appendix 6-D
Baseline Air Quality Monitoring Report: Denison Mines – Wheeler River Project

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1.0 INTRODUCTION

Independent Environmental Consultants (IEC) was retained by Denison Mines Corp. (Denison) to assist in the completion of a baseline air quality monitoring program in support of the Environmental Impact Statement (EIS) for the Wheeler River Project (the Project). The Project site is located approximately 35 km north of Cameco's Key Lake uranium operation and approximately 4 km west of Highway 914. Denison is proposing to apply an innovative approach to uranium mining called In-Situ Recovery (ISR), which is used extensively internationally but has yet to be used in Canada. This approach eliminates the need for large open pits, shafts, and underground mine workings that are the norm for uranium mining in Canada to-date.

The scope of the baseline air monitoring program was developed with consideration to the potential Project-environment interactions that may exist during the construction, operation, decommissioning, and closure of the Project site, and the contaminants of potential concern (COPCs) that may be associated with these activities. Based on the description of the Project site and processes from the Pre-Feasibility Study [1], the projected activities during the various Project stages that have the potential to impact air quality include the following:

- Site preparation and earthworks activities during construction,
- Construction activity associated with building the access road and other mine site roads,
- Construction activity associated with building infrastructure,
- Increased road traffic on Highway 914 (construction crews, site personnel, deliveries, yellowcake shipping, etc.),
- Air traffic to/from the new airstrip,
- Operation of mobile equipment on-site (mining equipment, haul trucks, light-duty trucks, etc.),
- Operation of the standby diesel power generating station,
- Drilling activities in the ISR wellfield,
- Fugitive dust from unpaved roads, windblown dust,
- Radon emissions from ISR wellfield operations,
- Emissions from the ISR plant operations,
- Building demolition, and
- Re-grading and re-vegetation of site.

This report outlines the regulatory context of the baseline program in relation to the broader Environmental Assessment (EA) process, rationale for the selection of COPCs, measurement methodologies for each COPC inclusive of quality assurance and quality control (QA/QC) procedures, and the results of the air quality baseline monitoring program. The report is concluded with key observations from the monitoring program.

2.0 REGULATORY CONTEXT

The baseline air quality monitoring program is intended to support the development of an eventual EA for the Wheeler River Project, by establishing the existing air quality conditions prior to the construction and operation of the Project. As the baseline work will form the basis of the EA work pertaining to air quality (i.e., assessment of air quality impacts), it is important to consider the requirements of the EA process for the assessment of air quality in the scoping of the baseline program. As the Project is a proposed uranium mining operation, an EA will be required that will need to meet both Federal and Provincial EA processes.

2.1 PROVINCIAL REQUIREMENTS

The Provincial EA process is overseen by the Saskatchewan Ministry of Environment (SkMOE). As the baseline program involves measurements of air quality parameters, the SkMOE air quality monitoring guidance and requirements as outlined in its 2012 publication *Air Monitoring Guideline for Saskatchewan* [2] (the *Monitoring Guideline*) were followed in the development of the baseline program. This document outlines relevant information, such as permissible instrumentation and siting requirements that facilities are required to follow when completing ambient air monitoring in Saskatchewan. The Monitoring Guideline also includes SkMOE ambient air quality criteria; however, it should be noted that these criteria are not the most current and have been superseded by those in the Saskatchewan Environmental Quality Standard (SEQS) [3]. The Saskatchewan Ambient Air Quality Standards (SAAQS) are summarized in Table 20 of the SEQS, and the Saskatchewan Environmental Code identifies in Division E.1.2 that these standards must be met for industrial sources, including mine sites [4]. As such, the Project would need to be able to demonstrate compliance with the SAAQS in the impact assessment supporting the Provincial EA. These criteria identify the contaminants of interest to the SkMOE that should be considered for relevance during the baseline work. Not all of the contaminants listed in Table 20 of the SEQS are relevant to the Project and proposed operations; those that are relevant are summarized in Table 1.

Table 1: Saskatchewan Ambient Air Quality Standards

Pollutant	Average Concentration for Applicable Time Period ($\mu g/m^3$)				
	1-hr	8-hr	24-hr	30-day	Annual
Particulate Matter ($PM_{2.5}$)			28[1]		10
Particulate Matter (PM_{10})			50		
Total Suspended Particulates (TSP)			100		60[2]
Nitrogen dioxide	300 (159 ppb)		200 (106 ppb)		45[3] (24 ppb)
Sulphur dioxide	450 (172 ppb)		125 (48 ppb)		20[3] (8 ppb)

Pollutant	Average Concentration for Applicable Time Period (µg/m³)				
	1-hr	8-hr	24-hr	30-day	Annual
Carbon monoxide	15,000 (13,000 ppb)	6,000 (5,000 ppb)			

Notes:
[1] The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
[2] Geometric means
[3] Arithmetic means

While carbon monoxide is relevant to the Project (as it is a combustion product, and there are a number of proposed combustion sources associated with operations), it is not measurable without access to power.

2.2 FEDERAL REQUIREMENTS

As the Project is a proposed uranium mining operation, a Federal EA will be triggered under the Canadian Environmental Assessment Act (CEAA), with the Canadian Nuclear Safety Commission (CNSC) acting as the lead agency. As a result, the baseline assessment framework has been developed to align with Federal standards and guidance. The Project will be expected to demonstrate compliance with the Canadian Ambient Air Quality Standards (CAAQS), and the monitoring program will be expected to include other ambient atmospheric parameters of interest to the CNSC, such as radon and gamma. The CAAQS have been developed by the Canadian Council of Ministers of the Environment (CCME) [5], and have been adopted federally by Environment and Climate Change Canada (ECCC), and are presented in Table 2.

Table 2: Canadian Ambient Air Quality Standards

Pollutant	Averaging Time	Numerical Value		
		2015	2020	2025
Fine particulate matter ($PM_{2.5}$)	24-hr [1]	28 µg/m³	27 µg/m³	
	Annual [2]	10 µg/m³	8.8 µg/m³	
Sulphur dioxide (SO_2)	1-hr [4]		183.4 µg/m³ (70 ppb)	170.3 µg/m³ (65 ppb)
	Annual [5]		13.1 µg/m³ (5 ppb)	10.5 µg/m³ (4 ppb)
Nitrogen dioxide (NO_2)	1-hr [6]		112.8 µg/m³ (60 ppb)	79 µg/m³ (42 ppb)
	Annual [5]		32.0 µg/m³ (17 ppb)	22.6 µg/m³ (12 ppb)

Notes:
[1] 3-year average of the annual 98th percentile of the daily 24-hr average concentrations
[2] 3-year average of the annual average of all 1-hr concentrations
[3] 3-year average of the annual 4th highest of the daily maximum 8-hr concentrations
[4] 3-year average of the annual 99th percentile of the daily maximum 1-hr average concentrations
[5] the average over a single year of all 1-hr average concentrations
[6] 3-year average of the annual 98th percentile of the daily maximum 1-hr average concentrations

2.3 ADDITIONAL GUIDANCE

Particulate matter of less than 10 micron (PM_{10}) was identified as a COPC for the Project and included in the monitoring program. However, there is no annual provincial or federal limit currently in force. The WHO provides an annual standard for PM_{10} of 20 µg/m^3 [6] which will be used for comparative purposes in the assessment. In addition, when updating the provincial air quality standards from what is published in the SkMOE Monitoring Guideline to the current SAAQS, the standard for settleable particulates was removed. The standard for settleable particulates was formerly 2.0 mg/cm^2/30-days [2] and has been included in this assessment for comparison to the measured levels.

3.0 SAMPLING METHODOLOGIES

Sampling methodologies were selected with consideration to the regulatory context, project setting, contaminant of concern, and industry standard practice. Section 2.3 of the SkMOE Monitoring Guideline identifies that analyzers "*used for an ambient air monitoring program within the province must satisfy the requirements of the US EPA equivalent reference methods for ambient air monitoring*" [2]. As a result of this requirement, the U.S. EPA *List of Designated Reference and Equivalent Methods* [7] was referenced when scoping the program to select equipment that would be acceptable to the SkMOE. Many of the instruments included in the U.S. EPA list are dependent upon access to a dedicated AC power supply and temperature-controlled enclosure. As the site is currently in the exploration phase, there is insufficient access to power to operate such equipment. It should be noted that the SkMOE does acknowledge that access to power may be a limiting factor for some projects and identifies in section 2.6 of the Monitoring Guideline that sampling using passive means is acceptable for such circumstances [2]. As such, where U.S. EPA reference or equivalent methods were either not available or not feasible, passive methods were considered.

3.1 SETTLEABLE PARTICULATES (DUSTFALL)

3.1.1 Equipment and Operation

Section 2.6 of the SkMOE Monitoring Guideline indicates that sampling using passive means is acceptable for areas where there is no access to power [2]. Dustfall was included in the baseline air quality monitoring program as it provided a cost-effective means to provide robust spatial coverage for particulate monitoring, and the resulting data on the dust deposition rate is of use to other EA disciplines such as the Human Health Risk Assessment (HHRA) component.

The dustfall monitoring procedure applied at the site was based on ASTM Standard D1739:1998 [8] and procedures from the British Columbia Environmental Lab Manual [9], with supplies and analysis being provided by ALS Environmental (ALS). Samples of dustfall are collected in open-topped polymer containers, which are inserted to a stand-mounted holder equipped with a wind shield and bird ring. The dustfall containers provided by ALS feature a tight-fitting screw lid, which is removed at the time of exposure and re-fitted at the time of retrieval. At the time of deployment, a 50% isopropanol solution is added as an anti-freezing agent and algae inhibitor. The containers are then placed in the holders and left open to the atmosphere for a period of 30 days (+/- 2 days) to collect settling particles. The field protocol outlines that periodic checks should be completed where possible to ensure that there is always some liquid in the container (to assist with entrainment of dust), and if not, to add deionized water to the container. At the end of the exposure period, the samples are resealed by fixing the screw lid in place. Field sheets are used to keep track of the sample location, the start and end dates, and the amount of liquids added to the container. The full field protocol and an example field sheet is provided in Appendix A.

3.1.2 Siting

Siting criteria are provided in ASTM Standard D1739:1998, which outlines that there should be no structures higher than 1 m within 20 m of the container (or objects within 20 m should be less than 30° from the horizontal at the container top), and that the container should be approximately 2 m above the ground [8]. These criteria are similar those from the Monitoring Guideline, which for passive equipment outlines that the height above ground should be between 1-3 m, and the elevation angle should be less than 30° from the sample inlet to the top of any obstacle [2]. Monitoring was completed at six (6) locations at the Project site (see Figure 1).

3.1.3 Sampling Schedule

The SkMOE criterion for settleable particulates is presented in terms of a deposition rate on a 30-day basis (2.0 mg/cm^2/30-days). The ASTM Standard outlines that the canister should be exposed to the atmosphere for a period of 30 days, +/- 2 days. This requirement appears in the field protocol, provided in Appendix A. The dustfall sample schedule that was followed in support of this study is summarized in Table 3.

Table 3: Dustfall Sampling Schedule (2018-2021)

Year	Round	Deployed	Retrieved	Average Exposure Period (days)
2018/2019	2019-1	October 2018	January 2019	113
	2019-2	January 2019	May 2019	110
2020	2020-1	July	August	34.9
	2020-2	August	September/October	34.1
	2020-3	September/October	November	33.6
2021	2021-1	June	July	32.0
	2021-2	July	August	38.0
	2021-3	August	September	35.4
	2021-4	September	October	30.5

NOTES:
[1] All results were prorated to a daily average exposure period by ALS. These were prorated to a period of 30 days for this report, in order to compare the results to the SkMOE standard. The results of the program are discussed in section 4.2.

3.1.4 Calibration and QA/QC

As the dustfall sampling is a passive method, there are no calibration requirements. A number of QA/QC procedures were written into the field protocol to ensure sample integrity. The following general approaches were applied:

- sample containers were kept sealed until the moment of deployment in the field,

- duplicate samples were collected at each site, to account for the possibility of a compromised sample,
- an algae inhibiting solution (50% isopropanol) was added to the container upon deployment to avoid sample contamination due to algae build-up,
- detailed field notes were maintained by the technicians to track the exact deployment and retrieval dates and times, location IDs, and any relevant observations,
- upon retrieval, the container lids were firmly screwed into place. Prior to shipping, the lids were taped to ensure they would not loosen during shipping, and
- the field technicians did not attempt to remove any debris from the canisters upon collection – the field technicians only contacted the external surface of the containers.

3.2 Nitrogen Oxides and Sulphur Dioxide

3.2.1 Equipment and Operation

A passive sampling system developed by Bureau Veritas Laboratories (BVL) was used for the measurement of nitrogen dioxide and sulphur dioxide in ambient air. While the passive method is not a recognized U.S. EPA reference or equivalent method for NO_2 or SO_2, the SkMOE Monitoring Guideline does allow for the use of passive systems in areas where there is limited access to power [2]. The U.S. EPA Reference and Equivalent methods for NO_2 and SO_2 each require a continuous power source to operate and are generally rack-mounted systems that are intended to operate in an indoor, temperature-controlled environment, with a sample inlet extending out of the shelter and sample air being drawn via an electric pump. Such a system is not feasible for operation at this stage of the Project development, and so passive samplers were used to estimate the existing baseline condition.

The BVL Passive Air Sampling System (PASS) consists of a domed rain shelter with three slots on the underside for the installation of cartridges that are specially treated for the collection of various air contaminants. Cartridges for NO_2 and SO_2 were applied in this program. The cartridges are provided by BVL in sealed containers and are deployed simply by unsealing the cartridge in the field and installing it to the rain shelter. The cartridges are then exposed to the atmosphere for the approximately 30 days. Upon completion of the sample period, the cartridges are collected from the rain shelters and re-sealed in the sample containers. A field monitoring protocol for the passive samplers was developed by IEC and provided to the field team with IEC providing remote support. The field protocol is provided in Appendix A.

3.2.2 Siting

As noted previously, the SkMOE outlines siting criteria for static monitors in Section 2.2.2 of the Monitoring Guideline. These criteria include a sampler height above ground of between 1-3 m, and an elevation angle of less than 30^{o} from the sampler inlet to the top of any nearby obstacle [2]. This matches exactly with the siting criteria recommended by BVL for its sampling system. Monitoring was completed at two (2) locations, as shown in Figure 1.

3.2.3 Sampling Schedule

The exposure period recommended by BVL for the passive samplers is 30 days. The sample schedule that was followed in support of this study is summarized in Table 4.

Table 4: Passive Gaseous Compound Sampling Schedule (2019-2021)

Year	Round	Deployed	Retrieved	Average Exposure Period (days)
2019	2019-1	August	September	34.9
	2019-2	September	October	26.0
	2019-3	October	November	23.0
2020	2020-1	July	August	33.6
	2020-2	August	September/October	35.1
	2020-3	September/October	November	31.9
2021	2021-1	June	July	32.1
	2021-2	July	August	38.0
	2021-3	August	September	34.8
	2021-4	September	October	30.9

3.2.4 Calibration and QA/AC

The selected sampling method is a passive system, and so there are no equipment calibration requirements; however, there are a number of QA/AC measures that need to be observed to maintain sample integrity. These procedures are included in the field protocol that is provided for the sampling system in Appendix A. In general, the practices employed to ensure sample integrity included the following:

- duplicate samples were collected at each site, to account for the possibility of a compromised sample,
- samplers were kept in the sealed plastic bags and storage tins until the moment of deployment in the field,
- samplers were handled carefully by the field technicians, touching only the rim of the sampler and not the diffusion barrier,
- field technicians kept field notes to track the deployment and retrieval dates, sampler IDs, sample locations, and any relevant observations,
- technician field notes were used to ensure that the samplers were returned to the containers matching the sample ID for the sample location,
- upon retrieval, the samplers were returned to the associated plastic bag and sealed, prior to returning them to the metal container,

- the metal containers containing the retrieved samples were sealed with Teflon tape, to avoid contamination, and
- blank samples for each contaminant were requested from BVL for each round of sampling and returned to the lab with the collected samples.

3.3 External Gamma

Gamma is not included in the list of standards from the SkMOE or ECCC; however, due to the nature of the operation (uranium mining) and oversight by the CNSC during the EA stage, it was recommended that the baseline monitoring program include the establishment of baseline gamma conditions. This would allow for the tracking of levels as the Project moves through its life-cycle.

3.3.1 Equipment and Operation

Gamma is measured using dosimeters, which were provided by the supplier with an environmental enclosure (a waterproof plastic pouch) for ease of set-up (i.e., can attach to a vertical surface such as a tree or post). The dosimeters are then exposed to the atmosphere for a period of approximately 90 days. The dosimeters used in this program were InLight® dosimeters developed by Landauer. The InLight® dosimeter provides results using optically stimulated luminescence (OSL) technology. The dosimeter has a window that opens to aluminum, copper and plastic filters, and an aluminum oxide detector slide. After the exposure period, the analysis of the dosimeter involves using OSL technology, whereby an LED array is used to stimulate the aluminum oxide detectors, and the emitted light is detected and measured by a photomultiplier tube (PMT). The amount of light measured by the PMT is directly proportional to the radiation dose. The minimum detectable dose of gamma radiation is 1 µSv (0.1 mrem) for photons with energies above 15 keV.

Each shipment of dosimeters is provided with two control dosimeters. The dosimeters begin detecting radiation as soon as they are shipped from the lab, and so the control dosimeters provide necessary information on the radiation doses received during the shipment and deployment/retrieval activities. As per the protocol provided in Appendix A, the “transit control” dosimeter is to be returned to Landauer immediately (as soon as possible) upon arriving at the field site. This is used to calculate the dose received during shipping. The “deploy control” is brought to each of the monitoring locations, but not deployed. After the dosimeters that are being exposed at the sample locations are installed, the “deploy control” is stored in a safe place at the work site until the exposure period is over. At that point, the “deploy control” is taken along for the removal of the exposed dosimeters, and all dosimeters are returned to Landauer for analysis. The “deploy control” represents the conditions leading up to and following the exposure period. The results from the exposed dosimeters are adjusted based on the “transit control” and “deploy control” results, to provide a net exposure.

3.3.2 Siting

The gamma dosimeters were positioned at two locations at the site, with one positioned upwind and one positioned downwind of the approximate area where Project activities are expected to occur. The monitoring locations were co-located with other monitoring equipment (Radon1 and Radon10). Refer to Figure 1 for the positions of the gamma monitoring locations.

3.3.3 Sampling Schedule

As noted above, the dosimeters for measurement of external gamma are generally exposed to the atmosphere for a period of approximately 90 days. The sampling schedule for the external gamma monitoring campaigns completed in support of this project are summarized in Table 5.

Table 5: Passive Gaseous Compound Sampling Schedule (2019-2021)

Year	Round	Deployed	Retrieved	Average Exposure Period (days)
2019	2019-1	September	November	50
2020	2020-1	July	November	102
2021	2021-1	February/March	June	100
	2021-2	June	September	105

3.3.4 Calibration and QA/QC

The selected sampling method is a passive system, and so there are no equipment calibration requirements; however, there are a number of QA/AC measures that need to be observed to maintain sample integrity. These procedures are included in the field protocol that is provided for the sampling system in Appendix A. In general, the practices employed to ensure sample integrity included the following:

- samplers were kept sealed until the moment of deployment in the field,
- field technicians kept field notes to track the deployment and retrieval dates, sampler IDs, sample locations, and any relevant observations, and
- control samples (deploy and travel) were provided by the laboratory for each round of sampling and returned to the laboratory as instructed (transit control returned upon receipt, deploy control returned with samplers).

3.4 RADON

Radon is not included in the list of standards from the SkMOE or ECCC; however, due to the nature of the proposed operation, Denison has been completing regular radon monitoring since 2016 at the Wheeler River site. The continued operation of this network of samplers will allow for the tracking of levels as the Project moves through its life-cycle.

3.4.1 Equipment and Operation

Radon in an outdoor ambient setting is typically collected using passive long-term radon detectors. For this program, the detectors were Rapidos® alpha-track detectors from Radonova. In these systems, the detector is installed in a weather-protective casing that is then attached to a post or other vertical mount (e.g., tree), and exposed to the ambient air for three (3) months (90 days). Within the detector, alpha particles released during radon decay collide with a CR-39 chip, which leaves a track in the chip. The tracks are chemically etched and counted in the laboratory to determine the radon dose received in the detector, and to calculate a concentration in ambient air. Upon retrieval, the passive sampler is returned to the laboratory for analysis, along with the field and travel blanks supplied by the manufacturer, per the manufacturer instructions.

3.4.2 Siting

Radon monitoring at the Wheeler River Project site commenced in 2016 at ten stations around the site. As shown in Figure 1, the radon monitors are located upwind of the site (i.e., to the north-west) and continue through the site to the south-east. The radon detectors were installed at eye-level, within canisters that are designed by the manufacturer of the detectors for outdoor installation. Two canisters, each holding one detector were installed at each site, in order to help ensure that a radon result is obtained for each location during each campaign in the event that one of the detectors is compromised.

3.4.3 Sampling Schedule

The radon samplers were generally deployed for periods of 1 to 3 months. A summary the deploy and retrieval dates for each sampling campaign, as well as the number of exposure days included in each campaign, is provided in Table 6.

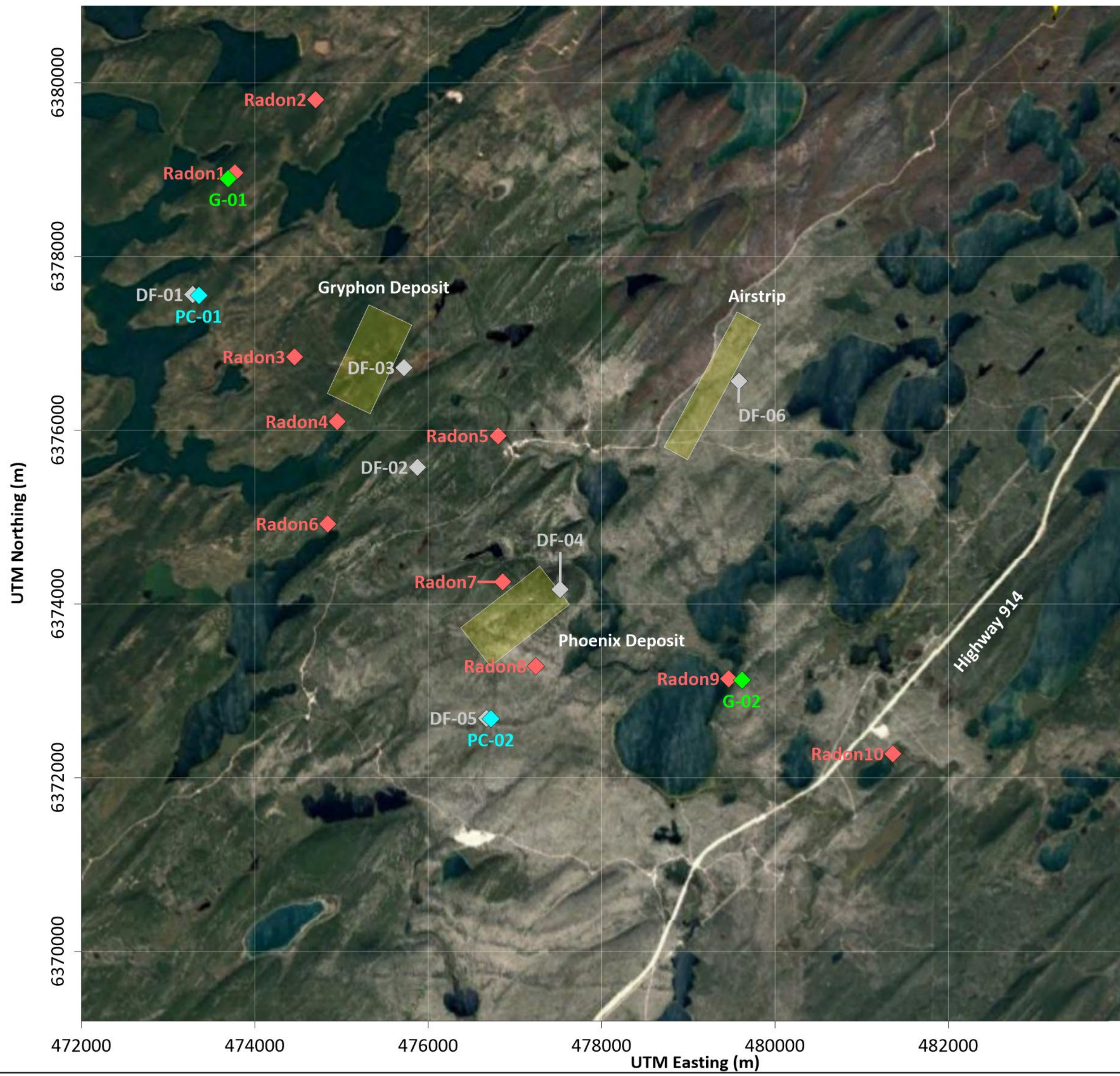
Table 6: Radon Sampling Schedule

Year	Campaign	Deployed	Retrieved	Average Exposure Period (days)
2016	2016-1	September	January (2017)	123
2017	2017-1	January	June	133
	2017-2	June	August	80
	2017-3	August	January (2018)	144
2018	2018-1	January	March	64
	2018-2	March	July	112
	2018-3	July	September	52
	2018-4	October	January (2019)	112
2019	2019-1	January	May	109
	2019-2	May	September	136
	2019-3	September	February (2020)	132
2020	2020-1	February	July	170
	2020-2	July	November	103
	2020-3	November	February (2021)	106
2021	2021-1	June	September	105

3.4.4 Calibration and QA/AC

The selected sampling method is a passive system, and so there are no equipment calibration requirements; however, there are a number of QA/AC measures that need to be observed to maintain sample integrity. These procedures are included in the field protocol that is provided for the sampling system in Appendix A. In general, the practices employed to ensure sample integrity included the following:

- samplers were kept in the sealed radon-proof bags until the moment of deployment in the field,
- field technicians kept field notes to track the deployment and retrieval dates, sampler IDs, sample locations, and any relevant observations, and
- transit control samples were provided by the laboratory for each round of sampling and returned to the laboratory with the collected samples.



LEGEND:

- Dustfall Monitor
- Passive NO2/SO2 Monitor
- Gamma Monitor
- Radon Monitor

NOTES:

SCALE:

0 m 1000 m 2000 m

REVISIONS:

No.	Date	By	Revision

REFERENCE:

Basemap: Google Earth
UTM Zone 13, WGS84

Denison Mines

Air Quality Monitoring Locations

Wheeler River Project

Drawn By:	Approved By:	Figure No.:
NZS	PLK	1
Date: Feb. 2022	Project No.: SX18-0064	

4.0 RESULTS AND DISCUSSION

The sample media collected as discussed throughout section 3.0 were provided to accredited laboratories for analysis. The laboratory certificates of analysis were used in conjunction with the data collected in the field to derive air concentrations for comparison to the criteria presented in Section 0. The results are discussed in the following sections.

4.1 SETTLEABLE PARTICULATES (DUSTFALL)

As described in section 3.1, deposition of settleable particulates were measured using dustfall jars. The laboratory analysis determines the total dustfall loading (mg) that was collected in each jar, and uses the surface area of the jar, and information on the deployment period to calculate the dustfall deposition rate in mg/dm^2/day in accordance with the B.C. Environmental Lab Manual [9]. The dustfall is reported in terms of "fixed", "volatile", and "total", with the "total" dustfall representing the water soluble and insoluble material collected in the container, the "fixed" dustfall representing only the inorganic component of the total, and "volatile" representing the organic component of the total. Summary information for the data set is provided in Table 7, which includes the results for total dustfall only. It should be noted that samples were collected in duplicate at each location, and the results in Table 7 include both of the co-located samples (e.g., 14 samples collected at DF-01 represent two samples for each of the seven campaigns). The detailed results, including fixed, volatile, and total dustfall for each campaign are provided in Appendix B, and the laboratory Certificates of Analysis (CofA) are provided in Appendix C.

Table 7: Summary of Settleable Particulate Monitoring Results

Parameter	Unit	Monitoring Location					
		DF-01	DF-02	DF-03	DF-04	DF-05	DF-06
n	--	18	18	18	18	18	16
n<DL	--	9	7	10	5	6	5
average detectable	mg/cm2/30-day	0.16	0.17	0.09	0.10	0.18	0.08
maximum	mg/cm2/30-day	0.56	0.91	0.14	0.26	0.77	0.17
minimum	mg/cm2/30-day	0.03	0.03	0.03	0.03	0.03	0.03
average	mg/cm2/30-day	0.10	0.12	0.06	0.08	0.13	0.06
SkMOE AAQC	**mg/cm2/30-day**	**2**	**2**	**2**	**2**	**2**	**2**

As would be expected in a natural, undisturbed environment, the average and maximum levels of settleable particulate are well below the SkMOE criteria of 2 mg/cm^2/30-days. The maximum dustfall amount from the various campaigns was 0.91 mg/cm^2/30-days, which was collected at DF-02A in the summer of 2021 (July-August). This value represents approximately 46% of the SkMOE standard for settleable particulates. The next highest value of 0.77 mg/cm^2/30-days (39% of the SkMOE standard) was measured during the same period at location DF-05A.

The predominant wind direction at the site is from the north-west, making DF-01 the upwind monitoring location, and the rest of the monitors downwind at various locations throughout the site. The results in Table X indicate that the average levels of settleable particulates at DF-01 were not the lowest amongst the various locations; however, it should be noted that the averages are being influenced by a sample collected at DF-01A in October 2021 which was 0.56 mg/cm2/30-days. The paired sample at this location had a result that was an order of magnitude lower, at 0.054 mg/cm2/30-days. If this result is excluded from the summaries, then the weighted average (i.e., including non-detectable results at the detection limit) was 0.06 mg/cm2/30-days, which is the same as the averages at DF-03 and DF-06 (both located at the north end of the site). As such, 0.06 mg/cm^2/30-days may be considered an average baseline level for the area.

A metals analysis was completed on the dustfall samples collected in the September 2021 and October 2021 campaigns. The complete results of the metals analysis are provided in Appendix B, and the certificates of analysis from the laboratory are provided in Appendix C. Most of the metals that were included in the analysis were not present at detectable levels. The metals that were generally detectable in one or both campaigns included aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, phosphorous, potassium, silicon, sodium, strontium, and uranium. There are no SAAQS or CAAQS for metals in dustfall. A summary of the detectable metals that are also to be represented as COPC in the Air Quality effects assessment is provided as a percentage by mass of the fixed (i.e., insoluble) dustfall in Table 8.

Table 8: Summary of Metals Composition in Fixed Dustfall

Parameter	Composition (%)											
	Arsenic (As)	Cadmium (Cd)*	Chromium (Cr)*	Cobalt (Co)*	Copper (Cu)	Lead (Pb)	Molybdenum (Mo)	Nickel (Ni)*	Selenium (Se)*	Uranium (U)	Vanadium (V)*	Zinc (Zn)
average	0.0015%	0.0006%	0.0057%	0.0012%	0.0136%	0.0013%	0.0058%	0.0057%	0.0115%	0.0004%	0.0115%	0.042%
maximum	0.0015%	0.0007%	0.0072%	0.0015%	0.0359%	0.0018%	0.0100%	0.0072%	0.0145%	0.0012%	0.0145%	0.056%

Notes:
*metal was not detectable in any sample; composition percentages based on the detection limit for the sample and were calculated only for samples where there was detectable fixed dustfall

4.2 NITROGEN OXIDES AND SULPHUR DIOXIDE

As discussed in section 3.2, baseline concentrations of NO_2 and SO_2 in the study area were assessed at two locations using passive samplers. The laboratory uses meteorological data, information on the deployment period to report, and the submitted blank samples, to provide air concentration data directly in the certificates of analysis. The air concentrations represent the average concentration for the deployment period, and so are not directly comparable to the criteria identified in section 0. To facilitate a comparison of the measured levels to the criteria, a conservative approach to adjusting the averaging period[1] was applied to the data. Summary information for the data set is provided in Table 9, Table 10, while detailed results are provided in Appendix B. Certificates of analysis from the laboratory are provided in Appendix C. The results show that the existing levels of NO_2 and SO_2 are well below the applicable criteria, as would be expected for this remote location.

Table 9: Summary of NO_2 and SO_2 Monitoring Results at PC-01

Parameter	NO_2 Concentration (µg/m3)				SO_2 Concentration (µg/m3)			
	Period	Annual	24-hr	1-hr	MP	Annual	24-hr	1-hr
Average monitoring period	32.0	days						
n	20				18			
n<DL	18				10			
average detectable	0.28	0.15	0.76	1.8	0.33	0.17	0.88	2.1
maximum detectable	0.38	0.19	0.99	2.4	0.52	0.27	1.4	3.4
minimum	0.19	0.09	0.45	1.1	0.26	0.12	0.63	1.5
weighted average	0.20	0.10	0.52	1.3	0.29	0.15	0.77	1.9
SAAQS	-	45	200	300	-	20	125	450
CAAQS (2025)	-	22.6	-	79	-	10.5	-	170.3

[1] Ontario Regulation 419/05 [12] provides the following method for scaling average concentrations for different time averaging periods:

$C_0 = C_1 * \left(\frac{t_1}{t_0}\right)^{0.28}$; where C_0 and C_1 are the air concentrations at time t_0 and t_1, respectively.

Table 10: Summary of NO_2 and SO_2 Monitoring Results at PC-02

Parameter	NO_2 Concentration (µg/m3)				SO_2 Concentration (µg/m3)			
	Period	Annual	24-hr	1-hr	MP	Annual	24-hr	1-hr
Average monitoring period	31.2	days						
n	20				20			
n<DL	18				17			
average detectable	0.28	0.13	0.67	1.6	0.52	0.27	1.4	3.5
maximum detectable	0.38	0.17	0.90	2.2	0.79	0.39	2.1	5.0
minimum	0.19	0.09	0.45	1.1	0.26	0.12	0.63	1.5
weighted average	0.20	0.10	0.51	1.3	0.30	0.15	0.79	1.9
SAAQS	-	45	200	300	-	20	125	450
CAAQS (2025)	-	22.6	-	79	-	10.5	-	170.3

The average detectable concentrations disregard any sample results that were below the detection limit, whereas the weighted average includes the non-detects, which were included in the average at the detection limit. It should be reiterated that these projected concentrations are averages from the measured values, which are considered monthly averages. For instance, the projected 1-hour concentration of NO_2 from the highest measured monthly average at Foran-P3 is 2.2 µg/m^3; however, actual hourly concentrations of NO_2 would have fluctuated about this level to some degree over the course of the measurement period. This comparison is simply intended to demonstrate how average conditions compare to the SAAQS and CAAQS, and these tables show that the measured results are well below both the SAAQS and CAAQS.

4.3 External Gamma

As discussed in Section 3.2, long-term baseline gamma doses were assessed at two locations using dosimeters. It should be reiterated that the gamma dose is not measured directly from the dosimeter, as the dosimeters register gamma during transportation from the laboratory to the site and continue to register gamma on the return shipment back to the laboratory after sampling. Control samples are used to calculate a net dose from the gross dosage that the dosimeter deployed in the field registered. The results of the external gamma monitoring program are provided in Table 11. It should be noted that the adjustment from a gross dose to a net dose resulted in negative values in some instances. This would indicate that the baseline gamma at the Project site is very low.

Table 11: Summary of External Gamma Monitoring

Location ID	Start Date	End Date	Exposure Days	Exposure (mSv)	
				Gross	Net
G-01	2019-09-25	2019-11-14	50	0.252	0.008
	2020-07-25	2020-11-03	101	Destroyed in field	
	2021-03-11	2021-06-08	89	0.469	-0.139
	2021-06-08	2021-09-21	105	0.31	-0.129
G-02	2019-09-26	2019-11-14	49	0.22	-0.024
	2020-07-24	2020-11-03	102	0.218	-0.098
	2021-02-17	2021-06-08	111	0.289	-0.06
	2021-06-08	2021-09-22	106	0.242	-0.197

4.4 RADON

Monitoring of baseline levels of radon have been occurring at the Wheeler River site since 2016, using alpha-track etch monitors, at ten locations around the site as shown in Figure 1. A statistical summary of the data collected at each of the locations is provided in Table 12. The full monitoring results for each station are provided in Appendix B, with certificates of analysis from the laboratory provided in Appendix C.

Table 12: Statistical Summary of Radon Monitoring Data (2016-2021)

Location	n	n<DL	Average Detectable (Bq/m³)	Max Detectable (Bq/m³)	Minimum (Bq/m³)	Weighted Average (Bq/m³)	Detectable Range (Bq/m³)
Radon 1	26	17	4.8 ± 3.3	9 ± 3	< 3	5.0	0 to 13
Radon 2	26	17	4.7 ± 3.0	8 ± 3	< 3	4.8	0 to 11
Radon 3	32	17	4.6 ± 2.8	9 ± 3	< 2	4.6	0 to 12
Radon 4	31	17	3.9 ± 2.9	10 ± 3	< 3	4.4	0 to 13
Radon 5	30	13	5.1 ± 2.8	12 ± 4	< 3	5.2	0 to 15
Radon 6	32	18	5.9 ± 3.1	19 ± 4	< 3	5.1	0 to 23
Radon 7	32	18	6.2 ± 3.1	19 ± 4	< 3	5.7	0 to 23
Radon 8	32	21	4.0 ± 3.2	5 ± 5	< 3	4.3	0 to 10
Radon 9	31	22	5.0 ± 3.1	9 ± 4	< 3	4.5	0 to 13
Radon 10	30	16	3.8 ± 2.8	6 ± 3	< 3	3.9	0 to 9

The maximum radon levels at the monitoring locations ranged from 9 Bq/m^3 at Radon 10 to 23 Bq/m^3 at Radon 6 and Radon 7. These maximums account for uncertainty measures from the laboratory (e.g., the maximum result at Radon 10 was reported by the laboratory as 6 ± 3 Bq/m^3 and reported in Table 12 as 9 Bq/m^3). Radon locations 6 and 7 (where the maximum concentrations were measured) are each located towards the west side of the site, between the Phoenix and Gryphon deposits, while location 10 (where the lowest concentration was measured) is located furthest to the south-east of the site, next to Highway 914. With the exception of locations 6 and 7, the maximum radon concentrations ranged from 9 to 15 Bq/m^3. In the CNSC *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016* [10], it is stated that the regional baseline in northern Saskatchewan is less than 7.4 Bq/m^3 to 25 Bq/m^3. All results from the baseline monitoring program are within this range.

5.0 CONCLUSIONS

Denison is proposing to develop a uranium mine at the Wheeler River property in northern Saskatchewan, which would utilize an ISR process for extracting uranium from the ore body and thereby eliminate the need for open pits, shafts and underground workings, and tailings storage that are associated with other uranium mines in the area. The Wheeler River Project site is located approximately 35 km north of Cameco's Key Lake uranium operation and approximately 4 km west of Highway 914. In preparation for the development of an EIS, Denison has been completing baseline air monitoring at the Project site since 2016. To-date, the program has included measurement of radon, dustfall, trace gases (NO_2 and SO_2), and external gamma. The results of the measurements indicate that the baseline levels of the COPC of interest are well below the provincial and federal air quality criteria that have been adopted for comparison and are within ranges that would be expected in an undeveloped remote site. The measured baseline concentrations will be used in conjunction with the predictive modelling of future impacts associated with the project, being completed in support of the EIS for the Project.

6.0 REFERENCES

[1] Denison Mines, "Prefeasibility Study Report for the Wheeler River Uranium Project Saskatchewan Canada," Denison Mines, Saskatoon, 2018.

[2] Saskatchewan Ministry of Environment, "Air Monitoring Guideline for Saskatchewan," Saskatchewan MoE, Regina, 2012.

[3] Government of Saskatchewan, "Saskatchewan Environmental Quality Guidelines," [Online]. Available: https://envrbrportal.crm.saskatchewan.ca/seqg-search/. [Accessed 25 01 2022].

[4] Government of Saskatchewan, "Saskatchewan Environmental Code," Government of Saskatchewan, Regina, 2014.

[5] Canadian Council of Ministers of the Environment, "2017 Air Quality," CCME, [Online]. Available: http://airquality-qualitedelair.ccme.ca/en/. [Accessed 28 May 2019].

[6] World Health Organization, "WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global Update 2005, Summary of Risk Assessment," WHO, Geneva, 2005.

[7] United States Environmental Protection Agency, "List of Designated Reference and Equivalent Methods," 15 December 2018. [Online]. Available: http://www.epa.gov/ttn/amtic/criteria.html. [Accessed 5 March 2019].

[8] ASTM International, "Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter) Designation D1739-98," ASTM, 1998.

[9] Province of British Columbia Ministry of Environment, "British Columbia Environmental Laboratory Manual," BC MOE, 2015.

[10] Canadian Nuclear Safety Commission (CNSC), "Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016," CNSC, Ottawa, 2018.

[11] Government of Ontario, *O.Reg. 419/05: Air Pollution - Local Air Quality,* 2005.

[12] Canadian Nuclear Safety Commission, "Nuclear Safety and Control Act, Radiation Protection Regularions," Minister of Justice, Ottawa, 2000.

Appendix A:

Field Protocols

Appendix B:

Detailed Result Summary Tables

Appendix C:

Laboratory Certificates of Analysis