Denison Mines

Wheeler River Project

Final Environmental Impact Statement

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PEOPLE, PARTNERSHIPS AND PASSION.

Appendix 6-A
Air Quality Technical Supporting Document
Denison Mines Corp. – Wheeler River Project

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1.0 INTRODUCTION

This technical report is supplementary to the discussion of the air quality assessment provided in the main body of the Environmental Impact Statement (EIS) report (Section 6 – Atmospheric and Acoustic Environment). The purpose of this supplemental report is to provide additional technical details on the air quality assessment methodology, including an overview of the assessment scenarios, source identification and emissions calculations, air dispersion modelling methods, and modelling outputs.

2.0 ASSESSMENT SCENARIOS

The Wheeler River Project (the Project) will be completed in four phases: construction, operation, decommissioning, and post-decommissioning. As the nature of operations in each phase differs, the assessment scenarios were developed with consideration to each of these phases to effectively bound the potential effects of the Project over its entire life cycle. As the post-decommissioning phase is effectively a period of monitoring, the air emissions have been assumed to be negligible and bounded by the other phases. The activities to be completed in the construction, operations and decommissioning phases are discussed in general terms below. The methods for characterizing the sources and the emission rates for each identified activities are discussed in Section 3.0 and 4.0, respectively.

2.1 CONSTRUCTION SCENARIO

The Construction scenario was based on the general activities associated with construction, assuming activities occur 24 hours per day. For the purposes of the air quality assessment, the Construction scenario considered the following activities occurring concurrently:

- Site preparation and earthworks occurring at various locations around site,
- Wellfield and freeze hole drilling,
- Deposit of drill cuttings in the clean waste rock pad and special waste pad,
- Surface infrastructure construction (e.g., camp, operations centre, etc.),
- Batch plant operation (i.e., concrete production),
- On-site and off-site operation of vehicles/equipment and transport of materials,
- Comfort heat provided by propane heaters,
- Power supplied by two (2) 1.1 MW generator sets operating near the freeze plant, and four (4) portable generator sets,
- Borrow area development, and
- Waste management (composting, domestic and industrial landfill operation, recycling).

For the purposes of bounding the air quality assessment, it was also assumed that wellfield pump tests may occur toward the end of the construction phase. The above construction activities and wellfield pump tests are not likely occur concurrently, but for the purposes of developing a conservative emissions scenario, it has been assumed it as such. The detailed source inventory for the Construction scenario is discussed in Section 3.0, and the approach to the characterization of each source is discussed in Section 4.1.

2.2 OPERATIONS SCENARIO

The Operations scenario was based on activities being completed in the late stages of the operations phase, with work being completed in Phase 5 of the mine plan with a recovered solution flow rate of 30 cubic metres per hour (m^3/h). During this stage, wellfield drilling is anticipated to continue, and all facilities are assumed to be fully operational. For the purposes of the air quality assessment, the general activities included in the Operations scenario are:

- Full operation of the wellfield and ISR processing plant,
- Full operation of the freeze plant,
- Wellfield and freeze hole drilling,
- Storage and disposal of drill waste rock, process precipitates and industrial wastewater treatment plant precipitates in their designated storage areas,
- Shipping of yellowcake product,
- Batch plant operation, mainly for cement needs,
- On-site and off-site operation of vehicles/equipment and transport of materials,
- Grading/maintenance of roads,
- Comfort heat provided by propane heaters,
- Backup power supplied by two (2) 1.1 MW generators operating near the freeze plant, two (2) 450 kW generator sets operating near the administration building and permanent camp, and two (2) portable generators,
- Water treatment in the industrial wastewater treatment plant, and
- Waste management (composting, domestic and industrial landfill operation, recycling).

During operations, the site will be connected to the provincial power supply but will occasionally require backup power from the installed generator sets. To assess worst-case 1-hour NOx, CO, and SO_2 emissions from the generators, an emissions scenario was assessed whereby all generators operate simultaneously. However, on an average annual basis, one (1) 1.1 MW generator was assumed to operate for two hours a day, while the portable generator sets were assumed to operate for 12 hours a day.

The detailed source inventory for the Operations scenario is discussed in Section 3.0, and approach to the characterization of each source is discussed in Section 4.2.

2.3 DECOMMISSIONING SCENARIO

Activities during the decommissioning period that may impact air quality include remediation works at the contaminated areas (e.g., wellfield, waste pads, processing plant area), and general site activity including use of equipment/vehicles. For the purposes of the air quality assessment, the general activities included in the Decommissioning scenario are:

- Ongoing water treatment in the industrial wastewater treatment plant,
- Wellfield restoration,
- Remediation of contaminated areas (wellfield, pads, ponds),
- On-site and off-site operation of vehicles/equipment and transport of materials,
- Grading/maintenance of roads, and

- Backup power supplied by one (1) 1.1 MW generator operating near the freeze plant, and four (4) portable generators.

It is important to note that the above decommissioning activities may not occur concurrently, but for the purposes of developing a conservative emissions scenario, it has been assumed it as such. The detailed source inventory for the Decommissioning scenario is discussed in Section 3.0, and approach to the characterization of each source are discussed in Section 4.3.

3.0 SOURCES OF AIR EMISSIONS

The sources of contaminants of potential concern (COPC) identified in Section 6.1.1.2 of EIS report are discussed in the following sections. Acrolein emissions from diesel combustion were also evaluated using a quantitative screening analysis but were determined to be negligible and not considered a COPC. The screening analysis is detailed in Appendix D of this report.

3.1 SOURCES OF PARTICULATE MATTER

Fugitive dust is particulate matter (i.e., total suspended particulate [TSP], particulate less than 10 microns [PM_{10}], and particulate less than 2.5 microns [$PM_{2.5}$]) emitted from sources other than point sources (i.e., stacks). A source of fugitive dust at the Project site is unpaved roads. Emissions from unpaved roads were calculated using emission factors from U.S. EPA AP-42 Chapter 13.2.2 [1], based on the anticipated road traffic volumes and traffic fleet, and the silt content of the roads. To control road dust during summer (May to October), water and/or chemical dust suppressant will be applied to all site roads, which was assumed to mitigate these emissions by 70% [2]. In the winter months (November to April), natural mitigation from snow/ice can control unpaved road dust by up to 90% [3]. Additionally, vehicle speeds at the Project site will be limited to 30 kilometres per hour (km/h) along the site haul roads, which will reduce the amount of road dust generated [4]. The roads are also maintained during the summer months using a grader, which is a lesser source of particulate matter along the roads. Particulate emissions for the grader were estimated using emission factors from U.S. EPA AP-42 Chapter 11.9 [5].

During the construction phase, general construction activities, like clearing, grubbing, and building construction will also be a source of fugitive dust. Emissions from general construction activities were based on emission factors from U.S. EPA AP-42 Chapter 13.2.3 [6] and Western Regional Air Partnership (WRAP) guidance [4]. In the summer months, water will be used to control dust emissions from construction activities. Based on guidance from WRAP, watering is assumed to mitigate construction dust by 50% [4]. Note that emissions from the concrete batch plant have been calculated separately from general construction emissions using emission factors from U.S. EPA AP-42 Chapter 11.12 [7] and the expected concrete production rates.

Another source of fugitive dust expected to be present during each phase of the Project is wind erosion. When winds are strong, erodible fines (i.e., small particles) can be picked up and dispersed by the wind. Wind erosion was assessed using WRAP emission factors [4] at locations where there is expected to be exposed, erodible material, including the landfill sites, the borrow area, and the clean and special waste pads. For short-term averaging periods (i.e., 24-hour), the emissions were assumed to be uncontrolled in the summer where no watering is expected (the landfills and the borrow pit), or by 50% where watering is expected (the waste pads).

For the winter periods and the annual averaging periods, natural controls were applied of 90% in winter (per above), and 47% in summer (based on the number of days with rainfall calculated from CALMET).

Fugitive dust from material handling has also been assessed, including the handling of well cuttings from the wellfield, placement of material at the waste pads, and collection and placement of material from the borrow pit to various locations (e.g., construction site, landfill). Handling emissions were estimated based on U.S. EPA AP-42 Chapters 13.2.4 and 11.19.2 [8] [9]. Short-term emissions assumed no controls, while average annual emissions utilized natural controls, as described above.

Other sources of fugitive dust include dozing at the wellfield and waste pads during the decommissioning phase only. Dozing during the construction phase is already accounted for in the general construction emissions and not calculated separately. Drilling in the wellfield will occur during the construction and operations phases, and emissions have been calculated using Environment and Climate Change Canada (ECCC) guidance [10] and the anticipated maximum number of holes to be drilled per year. Filling of the lime silo is expected to occur during the operations and construction phases, and dust emissions have been estimated using U.S. EPA emission factors from AP-42 Chapter 11.19.2 [9].

Additional sources of particulate matter include various combustion sources at the site, such as the diesel generators, the propane heaters, and diesel and gasoline combustion associated with construction equipment and vehicles utilizing the on-site roads. The ISR calciner, dryer, and hygiene scrubber stacks will also emit particulate matter in the form of yellowcake. Emissions for combustion sources were estimated using emission factors from U.S. EPA AP-42 [11] [12] [13] and diesel generator manufacturer data. Emissions of particulate matter from the ISR stacks were based expected emissions from pre-feasibility engineering design documents [14].

3.2 SOURCES OF METALS

Metals were assumed to be emitted as a fraction of TSP. The fraction of metals emitted from a particular source is dependent upon on the composition of the parent material (e.g., special waste, etc.). The compositions of the various sources used in this assessment are discussed in Appendix A. Sources of metal releases for this assessment included emissions from wellfield drilling in mineralized areas, wind erosion from the special waste pad, material handling at the wellfield and special waste pad, and stack emissions from the ISR Plant (the dryer, calciner, and hygiene scrubber stacks).

3.3 SOURCES OF NOX, SO_2 AND CO

Combustion of diesel, gasoline, or propane fuel results in emissions of gaseous contaminants including nitrogen oxides (NOx), sulphur dioxide (SO_2) and carbon monoxide (CO). Sources of diesel combustion include the standby diesel generators, off-road mobile equipment (e.g., dozer, grader, drill rigs), and vehicles such as haul trucks, transport, and shipping trucks. Gasoline combustion is from on-site vehicles such as the crew vans and pick-up trucks, while propane is generally combusted for heating of the various on-site facilities. The emissions from these sources were estimated using the same U.S. EPA AP-42 documents as referenced for the calculation of particulate emissions from combustion.

3.4 SOURCES OF RADON

During the Construction and Operations scenarios, radon gas (Rn-222) will be released during wellfield drilling from radium-bearing ore cuttings and when groundwater containing dissolved radon gas is exposed to the atmosphere. During Operations, radon released from the ore body is removed by the mining solution moving through the production wellfield and radon gas will be released to the atmosphere wherever the mining solution is vented. In the case of the Project, a portion of the radon is expected to be released in the wellfield from occasional venting from the wellheads and leaking transport piping. But, majority of the radon gas will be released to air when the uranium rich solution arrives at the recovered solution surge tank, where it will be vented to the atmosphere. Minor amounts of radon gas will also be released at the uranium rich solution holding area, and from the processing plant ventilation. Areas storing radium-bearing materials, such as the special waste and process precipitates storage pads, will passively emit radon gas.

As described in Section 2.1, well field pump tests were assumed to be conducted toward the end of the construction and included in the air emissions inventory. As detailed in Appendix A, six months of pump tests were conservatively assumed for the Construction scenario.

Radon is released during Decommissioning from well field restoration. The mechanisms of restoration are similar to wellfield production, therefore, the radon sources (wellheads, recovered solution surge tank, etc. are the same). In the ISR plant, radon is also expected from contaminated materials that remain in the plant. Radon gas will also be emitted from any radium-bearing materials being reclaimed during Decommissioning. Details are provided in Appendix A.

U.S. NRC and IAEA methods were the primary methods used to estimate radon gas emissions [15] [16] [17].

4.0 SUMMARY OF AIR EMISSION RATES

Emission rates for the COPC were estimated for each of three assessment scenarios described in Section 2.0. In accordance with Saskatchewan Ministry of the Environment (SaskMoE) air quality modelling guidance [18], emission inventories were developed to capture the maximum or worst-case emission rates for each of the scenarios. In addition, each assessment scenario included two emissions scenarios representing different averaging periods so that the model results could be compared to the Project air quality criteria summarized in Section 6.1.1.2.4 of the EIS. These included:

- A short-term emissions scenario (e.g., 24-hour), which considers emissions from all Project sources on a worst-case day. For example, this might be a day when the power supply from the SaskPower grid is unavailable, and all the on-site diesel generators must operate to support the continued operation of the site. The short-term scenario also does not consider natural sources of dust mitigation (e.g., rain).
- An average annual emissions scenario, which considers emissions from all Project sources over an entire year. Although this scenario is still conservative (e.g., based on maximum annual production rates), emission rates are intended to be more reflective of the typical operating case. For example, emissions from the generators are based on the expected number of annual operating hours, and natural sources of dust mitigation such as rainfall are included.

To develop the above emissions inventories, assumptions were made in the calculations that have resulted in conservative emissions estimates. For example, the emission sources were assumed to operate concurrently at their individual maximum rates of production to estimate the worst-case emission rates in each of the scenarios. In reality, production rates will vary on a day-to-day basis and some activities may not actually occur simultaneously. However, this approach provides an upper bound estimate of air emissions for the assessment scenario and helps to ensure that the predicted COPC concentrations reflect the concurrence of maximum emission rates with worst-case meteorological conditions. Other assumptions that resulted in conservative emissions estimates are detailed in the emissions calculations provided in Appendix A.

Summaries of the calculated emission rates for each phase are provided in the following sections. Note that for some sources, like unpaved roads, emissions of particulate matter vary between summer (May to October) and winter (November to April) to account for differences in dust mitigation levels. In general, dust emissions were considered to be 90% controlled in the winter months.

4.1 CONSTRUCTION SCENARIO

A summary of the maximum short-term emission rates for the Construction scenario is provided in Table 1 along with the average annual radon emission rates. The maximum site-wide emission rate of TSP occurs in the summer and is estimated to be 26.4 g/s. This is largely driven by the unpaved road dust emissions, which totals to 19.7 g/s, or 74.6% of the site-wide TSP emissions. The next highest contribution is from general construction activities, which totals 6.2 g/s, or 23.5% of site wide TSP emissions. These sources together therefore account for 98.1% of the TSP emissions from the site during construction. The maximum site-wide emissions of PM_{10} and $PM_{2.5}$ also occur in the summer and are estimated to be 8.13 g/s and 1.06 g/s, respectively. Like TSP, PM_{10} emissions are dominated by unpaved roads and general construction emissions. These two sources combine to make up 95.4% of the total PM_{10} emissions from the site. For $PM_{2.5}$, the unpaved roads and construction activity sources make up 73.1% of the total $PM_{2.5}$ emissions from the site, with the diesel generators contributing an additional 22.8% (i.e., 95.9% of $PM_{2.5}$ emissions from these three sources).

The maximum gaseous emissions are estimated to be 9.4 g/s for NOx, 7.0E-03 g/s for SO_2, and 1.64 g/s for CO. Short-term NOx emissions are dominated by the diesel generators (84.7% of the total site-wide NOx emissions), with off-road mobile equipment contributing an additional 15.1% (i.e., 99.8% of site-wide NOx emissions are from the diesel generators and off-road mobile equipment). The SO_2 emissions from the generators represent 75.4% of the site-wide SO_2 emissions, while emissions of CO from the generators represent 73.8% of the site-wide CO emissions.

Radon was assessed on an annual basis for the Construction scenario. The total annual site-wide radon emissions are estimated to be 1.47E+06 Bq/s. The main contributing sources to site-wide radon emissions is the recovered solution surge tank (8.0E+05 Bq/s, or 54.4%) and the wellfield area (6.61E+05, or 45.0%), which account for 99.4% of the site-wide radon releases. The other sources of radon releases during construction include the special waste storage pad and the core shack.

4.2 OPERATIONS SCENARIO

A summary of the maximum short-term emission rates for the Operations scenario is provided in Table 2 along with the average annual radon emission rates. The maximum site-wide emission rate of TSP during operations

occurs in the summer and is estimated to be 15.4 g/s. As with construction, the TSP emissions are largely dominated by dust from vehicle travel on unpaved roads, which makes up 94.2% of the site-wide TSP emissions. The overall lower TSP emissions (and higher percentage attributable to road dust) is due to the construction source no longer being active. While other sources of TSP are introduced in this scenario (e.g., additional wind erosion sources, process stack emissions), the contributions are not as significant as the construction source with respect to dust emissions. Similarly, site wide emissions of PM_{10} (totalling 4.67 g/s in the summer) are also driven largely by unpaved road sources (4.21 g/s, or 90.1%). With regard to $PM_{2.5}$, the unpaved road dust sources make up only 54.5% of the total site-wide emissions (4.21E-01 g/s out of the total of 7.76E-01 g/s). The operation of the diesel generators makes up an additional 26.8% of the total $PM_{2.5}$ site-wide releases, and another 13.7% is estimated to be from the hygiene scrubber stack at the ISR plant.

Maximum short-term gaseous emission rates during the Operations scenario are estimated to be 10.0 g/s for NOx, 8.23E-03 g/s for SO_2, and 1.70 g/s for CO. As with the construction emissions, these were largely attributable to the diesel generators and fuel combustion in off-road mobile equipment.

The total annual site-wide emissions of radon during the Operations scenario are estimated to be 1.42E+07 Bq/s. The source with the highest radon emission rate is the recovered solution surge tank, which accounts for 70% of the site-wide radon emissions during operations (9.95E+06 Bq/s). Emissions from the special waste pad are estimated to be the next most significant source, with emissions of 3.25E+06 Bq/s or 22.9% of the total site-wide radon emissions. Other sources of radon emissions in the Operations scenario include the wellfield, the recovered mining solution pond, the ISR plant, and the process precipitates storage area.

4.3 DECOMMISSIONING SCENARIO

A summary of the maximum short-term emission rates for the decommissioning phase is provided in Table 3 along with the average annual radon emission rates. The maximum short-term site-wide emission rate of TSP during decommissioning occurs in the summer and is estimated to be 11.9 g/s. As with previous phases, this is dominated by the generation of dust from use of unpaved roads. This source makes up 10.4 g/s of the total site-wide TSP emissions, or 87.4%. This is similar for PM_{10}, for which the unpaved road dust emission rate of 2.95 g/s makes up 82.2% of the total PM10 emission rate (3.59 g/s). The site-wide (short-term) total $PM_{2.5}$ emissions are 6.69E-01 g/s, of which 2.95E-01 g/s, or 44.1% is estimated to be comprised of road dust. Another 36.2% is estimated to be from the diesel generators.

Maximum short-term gaseous emission rates during the decommissioning phase are estimated to be 9.0 g/s for NOx, 6.53E-03 g/s for SO_2, and 1.64 g/s for CO. As with the other phases discussed in previous sections, these were largely attributable to the diesel generators and fuel combustion from off-road mobile equipment.

The total annual site-wide emissions of radon during the operations phase are estimated to be 9.32E+06 Bq/s. The source with the maximum radon emissions is estimated to be the recovered solution surge tank (8.26E+06 Bq/s, or 88.6% of the total), followed by the wellfield (1.00E+6 Bq/s, or 10.7% of the total). Other sources of radon emissions in the decommissioning phase included the process precipitates storage pad, the ISR plant, special waste pad, the recovered solution pond, and the gypsum pond.

Table 1: Construction Emissions Summary (Summer Rates)

Model ID	Description	Maximum Short-Term Emissions (g/s)																		Annual Emissions (Bq/s)
		TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NOx	As	Cd	Co	Cu	Pb	Mo	Ni	Se	U	Vn	Zn	Cr	Rn
HWY914	Highway 914 (5 km)	7.38	2.10	0.21	0.00	2.73E-06	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCESS	Project access road	4.39	1.25	0.13	0.01	1.20E-05	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE1	Project site road 1	1.34	0.38	0.04	0.01	1.13E-05	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE2	Project site road 2	2.73	0.78	0.08	0.04	8.28E-05	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE3	Project site road 3	4.12	1.18	0.12	0.01	1.12E-05	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
BATCH [1]	Batch plant operation (concrete); crusher at borrow area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONST	Construction (general)	6.27	2.24	0.29	0.54	1.87E-03	2.05	7.97E-07	9.56E-08	4.69E-07	2.34E-05	2.43E-05	9.46E-07	1.26E-06	2.18E-07	5.90E-04	2.47E-06	8.03E-06	7.32E-07	6.70E+05
GEN1	Generator 1 (1.1 MW)	0.10	0.10	0.10	0.53	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN2	Generator 2 (1.1 MW)	0.10	0.10	0.10	0.53	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN3	Generator 3 (450 kW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN4	Generator 4 (450 kW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFL	Domestic land fill	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFLC	Construction waste laydown area	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RN_TANK	Recovered solution surge tank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.00E+05
Total		**26.43**	**8.13**	**1.06**	**1.67**	**7.05E-03**	**9.43**	**5.35E-07**	**6.42E-08**	**3.15E-07**	**1.57E-05**	**1.63E-05**	**6.35E-07**	**8.45E-07**	**1.47E-07**	**3.96E-04**	**1.66E-06**	**5.39E-06**	**4.91E-07**	**1.47E+06**

Notes:
[1] Emissions captured in the general construction model source (CONST)

Table 2: Operations Emissions Summary (Summer Rates)

Model ID	Description	Maximum Short-Term Emissions (g/s)																		Annual Emissions (Bq/s)
		TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NOx	As	Cd	Co	Cu	Pb	Mo	Ni	Se	U	Vn	Zn	Cr	Rn
HWY914	Highway 914 (5 km)	6.50	1.85	0.18	1.32E-03	2.27E-07	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCESS	Project access road	3.88	1.11	0.11	2.17E-02	6.94E-05	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE1	Project site road 1	1.05	0.30	0.03	9.49E-03	2.02E-05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE2	Project site road 2	1.25	0.36	0.04	1.02E-02	2.31E-05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE3	Project site road 3	2.09	0.60	0.06	3.39E-02	8.39E-05	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0
BATCH	Batch plant	0.00	0.00	0.00	7.18E-04	1.12E-07	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
ISR	ISR general ventilation	0.01	0.01	0.01	1.40E-01	4.79E-05	0.25	0	0	0	0	0	0	0	0	0	0	0	0	2.28E+04
STORAGE	Storage area (propane)	0.00	0.00	0.00	2.13E-02	7.87E-05	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0
PH5	Wellfield Phase 5	0.02	0.02	0.02	1.35E-01	5.53E-04	0.60	8.74E-07	1.05E-07	5.14E-07	2.56E-05	2.66E-05	1.04E-06	1.38E-06	2.39E-07	6.47E-04	2.71E-06	8.80E-06	8.02E-07	9.15E+05
CAMP	Camp (propane)	0.00	0.00	0.00	4.22E-02	1.30E-04	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMP	Pumphouse (propane)	0.00	0.00	0.00	1.42E-04	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
FREEZE	Freeze plant	0.00	0.00	0.00	2.36E-03	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
OPS	Admin bldg. (propane)	0.00	0.00	0.00	2.43E-03	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBSTN	Substation (propane)	0.00	0.00	0.00	1.58E-04	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRPORT	Airport bldg. (propane)	0.00	0.00	0.00	4.40E-04	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN1	Generator 1 (1.1 MW)	0.10	0.10	0.10	5.33E-01	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN2	Generator 2 (1.1 MW)	0.10	0.10	0.10	5.33E-01	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN3	Generator 3 (450 kW)	0	0	0	1.01E-01	7.52E-04	0.77	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN4	Generator 4 (450 kW)	0	0	0	1.01E-01	7.52E-04	0.77	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFL	Domestic landfill	0.02	0.01	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFLC	Construction waste laydown area	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFLCN	Industrial landfill	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BORROW	Borrow area	0.13	0.06	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FE_RA	Process precipitates pad	0.04	0.02	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.73E+04
SWPAD	Special waste pad	0.02	0.01	0.00	0	0	0	5.22E-06	6.26E-07	3.07E-06	1.53E-04	1.59E-04	6.20E-06	8.24E-06	1.43E-06	3.87E-03	1.62E-05	5.26E-05	7.97E-06	3.25E+06
CWPAD	Clean waste pad	0.02	0.01	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIME	Lime silo	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1	Dryer scrubber stack	0.00	0.00	0.00	0	0	0	4.32E-11	1.20E-09	5.88E-09	2.93E-07	3.05E-07	4.32E-11	1.58E-08	2.74E-09	1.84E-05	3.09E-08	1.01E-07	1.53E-08	0
S2	Calciner scrubber stack	0.00	0.00	0.00	0	6.70E-04	0	3.62E-10	1.00E-08	4.92E-08	2.45E-06	2.55E-06	3.62E-10	1.32E-07	2.29E-08	1.54E-04	2.59E-07	8.41E-07	1.28E-07	0
S3	Hygiene scrubber stack	0.11	0.11	0.11	0	0	0	1.50E-07	4.15E-06	2.04E-05	1.02E-03	1.06E-03	1.50E-07	5.46E-05	9.48E-06	6.36E-02	1.07E-04	3.48E-04	5.29E-05	0
S4	Calciner burner stack	0.00	0.00	0.00	8.80E-03	0	0.02	0	0	0	0	0	0	0	0	0	0	0	7.94E-06	0
CORE	Core shack ventilation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.43E+02
UBS	Recovered mining solution pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.94E+04
RN_TANK	Recovered solution surge tank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.95E+06
GYPSUM	Gypsum pad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.05E+03
Total		**15.36**	**4.67**	**0.78**	**1.70**	**8.23E-03**	**10.05**	**6.25E-06**	**4.89E-06**	**2.40E-05**	**1.20E-03**	**1.24E-03**	**7.38E-06**	**6.44E-05**	**1.12E-05**	**6.83E-02**	**1.26E-04**	**4.11E-04**	**6.98E-05**	**1.42E+07**

Table 3: Decommissioning Emissions Summary (Summer Rates)

Model ID	Description	Maximum Short-Term Emissions (g/s)																		Annual Emissions (Bq/s)
		TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NOx	As	Cd	Co	Cu	Pb	Mo	Ni	Se	U	Vn	Zn	Cr	Rn
HWY914	Highway 914 (5 km)	1.87	0.53	0.05	3.81E-04	6.54E-08	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCESS	Project access road	1.21	0.35	0.04	1.35E-02	4.75E-05	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE1	Project site road 1	0.79	0.22	0.02	8.24E-03	1.63E-05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE2	Project site road 2	1.87	0.53	0.05	3.51E-02	8.15E-05	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0
SITE3	Project site road 3	4.95	1.41	0.14	2.89E-02	6.45E-05	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0
BATCH	Batch plant	0.00	0.00	0.00	2.15E-03	3.35E-07	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
ISR	ISR general ventilation	0.00	0.00	0.00	6.96E-02	8.86E-05	0.14	0	0	0	0	0	0	0	0	0	0	0	0	1.14E+04
STORAGE	Storage area (propane)	0.00	0.00	0.00	2.64E-02	9.74E-05	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0
PH5	Wellfield Phase 5	0.45	0.16	0.10	2.81E-01	6.95E-04	1.02	0	0	0	0	0	0	0	0	0	0	0	0	1.00E+06
CAMP	Camp (propane)	0.00	0.00	0.00	5.36E-02	1.73E-04	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMP	Pumphouse (propane)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FREEZE	Freeze plant	0.00	0.00	0.00	2.36E-03	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
OPS	Admin bldg. (propane)	0.00	0.00	0.00	2.43E-03	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBSTN	Substation (propane)	0.00	0.00	0.00	1.58E-04	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRPORT	Airport bldg. (propane)	0.00	0.00	0.00	4.40E-04	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN1	Generator 1 (1.1 MW)	0.10	0.10	0.10	5.33E-01	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN2	Generator 2 (1.1 MW)	0.10	0.10	0.10	5.33E-01	2.53E-03	3.66	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN3	Generator 3 (450 kW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN4	Generator 4 (450 kW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFL	Domestic landfill	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFLC	Construction waste laydown area	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNDFLCN	Industrial landfill	0.01	0.00	0.00	0	0	0	7.67E-09	9.19E-10	4.51E-09	2.25E-07	2.34E-07	9.10E-09	1.21E-08	2.10E-09	5.67E-06	2.38E-08	7.72E-08	7.03E-09	0
BORROW	Borrow area	0.13	0.06	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FE_RA	Process precipitates pad	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.66E+03
SWPAD	Special waste pad	0.00	0.00	0.00	0	0	0	5.27E-07	6.32E-08	3.10E-07	1.55E-05	1.61E-05	6.25E-07	8.32E-07	1.44E-07	3.90E-04	1.64E-06	5.30E-06	8.01E-07	8.22E+03
CWPAD	Clean waste pad	0.39	0.10	0.04	4.94E-02	2.08E-04	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0
LIME	Lime silo	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1	Dryer scrubber stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S2	Calciner scrubber stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S3	Hygiene scrubber stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S4	Calciner burner stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORE	Core shack ventilation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UBS	Recovered mining solution pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.94E+04
RN_TANK	Recovered solution surge tank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.26E+06
GYPSUM	Gypsum pad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.05E+03
Total		**11.89**	**3.59**	**0.67**	**1.64**	**6.53E-03**	**9.03**	**5.35E-07**	**6.41E-08**	**3.15E-07**	**1.57E-05**	**1.63E-05**	**6.34E-07**	**8.44E-07**	**1.46E-07**	**3.96E-04**	**1.66E-06**	**5.38E-06**	**8.08E-07**	**9.32E+06**

5.0 AIR DISPERSION MODEL

Air dispersion modelling was performed using CALPUFF (version 7), which is an advanced three-dimensional (3-D) dispersion model. While the Saskatchewan Air Quality Modelling Guideline identifies that AERMOD is used for most assessments in Saskatchewan, Section 3.3 of the guideline does allow for the use of more sophisticated models, including CALPUFF, where justified [18]. CALPUFF was selected for this assessment primarily because of its ability to model long range transport in the large Study Area and to maintain consistency with dispersion modelling assessments completed for other nuclear facilities in northern Saskatchewan. CALPUFF also includes wet and dry removal processes and chemical transformation algorithms that are needed to generate inputs for the Terrestrial Environment and Human Health assessments. CALPUFF can also manage multiple emission sources and COPC within a single model run, which creates efficiencies for the assessment and enables detailed study of complex operating scenarios (see Section 2.0). An overview of the modelling approach is described below, while details are provided in Appendix B.

5.1 CALMET

To overcome the limited meteorological observing record in the Project Study Areas, a meteorological data set was generated using the Weather Research Forecast Non-Hydrostatic Mesoscale Model (WRF-NMM), which was run for one year, 2016. The approach was discussed with and agreed to by staff at the SaskMoE [19]. 2016 was selected in conjunction with the SaskMoE so that they could compare the CALMET model results to their AERMOD-ready regional meteorological data set applicable to the Project Study Areas.

WRF-NMM was run in hindcast mode and initialised using North American Mesoscale Forecast System (NAM) analyses available from the U.S. National Centre for Environmental Prediction (NCEP). The NAM analyses assimilate meteorological observations (e.g., land surface measurements, radiosonde, etc.) and are available every six hours at a 12 kilometre (km) horizontal grid resolution. WRF-NMM uses the NAM analyses as both the initial conditions and boundary conditions within the model and updates these values every 24 hours and six hours, respectively.

The WRF-NMM model was run using a grid spacing of four kilometres to better resolve meteorological features within the Project Study Areas. The outputs from WRF-NMM were used to generate a 3D.DAT file to input to the CALMET model. The CALMET model (version 6.5) was then run in “NOOBS” mode 1, which used a combination of data from the 3D.DAT file and Key Lake observations for the surface data, and upper air data from the 3D.DAT file. Two CALMET runs were completed: one for a 60 km by 60 km domain having a horizontal grid spacing of one kilometre; and one for a 20 km by 20 km domain having a horizontal grid spacing of 200 metres (m). This approach was necessary to reduce model run times and to generate reasonably sized CALMET output files for input to CALPUFF. Details of the CALMET modelling are provided in Appendix B.

5.2 CALPUFF

The emission sources described in Section 3.0 were parameterized in the CALPUFF model using either area sources, volume sources, or point sources, the details of which are provided in Appendix B. Using the CALMET data set, CALPUFF was run for each individual source with a unit emission rates (i.e., 1 g/s). Using the post-processing tool POSTUTIL and the emission rates described in Section 4.0, concentrations and deposition

rates were determined for each COPC at each receptor location included in the model. For this assessment, a nested receptor grid with the following spacing was used in CALPUFF:

a) 50 m spacing in a 2 km by 2 km box, centred approximately on the Project Area,
b) 250 m spacing in a 5 km by 5 km box and outside of the area described in (a),
c) 500 m spacing in a 10 km by 10 km box and outside of the area described in (b),
d) 1,000 m spacing in a 20 km by 20 km area and outside of the area described in (c), and
e) 2,000 m spacing in a 40 km by 40 km area and outside of the area described in (d).

In addition to the nested model grid, receptors were placed every 50 m along the Property Boundary, and road receptors were placed parallel to the unpaved roads at distances of 50 m, 150 m, and 250 m from the road edge at a spacing of 200 m. In addition, 16 receptors were included for the for the human health and ecological risk assessment (HHERA) and the worker exposure assessment. The UTM coordinates of these discrete receptors are provided in Table 4, while the full receptor grid is illustrated graphically in Appendix B.

Although receptors inside of the Property Boundary were modelled, they were not considered when assessing the model results against the Project criteria in accordance with the Saskatchewan Air Quality Modelling Guideline [18].

Table 4: Discrete Receptor Locations in CALPUFF

ID	Receptor Type	Description	UTM Coordinates	
			X (m)	X (m)
WE1	Worker exposure	ISR Plant	477122	6374321
WE2	Worker exposure	Special waste pad	477342	6374486
WE3	Worker exposure	Industrial landfill	476829	6375006
WE4	Worker exposure	Process precipitates storage pad	477115	6374492
WE5	Worker exposure	Wash bay/scanning facility	477087	6374079
WE6	Worker exposure	Fe disposal wellfield	477486	6374846
WE7	Worker exposure	Wellfield boundary 1	476721	6373937
WE8	Worker exposure	Wellfield boundary 2	476777	6373864
WE9	Worker exposure	Wellfield boundary 3	477043	6374042
WE10	Worker exposure	Wellfield boundary 4	477001	6374109
WE11	Worker exposure	Freeze plant	477012	6374211
Risk1	Risk	Ecological on-site	477708	6374351
Risk2	Risk	Human Location – Seasonal Resident at McGowan Lake	478245	6372039
Risk3	Risk	Human Location - Camp Worker	476896	6373487
Risk4	Risk	Human Location - Seasonal Resident at Russell Lake	478415	6368289
Risk5	Risk	Reference Receptor Location	473146	6375099

Notes:
The locations of the receptors are in UTM coordinates in metres relative to the NAD83 datum (Zone 13N).

6.0 SUMMARY OF MODELLING RESULTS

Results of the air dispersion modelling are presented in Section 6.1 (Construction), Section 6.2 (Operations), and Section 6.3 (Decommissioning). The overall maximum predicted COPC concentrations outside of the Project Property Boundary are presented in tabular format. For traceability, predicted COPC concentrations for the HHERA and worker exposure receptors are summarized in tabular format in Appendix C; however, the effects of the predicted concentrations on human and ecological health are assessed in the Human Health and Terrestrial Environment reports under separate cover. Contour plots have also been created for those COPC that have applicable provincial or federal air quality standards or criteria, as well as radon. Contour plots of uranium and metals were only created if the maximum predicted concentration was greater than 5% of the applicable Project criteria. As a result, contour plots are limited to uranium in this report.

As previously discussed, the SaskMoE requires that background COPC concentrations be added to modelled concentrations before comparing the results to the Project criteria. As a result, predicted COPC concentrations presented in the Tables and Figures of this report are ***total*** concentrations (i.e., modelled + background). As discussed in Section 6.1.3.5 of the EIS, the provincial background value for SO_2 is zero; therefore, predicted concentrations for SO_2 are incremental. The model results for radon have also been presented as incremental concentrations since background concentrations are used to provide context for the results (see Section 6.1.1.2.3 of the EIS).

For refined air dispersion modelling assessments, the Saskatchewan Air Quality Modelling Guideline [18] allows for the elimination of the top n^{th} highest concentrations predicted at each receptor location to lessen the influence of "rare and unusual" meteorological conditions on the model-predicted concentrations. Therefore, when comparing modelled concentrations to Project criteria, meteorological anomalies were removed in this assessment, as follows:

- The top eight concentrations for those COPC with 1-hour air quality standards were eliminated, and
- The top concentration for those COPC with 8-hour or 24-hour air quality standards were eliminated.

As discussed in Section 4.0, the emission rates used in the modelling were conservatively based on maximum production rates expected to occur in each of the Project assessment scenarios. Actual emissions of COPC from Project activities are expected to be less than the emission rates considered in this assessment most of the time. As such, this dispersion modelling assessment represents an upper bound case for Project activities to ensure that the predicted COPC concentrations reflect the concurrence of maximum emission rates with adverse meteorological conditions. This conservative approach is expected to adequately capture the potential maximum effects from any year of construction, operations, or decommissioning in the current Project schedule. Given these considerations and the multiple levels of conservativism built into the assessment, it is expected that actual air concentrations of COPC due to the Project will be lower than those predicted by the model and discussed in the proceeding sections.

6.1 CONSTRUCTION SCENARIO

The Construction scenario represents the three-year construction phase of the Project, and considered activities like earthworks, building construction, freeze hole drilling, and field pump tests. Table 5 presents the overall,

off-property maximum COPC concentrations (including background concentrations) predicted for this scenario, while concentration isopleths are provided graphically in Figures 1 through 17.

6.1.1 Particulate Matter

Model predicted concentrations of TSP, PM_{10}, $PM_{2.5}$ and dustfall (including background) for the Construction scenario are provided in Table 5 for the maximum off-property receptor and contour plots for particulate matter and dustfall are provided in Figure 1 through Figure 6. As shown in the Table and Figures, maximum 24-hour concentrations of TSP and PM_{10} are predicted to be above the Project criteria at some off-property locations in the LSA, while dustfall, annual TSP concentrations, and 24-hour and annual $PM_{2.5}$ concentrations are below the Project criteria throughout the LSA. The overall, off-property maximum concentrations of 24-hour TSP, and PM_{10} are 313.3 µg/m³ and 116.2 µg/m³, respectively, or 313% and 242% of the Project criteria.

Figure 1 shows that the maximum predicted 24-hour concentrations of TSP are above the Project criteria along a small section of the northwest Property Boundary and at locations outside of the site around Highway 914, with the overall maximum occurring at a receptor next to the Highway. Figures 1 and 2 also show that the isopleths of 24-hour and annual TSP concentrations closely follow the shape of the roadways, indicating that one of the largest contributors to TSP concentrations is unpaved road dust. Concentrations are also elevated around the centre of the Project Area, showing the influence of dust from earthworks activities during construction.

Isopleths of predicted 24-hour PM_{10} concentrations (Figure 4) and dustfall (Figure 3) have a similar pattern to TSP, illustrating that unpaved road dust and earthworks activities also influence PM_{10} and dustfall during construction. As shown in Figure 5, the concentration isopleths of 24-hour $PM_{2.5}$ also have a similar pattern to TSP, illustrating that unpaved road dust influences $PM_{2.5}$ concentrations during construction. However, concentrations of $PM_{2.5}$ are elevated near the standby generators, reflecting emissions of fine particulate matter from diesel combustion.

6.1.2 Gaseous COPC

The predicted incremental concentrations of combustion gases (CO, SO_2, and NO_2) associated with Project construction are provided in Table 5 for the maximum off-property receptor. Contour plots for these COPC are provided in Figure 7 through Figure 14. As discussed in Section 6.1.3.2.5 of the EIS, background SO_2 concentrations are zero, therefore, predicted concentrations of SO_2 are presented as incremental concentrations (i.e., without the addition of background).

As shown in Table 5 and the Figures, no exceedances of the Project criteria for CO or SO_2 are predicted at any receptor location. 24-hour and annual NO_2 concentrations are also predicted to be below the Project criteria outside of the Property Boundary. However, the predicted 1-hour NO_2 concentrations are above the applicable Project criteria of 79 µg/m³ at some off-property receptors in the LSA (Figure 12).

The overall maximum off-property 1-hour NO_2 concentration is 176.5 µg/m³ (or 224% of the Project criteria) and occurs at a receptor that is located approximately 220 m from the northwest Property Boundary (see Figure 12). Figures 12 to 14 also show that NO_2 concentrations are highest near the centre of the Project Area, where the diesel generators will be located, indicating that the largest contributor to NO_2 concentrations during construction is on-site power generation.

6.1.3 Uranium and Metals

The predicted incremental concentrations of uranium and metals associated with Project construction are provided in Table 5 for the maximum off-property receptor. As the Table shows, predicted concentrations of uranium and metals are all below their applicable Project criteria throughout the LSA. Only uranium has predicted concentrations that are greater than 5% of the Project criteria. The maximum off-property uranium concentration is 8.75E-03 µg/m³ or 6% of the Project criteria for 24-hours, and 1.00E-03 µg/m³ or 3% of the Project criteria for the annual averaging period. As a result, only contour plots for uranium are presented for the Construction scenario.

Figure 15 and Figure 16 show that the contours of uranium are elevated near the ore zone, with the maxima occurring at northwest property boundary receptors. This pattern shows the influence of drilling and handling drill cuttings in the wellfield area during construction.

6.1.4 Radon

The predicted incremental concentrations radon associated with Project construction are provided in Table 5 for the maximum off-property receptor. Annual radon concentrations during construction are predicted to be low and well below the range of background concentrations (<7.4 to 25 Bq/m³) reported by the Canadian Nuclear Safety Commission (CNSC) [20]. The predicted radon concentration at the maximum off-property receptor is 1.1 Bq/m³.

Like uranium, Figure 17 shows that annual radon concentrations are highest near the ore zone reflecting emissions from wellfield development (i.e., drilling), as well as pump tests. The contour plot also shows that radon concentrations drop off quickly with distance from the Project site - within approximately 1 km of the Project Boundary, concentrations are predicted to be less than 0.5 Bq/m³.

Table 5: Model Predicted COPC Concentrations for the Construction Scenario

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Particulate	TSP	24-hour	µg/m³	100	46.2	**313.3**	**313%**	**104 days per year**	477.809	6369.081
		Annual	µg/m³	60	12.4	25.9	43%	n/a	478.087	6369.414
	PM_{10}	24-hour	µg/m³	50	23.1	**116.2**	**232%**	**61 days per year**	478.087	6369.414
	$PM_{2.5}$	24-hour	µg/m³	27	6.5	16.3	60%	0	478.087	6369.414
		Annual	µg/m³	8.8	3.1	3.6	41%	n/a	478.087	6369.414
	Dustfall	30-Day	mg/cm²/30 days	2	0.06	0.19	9%	0	477.286	6368.111
Gases	CO	1-hour	µg/m³	15,000	575	614.7	4%	0	475.995	6375.539
		8-hour	µg/m³	6,000	575	596.0	10%	0	476.185	6375.316
	SO_2	1-hour	µg/m³	170	0	1.71E-01	0%	0	475.995	6375.539
		24-hour	µg/m³	125	0	3.55E-02	0%	0	476.406	6375.735
		Annual	µg/m³	10	0	3.29E-03	0%	n/a	477.981	6373.810
	NO_2	1-hour	µg/m³	79	11.3	**176.5**	**224%**	**28 hours per year**	475.995	6375.539
		24-hour	µg/m³	200	9.4	42.9	21%	0	476.406	6375.735
		Annual	µg/m³	23	3.8	6.8	30%	n/a	477.981	6373.810
Metals and Radon	As	24-hour	µg/m³	0.3	3.00E-03	3.01E-03	1%	0	476.094	6374.966
	Cd	24-hour	µg/m³	0.025	2.77E-04	2.78E-04	1%	0	476.094	6374.966
		Annual	µg/m³	0.005	7.44E-05	7.45E-05	1%	n/a	476.090	6374.922
	Co	24-hour	µg/m³	0.1	2.63E-03	2.64E-03	3%	0	476.094	6374.966
	Cr	24-hour	µg/m³	0.5	5.54E-04	5.62E-04	0%	0	476.094	6374.966
	Cu	24-hour	µg/m³	50	3.29E-01	3.29E-01	1%	0	476.094	6374.966
	Mo	24-hour	µg/m³	120	2.68E-03	2.69E-03	0%	0	476.094	6374.966
	Ni	24-hour	µg/m³	0.2	2.00E-03	2.01E-03	1%	0	476.094	6374.966
		Annual	µg/m³	0.04	4.00E-04	4.01E-04	1%	n/a	476.090	6374.922
	Pb	24-hour	µg/m³	0.5	1.62E-02	1.64E-02	3%	0	476.094	6374.966

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Metals and Radon	Pb	30 days	µg/m³	0.2	6.24E-03	6.27E-03	3%	0	476.087	6374.878
	Se	24-hour	µg/m³	10	8.03E-04	8.05E-04	0%	0	476.094	6374.966
	U	24-hour	µg/m³	0.15	3.00E-03	8.75E-03	6%	0	476.094	6374.966
		Annual	µg/m³	0.03	6.00E-04	1.00E-03	3%	n/a	476.090	6374.922
	Vn	24-hour	µg/m³	2	5.31E-03	5.34E-03	0%	0	476.094	6374.966
	Zn	24-hour	µg/m³	120	1.13E+00	1.13	1%	0	476.094	6374.966
	Rn-222	Annual	Bq/m³	n/a	n/a	1.12	n/a	n/a	476.098	6375.011

Notes:
[1] **Bold** values indicate predicted concentrations that are above the Project criteria.
[2) Predicted concentrations are presented after removal of meteorological anomalies.
[3) The locations of the maximum predicted concentrations are listed in UTM coordinates in kilometres relative to the NAD83 datum (Zone 13N).
[4) Results include the addition of background air concentrations where available.
[5) n/a – not applicable

6.2 OPERATIONS SCENARIO

The Operations scenario represents a conservative, upper-bound emissions scenario based on work being completed in Phase 5 of mine plan and a recovered solution flow rate of 30 m^3/h. Table 6 presents the overall, off-property maximum COPC concentrations (including background concentrations) predicted for this scenario, while concentration isopleths are also provided graphically in Figures 18 through 34.

6.2.1 Particulate Matter

Model predicted concentrations of TSP, PM_{10}, $PM_{2.5}$, and dustfall (including background) for the Operations scenario are provided in Table 6 for the maximum off-property receptor. Contour plots for particulate matter concentrations and dustfall are also provided in Figure 18 through Figure 23. As shown in Table 6, 24-hour concentrations of TSP and PM_{10} are predicted to be above the Project criteria at the maximum off-property receptor. The maximum off-property concentrations of 24-hour TSP and PM_{10} are 281.2 $\mu g/m^3$ and 103.8 $\mu g/m^3$, respectively or 281% and 208% of the Project criteria. Figure 18 shows that 24-hour TSP concentrations closely follow the shape of the roadways, with exceedances of the Project criteria occurring at off-property receptors located along Highway 914. This pattern indicates that one of the largest contributors to TSP concentrations is unpaved road dust. Isopleths of predicted 24-hour PM_{10} (Figure 21) have a similar pattern to TSP, illustrating that unpaved road dust is also a main contributor to PM_{10} concentrations during the Operations scenario.

Annual TSP concentrations, 30-day dustfall rates, and 24-hour and annual $PM_{2.5}$ concentrations are below the Project criteria at the maximum off-property receptor. Isopleths of dustfall (Figure 20) have a similar pattern to TSP, illustrating that unpaved road dust also influences dustfall during operations. The concentration isopleths of 24-hour $PM_{2.5}$ (Figure 22) also follow the shape of the roadways, illustrating that unpaved road dust influences $PM_{2.5}$ concentrations. However, concentrations of 24-hour $PM_{2.5}$ are elevated around the standby generators at the freeze plant, reflecting emissions of fine particulate matter from diesel combustion.

Compared to the Construction scenario, particulate matter levels are lower in the Operations scenario, which is expected given that site-wide emission rates of particulate matter are reduced relative to the Construction scenario (see Section 4.0). The reduction is more pronounced at receptors near the Project Area since dust-generating earthworks activities have ceased, and little fugitive dust is produced by the ISR process. Since traffic is similar between the two scenarios, there is only a small reduction in road dust emissions along Highway 914 and the overall maximum 24-hour TSP and PM_{10} concentrations predicted near the Highway are similar as a result.

6.2.2 Gaseous COPC

The predicted incremental concentrations of combustion gases (CO, SO_2, and NO_2) associated with operations are provided in Table 6 for the maximum off-property receptor. Contour plots for these COPC are provided in Figure 24 through Figure 31. As mentioned earlier, background SO_2 concentrations are zero; therefore, predicted concentrations of SO_2 are presented as incremental concentrations (i.e., without the addition of background; see Section 6.1.3.2.5 of the EIS).

As shown in the Table and the Figures, no exceedances of the Project criteria for CO or SO_2 are predicted at any receptor location. 24-hour and annual NO_2 concentrations are also predicted to be below the Project criteria outside of the Property Boundary. However, the predicted 1-hour NO_2 concentrations are above the applicable Project criteria of 79 µg/m³ at some off-property receptors in the LSA (Figure 29).

The overall maximum off-property 1-hour NO_2 concentration is 177.7 µg/m³ (or 225% of the Project criteria) and occurs at a receptor that is located approximately 260 m from the northwest Property Boundary (see Figure 29). Figure 29 and Figure 30 illustrate how short-term NO_2 concentrations are elevated where the standby diesel generators will be located – at the freeze plant, near the worker camp, and near the operations building.

Compared to the Construction scenario, 1- and 24-hour NO_2 concentrations for the Operations scenario are similar at the maximum off-property receptor location since both scenarios assessed worst-case conditions where power is not available from the grid (see Section 2.0).

6.2.3 Uranium and Metals

The predicted concentrations of uranium and metals (i.e., including background) associated with Project operations are provided in Table 6 for the maximum off-property receptor. The Table shows that predicted concentrations of all metals are below their applicable Project criteria at the maximum off-property receptor. Annual uranium concentrations are predicted to be below the Project criteria at the maximum off-property; however, 24-hour uranium concentrations are predicted to exceed the Project criteria at the maximum off-property receptor.

The maximum off-property uranium concentration predicted for the Operations scenario is 2.23E-01 µg/m³ for 24-hours or 148% of the Project criteria, and 1.87E-02 µg/m³ for an annual averaging period or 62% of the Project criteria. Compared to the Construction scenario, uranium concentrations are two orders of magnitude higher, which is explained by uranium emissions from the ISR plant (see Section 4.0). The influence of the ISR plant on uranium concentrations is illustrated in Figure 32 and Figure 33, which show how the contours of uranium are elevated within the Project Area near the ISR plant, with the maxima occurring at a Property Boundary receptor located downwind of the plant.

6.2.4 Radon

The predicted incremental concentrations radon associated with Project operations are provided in Table 6 for the maximum off-property receptor. Compared to the Construction scenario, annual radon concentrations are predicted to be about 10 times higher at off-property receptor locations, which is primarily explained by emissions from wellfield operations, particularly the recovered solution surge tank (see Section 4.0). Although concentrations have increased, the maximum off-property concentration is within the range of background concentrations (<7.4 to 25 Bq/m³) reported by the CNSC [20]. The radon concentration predicted at the maximum off-property receptor is 13.8 Bq/m³.

Figure 34 shows that annual radon concentrations are highest near the recovered solution surge tank, with the overall maximum concentration occurring downwind from this primary emission source. Radon concentrations then drop off quickly with distance from the Project site and within 1 km of the Project Boundary, concentrations are predicted to be less than 5 Bq/m³.

Table 6: Model Predicted COPC Concentrations for the Operations Scenario

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Particulate	TSP	24-hour	µg/m³	100	46.2	**281.2**	**281%**	**80 days per year**	477.809	6369.081
		Annual	µg/m³	60	12.4	18.8	31%	n/a	478.087	6369.414
	PM_{10}	24-hour	µg/m³	50	23.1	**103.8**	**208%**	**42 days per year**	478.087	6369.414
	$PM_{2.5}$	24-hour	µg/m³	27	6.5	15.0	55%	0	478.087	6369.414
		Annual	µg/m³	8.8	3.1	3.3	38%	n/a	478.087	6369.414
	Dustfall	30-Day	mg/cm²/30 days	2	0.06	0.12	6%	0	477.286	6368.111
Gases	CO	1-hour	µg/m³	15,000	575	614.2	4%	0	475.995	6375.539
		8-hour	µg/m³	6,000	575	596.2	10%	0	476.245	6375.789
	SO_2	1-hour	µg/m³	170	0	1.72E-01	0%	0	476.646	6375.539
		24-hour	µg/m³	125	0	4.03E-02	0%	0	476.245	6375.789
		Annual	µg/m³	10	0	9.55E-04	0%	n/a	477.458	6373.283
	NO_2	1-hour	µg/m³	79	11.3	**177.7**	**225%**	**28 hours per year**	475.995	6375.539
		24-hour	µg/m³	200	9.4	46.8	23%	0	476.245	6375.789
		Annual	µg/m³	23	3.8	4.4	20%	n/a	477.458	6373.283
Metals and Radon	As	24-hour	µg/m³	0.3	3.00E-03	3.07E-03	1%	0	476.087	6374.878
	Cd	24-hour	µg/m³	0.025	2.77E-04	2.94E-04	1%	0	475.997	6374.859
		Annual	µg/m³	0.005	7.44E-05	7.59E-05	2%	n/a	478.132	6374.207
	Co	24-hour	µg/m³	0.1	2.63E-03	2.72E-03	3%	0	475.997	6374.859
	Cr	24-hour	µg/m³	0.5	5.54E-04	7.98E-04	0%	0	476.087	6374.878
	Cu	24-hour	µg/m³	50	3.29E-01	3.33E-01	1%	0	475.997	6374.859
	Mo	24-hour	µg/m³	120	2.68E-03	2.76E-03	0%	0	476.087	6374.878
	Ni	24-hour	µg/m³	0.2	2.00E-03	2.22E-03	1%	0	475.997	6374.859
		Annual	µg/m³	0.04	4.00E-04	4.19E-04	1%	n/a	478.132	6374.207
	Pb	24-hour	µg/m³	0.5	1.62E-02	2.05E-02	4%	0	475.997	6374.859

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Metals and Radon	Pb	30 days	µg/m³	0.2	6.24E-03	7.02E-03	4%	0	476.087	6374.878
	Se	24-hour	µg/m³	10	8.03E-04	8.42E-04	0%	0	475.997	6374.859
	U	24-hour	µg/m³	0.15	3.00E-03	**2.23E-01**	**148%**	**3**	477.105	6373.029
		Annual	µg/m³	0.03	6.00E-04	1.87E-02	62%	n/a	477.981	6373.810
	Vn	24-hour	µg/m³	2	5.31E-03	5.75E-03	0%	0	475.997	6374.859
	Zn	24-hour	µg/m³	120	1.13E+00	1.13	1%	0	475.997	6374.859
	Rn-222	Annual	Bq/m³	n/a	n/a	13.8	n/a	n/a	478.106	6374.169

Notes:
[1] **Bold** values indicate predicted concentrations that are above the Project criteria.
[2) Predicted concentrations are presented after removal of meteorological anomalies.
[3) The locations of the maximum predicted concentrations are listed in UTM coordinates in kilometres relative to the NAD83 datum (Zone 13N).
[4) Results include the addition of background air concentrations where available.
[5) n/a – not applicable

6.3 DECOMMISSIONING SCENARIO

The Decommissioning scenario represents the six-year decommissioning phase of the Project, which considered remediation works such as disposal of contaminated materials. Table 7 presents the overall, off-property maximum COPC concentrations (including background concentrations) predicted for this scenario, while concentration isopleths are also provided graphically in Figure 35 through Figure 49.

6.3.1 Particulate Matter

Model predicted concentrations of TSP, PM_{10}, $PM_{2.5}$, and dustfall (including background) for the Decommissioning scenario are provided in Table 7 for the maximum off-property receptor and contour plots are also provided in Figure 35 through Figure 40. As shown in Table 7, the 24-hour concentration of TSP is predicted to be above the Project criteria at the maximum off-property receptor, with a value of 114.8 µg/m³ or 115% of the Project criteria. However, there are no off-property receptors where the 24-hour Project criteria for PM_{10} is exceeded. Figure 35 shows that 24-hour TSP concentrations follow the shape of the roadways, with exceedances of the Project criteria occurring at off-property receptors along Highway 914. This pattern indicates that one of the largest contributors to TSP concentrations is unpaved road dust. Concentrations are also elevated around the centre of the Project Area, also showing the influence of dust from material handling activities during decommissioning. Isopleths of predicted 24-hour PM_{10} (Figure 38) have a similar pattern to TSP, indicating that the same sources influence PM_{10} concentrations.

Annual TSP concentrations, 30-day dustfall rates, and 24-hour and annual $PM_{2.5}$ concentrations are below the Project criteria at the maximum off-property receptor. As expected, isopleths of dustfall (Figure 37) have a similar pattern to TSP, illustrating that unpaved road dust and material handling influence dustfall during decommissioning. The concentration isopleths of 24-hour $PM_{2.5}$ (Figure 39) also follow the roadways, illustrating that unpaved road dust influences $PM_{2.5}$ concentrations. However, concentrations of 24-hour $PM_{2.5}$ are also elevated around the standby generators at the freeze plant, which emit fine particulate matter from combustion of diesel fuel.

Compared to the Construction and Operations scenarios, particulate matter levels are the lowest during the Decommissioning scenario, which is expected since there are limited sources of dust during decommissioning (see Section 4.0). During decommissioning, traffic volumes are reduced, and because there is limited waste generated by the project, disposal activities are also limited. As a result, particulate emissions are reduced.

6.3.2 Gaseous COPC

The predicted incremental concentrations of combustion gases (CO, SO_2, and NO_2) associated with the Decommissioning scenario are provided in Table 7 for the maximum off-property receptor. Contour plots for these COPC are provided in Figure 41 through Figure 48. As mentioned earlier, background SO_2 concentrations are zero, therefore, predicted concentrations of SO_2 are presented as incremental concentrations (i.e., without the addition of background; see Section 6.1.3.2.5 of the EIS).

As shown in the Table and Figures, no exceedances of the Project criteria for CO or SO_2 are predicted at any receptor location. 24-hour and annual NO_2 concentrations are also predicted to be below the Project criteria

outside of the Property Boundary. However, like the other scenarios, predicted 1-hour NO_2 concentrations are above the applicable Project criteria of 79 µg/m³ at some off-property receptors in the LSA (Figure 46).

The overall maximum off-property 1-hour NO_2 concentration is the same as the Operations scenario (177.7 µg/m³ or 225% of the criteria) and occurs at a receptor that is located approximately 260 m from the northwest Property Boundary. The source influencing the maximum off-property concentration (the freeze plant generators), is assumed to have the same short-term emission rate of NO_2 during operations and decommissioning (see Section 4.0); therefore, the maximum off-property concentration is the same.

6.3.3 Uranium and Metals

The predicted concentrations of uranium and metals (i.e., including background) associated with Project decommissioning are provided in Table 7 for the maximum off-property receptor. The Table shows that predicted concentrations of uranium and metals are low and all below their applicable Project criteria at the maximum off-property receptor.

Compared to the Construction and Operations scenario, the Decommissioning scenario has the lowest predicted uranium and metals concentrations. Since the Project generates minimal waste, sources of uranium and metals during decommissioning are limited and only includes disposal of special waste. At 5%, uranium has the highest predicted off-property concentrations relative to the 24-hour Project criteria. Since there are no COPC above 5% of the Project criteria, contour plots have not been generated for this scenario.

6.3.4 Radon

The predicted incremental radon concentrations associated with Project decommissioning are provided in Table 7 for the maximum off-property receptor. The radon concentration at the maximum off-property receptor is 7.94 Bq/m³, which is within the range of background concentrations (< 7.4 to 25 Bq/m³) reported by the CNSC [20]. The predictions are slightly lower than the Operations scenario, which can be explained by reduced emissions of radon from wellfield restoration compared to wellfield operations (see Section 4.0).

Like the Operations scenario, Figure 49 shows that annual radon concentrations are highest near the recovered solution surge tank, with the maxima occurring downwind from this primary emission source. Radon concentrations then drop off quickly with distance from the Project site and within 1 km of the Project Footprint, concentrations are predicted to be less than 3 Bq/m³.

Table 7: Model Predicted COPC Concentrations for the Decommissioning Scenario

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Particulate	TSP	24-hour	µg/m³	100	46.2	**114.8**	**115%**	**2 days per year**	477.563	6368.717
		Annual	µg/m³	60	12.4	16.0	27%	n/a	478.087	6369.414
	PM_{10}	24-hour	µg/m³	50	23.1	47.4	95%	0	478.087	6369.414
	$PM_{2.5}$	24-hour	µg/m³	27	6.5	9.9	35%	0	476.087	6374.878
		Annual	µg/m³	8.8	3.1	3.4	38%	n/a	476.098	6375.011
	Dustfall	30-Day	mg/cm²/30 days	2	0.06	0.09	5%	0	477.286	6368.111
Gases	CO	1-hour	µg/m³	15,000	575	614.9	4%	0	475.995	6375.539
		8-hour	µg/m³	6,000	575	595.7	10%	0	475.995	6375.539
	SO_2	1-hour	µg/m³	170	0	1.66E-01	0%	0	475.995	6375.539
		24-hour	µg/m³	125	0	3.42E-02	0%	0	477.066	6373.000
		Annual	µg/m³	10	0	2.84E-03	0%	n/a	477.811	6373.538
	NO_2	1-hour	µg/m³	79	11.3	**177.7**	**225%**	**25 hours per year**	475.995	6375.539
		24-hour	µg/m³	200	9.4	42.7	21%	0	477.066	6373.000
		Annual	µg/m³	23	3.8	6.6	29%	n/a	477.811	6373.538
Metals and Radon	As	24-hour	µg/m³	0.3	3.00E-03	3.01E-03	1%	0	476.098	6375.011
	Cd	24-hour	µg/m³	0.025	2.77E-04	2.78E-04	1%	0	476.098	6375.011
		Annual	µg/m³	0.005	7.44E-05	7.45E-05	1%	n/a	478.169	6374.333
	Co	24-hour	µg/m³	0.1	2.63E-03	2.64E-03	3%	0	476.098	6375.011
	Cr	24-hour	µg/m³	0.5	5.54E-04	5.63E-04	0%	0	476.098	6375.011
	Cu	24-hour	µg/m³	50	3.29E-01	3.29E-01	1%	0	476.098	6375.011
	Mo	24-hour	µg/m³	120	2.68E-03	2.69E-03	0%	0	476.098	6375.011
	Ni	24-hour	µg/m³	0.2	2.00E-03	2.01E-03	1%	0	476.098	6375.011
		Annual	µg/m³	0.04	4.00E-04	4.01E-04	1%	n/a	478.169	6374.333
	Pb	24-hour	µg/m³	0.5	1.62E-02	1.64E-02	3%	0	476.098	6375.011

COPC		Time Averaging Period	Units	Project AQ Criteria	Background Conc.	Maximum Off-Property Location				
						Max Predicted Conc.	% Of Criteria	Predicted No. of Exceedances	Location of Max Conc.	
									UTM X (km)	UTM Y (km)
Metals and Radon	Pb	30 days	µg/m³	0.2	6.24E-03	6.28E-03	3%	0	476.087	6374.878
	Se	24-hour	µg/m³	10	8.03E-04	8.05E-04	0%	0	476.098	6375.011
	U	24-hour	µg/m³	0.15	3.00E-03	7.41E-03	2%	0	476.098	6375.011
		Annual	µg/m³	0.03	6.00E-04	9.14E-04	3%	n/a	478.169	6374.333
	Vn	24-hour	µg/m³	2	5.31E-03	5.33E-03	0%	0	476.098	6375.011
	Zn	24-hour	µg/m³	120	1.13E+00	1.13	1%	0	476.098	6375.011
	Rn-222	Annual	Bq/m³	n/a	n/a	7.94	n/a	n/a	476.138	6375.187

NOTES:
[1] **Bold** values indicate predicted concentrations that are above the Project criteria.
[2) Predicted concentrations are presented after removal of meteorological anomalies.
[3) The locations of the maximum predicted concentrations are listed in UTM coordinates in kilometres relative to the NAD83 datum (Zone 13N).
[4) Results include the addition of background air concentrations where available.
[5) n/a – not applicable

7.0 FREQUENCY ANALYSIS

For all assessment scenarios, exceedances of the 24-hour Project criteria for TSP and the 1-hour Project criteria for NO_2 were predicted at off-property locations. In the Construction and Operations scenarios, exceedances of the 24-hour PM_{10} criteria were also predicted at the maximum off-property receptor. For the Operations scenario, 24-hour uranium concentrations also exceeded the Project criteria at the maximum off-property receptor.

To examine the nature of the predicted exceedances, a frequency analysis was completed and is discussed in the following sections. The total number of exceedances (including background) for each assessment scenario were determined over the one-year meteorological data period and are summarized in Table 5, Table 6, and Table 7 at the maximum off-property receptor. The frequency analysis is also presented graphically in Figure 50 through Figure 57.

7.1 PARTICULATE MATTER

The frequency analysis for 24-hour TSP shows that concentrations are predicted to exceed the Project criteria of 100 µg/m³ 28% of the time during Construction, 21% of the time during Operations, and 0.5% of the time during Decommissioning at the maximum off-property receptor. For the Construction and Operations scenarios, 24-hour PM_{10} concentrations are predicted to exceed the Project criteria of 50 µg/m³ 17% of the time at the maximum off-property receptor.

The results of the frequency analysis are also presented graphically in Figure 50 through Figure 54. Relative to the Property Boundary, the Figures show that the predicted exceedances of 24-hour TSP and PM_{10} are limited to areas within 250 m of the Property Boundary during the Construction scenario. Along Highway 914, exceedances are limited to about 300 m on either side of the roadway during Construction. The frequency of exceedances at these distances are expected to be only a single day per year (i.e., 0.3% of the time). In Operations and Decommissioning, the geographic extent of predicted exceedances is even less.

Although exceedances of the 24-hour TSP and PM_{10} Project criteria are predicted to occur at receptors outside of the Property Boundary in the LSA, the magnitude of these predictions and number of exceedances are considered conservative. As mentioned in Section 6.1.3.7 of the EIS, conservative background concentrations of particulate matter have been added to the maximum concentrations predicted by the air dispersion model. Additionally, as detailed in Section 4.0, conservative emission scenarios were used by assuming that sources operate individually at their maximum rates of production year-round. Production rates and background concentrations will vary day-to-day and the likelihood of worst-case particulate matter emissions occurring simultaneously with elevated background concentrations and unfavourable meteorological conditions (e.g., calm winds, stable conditions) is low. Therefore, concentrations of TSP and PM_{10}, and the number of exceedances of Project criteria are likely overestimated.

In addition to the mitigation measures already accounted for in the assessment, other strategies to avoid or reduce the likelihood of TSP and PM_{10} exceedances include:

- Planning: limit material handling activities during dry conditions and/or periods of high winds.
- Planning: limit vehicle and equipment speeds on unpaved roadways/surfaces.

- Planning: optimize the number of vehicle and equipment movements and minimize travel distances, where possible.
- Planning: maintain unpaved roads via grading or other maintenance practices to reduce the number of fine particles available for dispersion.
- Monitoring: collect dust measurements during construction, operations, and decommissioning, and determine whether the actual impact of Project activities is lower than that what was modelled.

7.2 NO_2

The analysis for 1-hour NO_2 shows that the frequency of exceedances of the Project criteria of 79 µg/m³ at the maximum off property receptor is limited for each scenario and is predicted to be less than 1% of the time during Construction, Operations, Decommissioning of the Project. As Figure 55 and Figure 56 show, exceedances are predicted in the LSA out to a maximum distance of 1 km from the Property Boundary; however, the frequency of exceedances at this distance is expected to be only a single day per year (i.e., 0.3% of the time).

Although exceedances of the 1-hour NO_2 criteria are predicted to occur in the LSA, concentrations are judged to be conservative. The Saskatchewan Air Quality Modelling Guideline [18] notes that ambient ratio method (see Section 6.1.1.2.4 of the EIS) used to convert NOx to NO_2 is conservative. In addition, the short-term emissions scenario for Operations and Decommissioning described in Section 2.0 and detailed in Appendix A, is considered a conservative operating case where electricity from the SaskPower grid is unavailable and all backup generators continuously supply power to support site activities. The likelihood of a power loss that requires all backup power to be fully utilized occurring concurrently with maximum emissions from other site activities and under adverse meteorological conditions is low. Therefore, actual concentrations of NO_2 and the number of exceedances of the 1-hour Project criteria are likely to be less than what has been predicted by the model, particularly for the Operations and Decommissioning scenarios.

Other strategies to avoid or reduce the likelihood of 1-hour NO_2 exceedances include:

- Planning: employ standard operating procedures for the use of equipment and machinery, including maintenance requirements.
- Planning: limit idling and optimize the number of vehicle and equipment movements to minimize travel distances, where possible.

7.3 URANIUM

The frequency analysis for 24-hour uranium for the Operations scenario shows that concentrations are predicted to exceed the Project criteria of 0.15 µg/m³ less than 0.8% of the time at the maximum off-property receptor. The results of the frequency analysis are also presented graphically in Figure 57, which shows that the predicted exceedances of uranium are limited to areas within the LSA out to a maximum distance of 400 m from the Property Boundary. At this distance, frequency of exceedances is expected to be only a single day per year (i.e., 0.3% of the time).

Although exceedances of the 24-hour uranium Project criteria are predicted to occur at receptors outside of the Property Boundary in the LSA, the magnitude of these predictions and number of exceedances are considered conservative. As detailed Appendix A, the uranium emission rates for the ISR stacks are considered

conservative. Emissions of particulate matter from the ISR stacks were based on pre-feasibility engineering design documents that applied a general emission target of 10 mg/Nm³ for particulate matter [14]. The maximum percentage of uranium in yellowcake was then applied to this target to develop conservative emission estimates of uranium. It is likely that lower emissions targets will be achieved during the detailed design phase on the Project; therefore, concentrations of uranium, and the number of exceedances of Project criteria are likely overestimated.

8.0 RECOMMENDED EMISSIONS MANAGEMENT PRACTICES

The following emissions management practices are recommended based on industry best practices for reducing the likelihood of impacts during the various phases of the Project.

Administrative controls

- Create and implement a dust management plan, including the application of water and/or chemical suppressant to control fugitive dust, in addition to other operational strategies to assist in dust control,
- Planning vehicle and equipment routes to minimize travel distances, where possible, and
- Employ standard operating procedures and complete regular inspections of equipment machinery to ensure it is in good working order

Physical controls

- Avoid dust-generating activities (e.g., earthworks, material handling) during dry or high wind conditions,
- Avoid dropping material from height,
- Ensure all exhausts (e.g., mobile equipment, generators) are in good working condition,
- Turn off vehicles and equipment when not being used,
- Minimize or reduce vehicle and equipment speed by enforcing speed limits,
- Apply water at least twice per day to unpaved roads and surfaces, and
- Maintain unpaved road surfaces via grading or other maintenance practices to reduce the amount of silt (i.e., fines) present in the roadbed material.

9.0 CONCLUSIONS

The air quality assessment considered the construction, operations, and decommissioning phases of the Project. Conservative assessment scenarios were prepared for each phase based on information from Denison on the expected construction fleet, construction activity, and operating/physical data for process sources. Emissions of COPC for each source were derived primarily from the compendium of emission factors published by the U.S. EPA in the AP-42 database. The COPC emissions associated with each scenario were then modelled based on planning drawings and pre-feasibility engineering data for the proposed Project configuration. The predictive modelling was completed in CALPUFF (version 7), an advanced 3-D dispersion model that can handle complex terrain and multiple emissions sources from facilities and activities located over large areas. The results of the modelling assessment were compared to Project air quality criteria derived from provincial and federal guidelines that have relevance to the Project.

The guidelines that were followed in the preparation of this assessment each required an accounting of the existing conditions at the site. As discussed in Section 6.1.3.2 of the EIS, Denison has been conducting baseline air quality monitoring at the Wheeler River site since 2016, including measurements of particulate (as dustfall), trace gases (NO_2 and SO_2), external gamma, and radon. The results indicated that the background air quality is typical of a remote setting. The model predictions indicate that COPC concentrations return to baseline ambient levels within approximately 15 km of the Property Boundary.

The comparison of model predicted COPC concentrations to the adopted Project air quality criteria indicate that:

- Majority of the COPC and averaging periods are below Project criteria at all receptor locations in the Study Areas, including:
    - 30-day dustfall,
    - Annual TSP concentrations,
    - 24-hour and annual $PM_{2.5}$ concentrations,
    - 1-, 24-hour and annual SO_2 concentrations,
    - 1- and 8-hour CO concentrations,
    - 24-hour and annual NO_2 concentrations,
    - 24-hour concentrations of arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, lead, selenium, vanadium, and zinc, and annual concentrations of cadmium, nickel, and uranium.
- In the Construction, Operations, and Decommissioning scenarios, annual average radon concentrations beyond the Property Boundary are expected to be below the range of background concentrations (< 7.4 to 25 Bq/m³) reported by the CSNC [20] and would be indiscernible from background. For the Operations and Decommissioning scenarios, predicted annual radon concentrations at the maximum off-property receptor were similar, and the overall maximum radon concentration was predicted to be 8.0 µg/m³ at a Property Boundary receptor. For Construction, the overall maximum radon concentration was 1.1 Bq/m³.
- In the Construction, Operations, and Decommissioning scenarios, concentrations of 24-hour TSP and PM_{10} were predicted to exceed the Project criteria at receptors located outside of the Property Boundary in the LSA. The highest off-property concentrations of particulate matter were predicted in

the Construction scenario when the highest emissions of particulate matter are expected. The maximum 24-hour TSP and PM_{10} concentrations were predicted to be 313 µg/m³ and 116 µg/m³, respectively.

- 1-hour NO_2 concentrations were predicted to exceed the Project criteria at off-property receptors in the LSA for the Construction, Operations, and Decommissioning scenarios, reflecting worst-case operations of the stand-by diesel generators. The highest 1-hour NO_2 concentration was predicted to be 177.1 µg/m³ at the maximum off-property receptor.
- 24-hour uranium concentrations were predicted to exceed the Project criteria at off-property receptors in the Operations scenario only, reflecting worst-case operations of ISR stacks. The highest 24-hour uranium concentration was predicted to be 2.23E 01 µg/m³ at the maximum off-property receptor.

An assessment of potential impacts was completed by evaluating the frequencies and geographic extent of the predicted exceedances. The analysis showed that:

- Exceedances of the 24-hour TSP and PM_{10} Project criteria are limited in frequency and extent and do not go beyond 250 m from the Property Boundary. Along Highway 914, 24-hour TSP and PM_{10} exceedances are limited to 300 m on either side of the roadway. Exceedances are predicted to occur less than 30% of the time at a maximum off-property receptor next to Highway 914.
- Exceedances of the 1-hour NO_2 Project criteria are limited in frequency and extent and are predicted to occur less than 1% of the time at the maximum off-property receptor. Exceedances also do not extend beyond 1 km from the Property Boundary.
- Exceedances of the 24-hour uranium Project criteria are limited in frequency and extent. Exceedances are predicted to occur less than 1% of the time at the maximum off-property receptor and do not extend beyond 400 m from the Property Boundary.

Due to the conservative assumptions that have been built into this air quality assessment, it is likely that the actual COPC concentrations and exceedances will be less than what was predicted by the dispersion model. Despite these assumptions, the assessment demonstrates that any potential excursions are limited in both space and duration.

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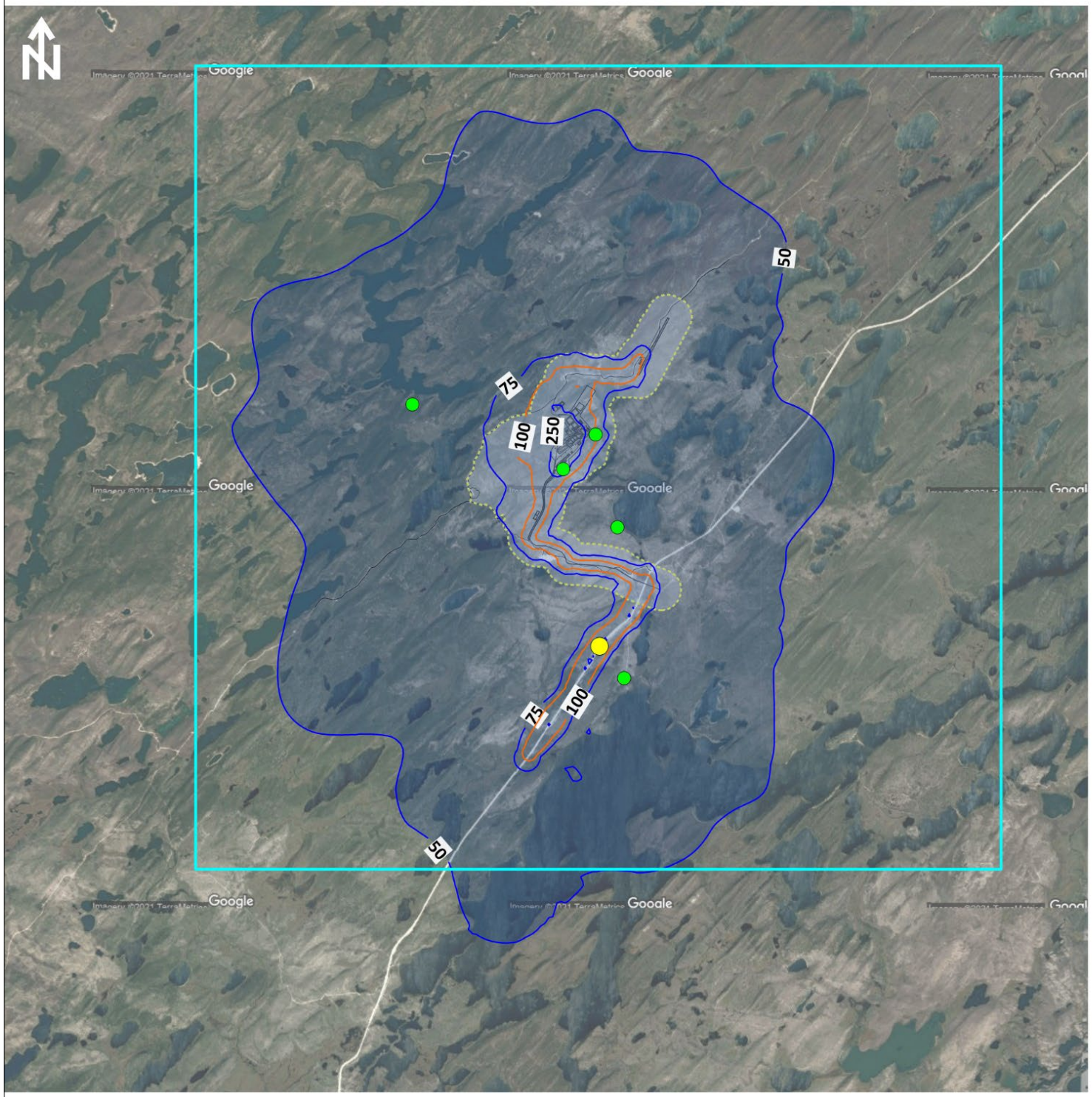
Figures:



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 46.2 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	1
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 12.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

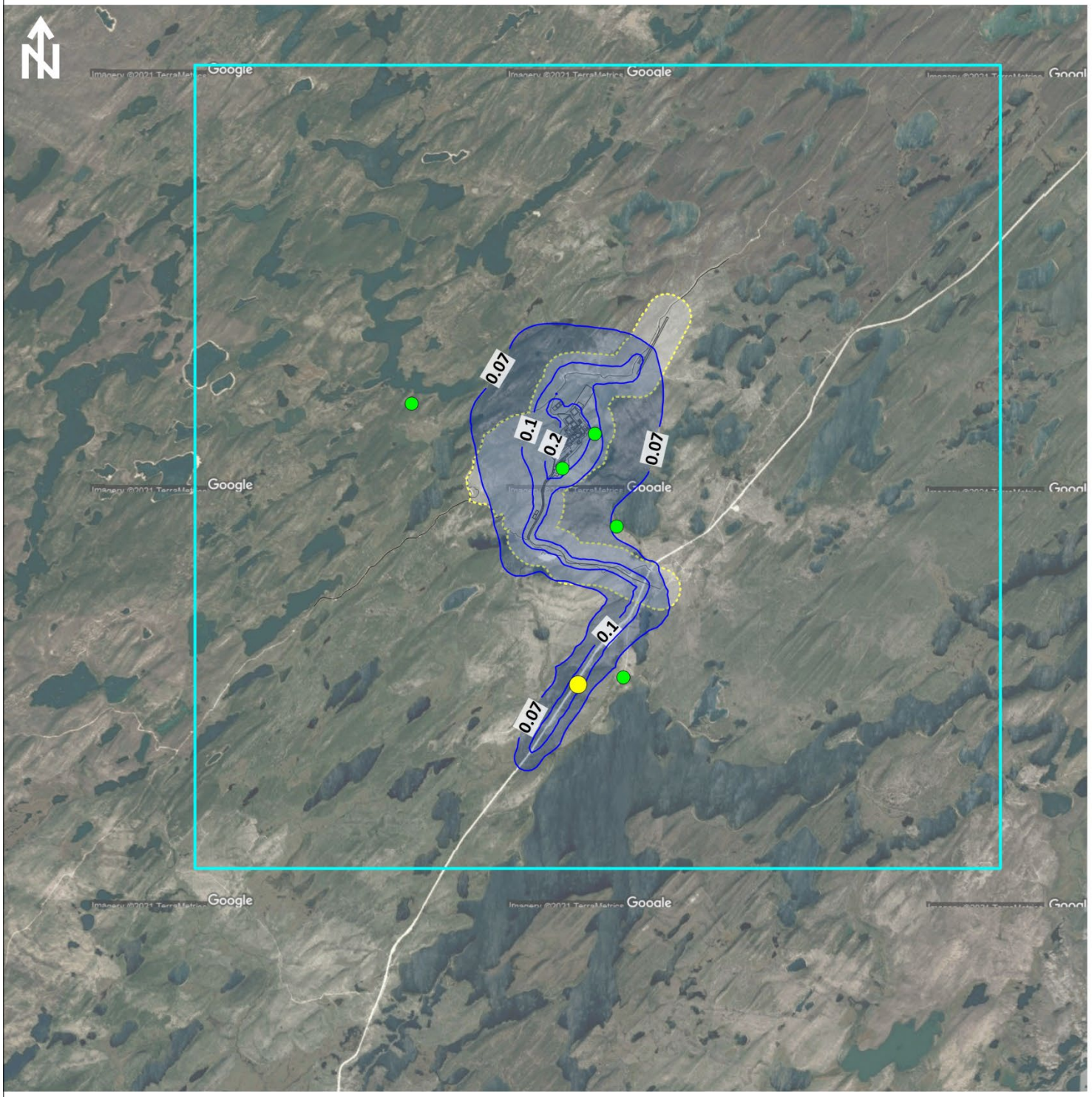
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum Annual TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	2
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Deposition (mg/cm²/30d)
- Project Criteria (mg/cm²/30d)
- Maximum off-property deposition location
- Risk Receptor

NOTES:

Dustfall includes the addition of a background value of 0.06 mg/cm²/30d.

SCALE:

0 km 2.5 km 5 km 7.5 km

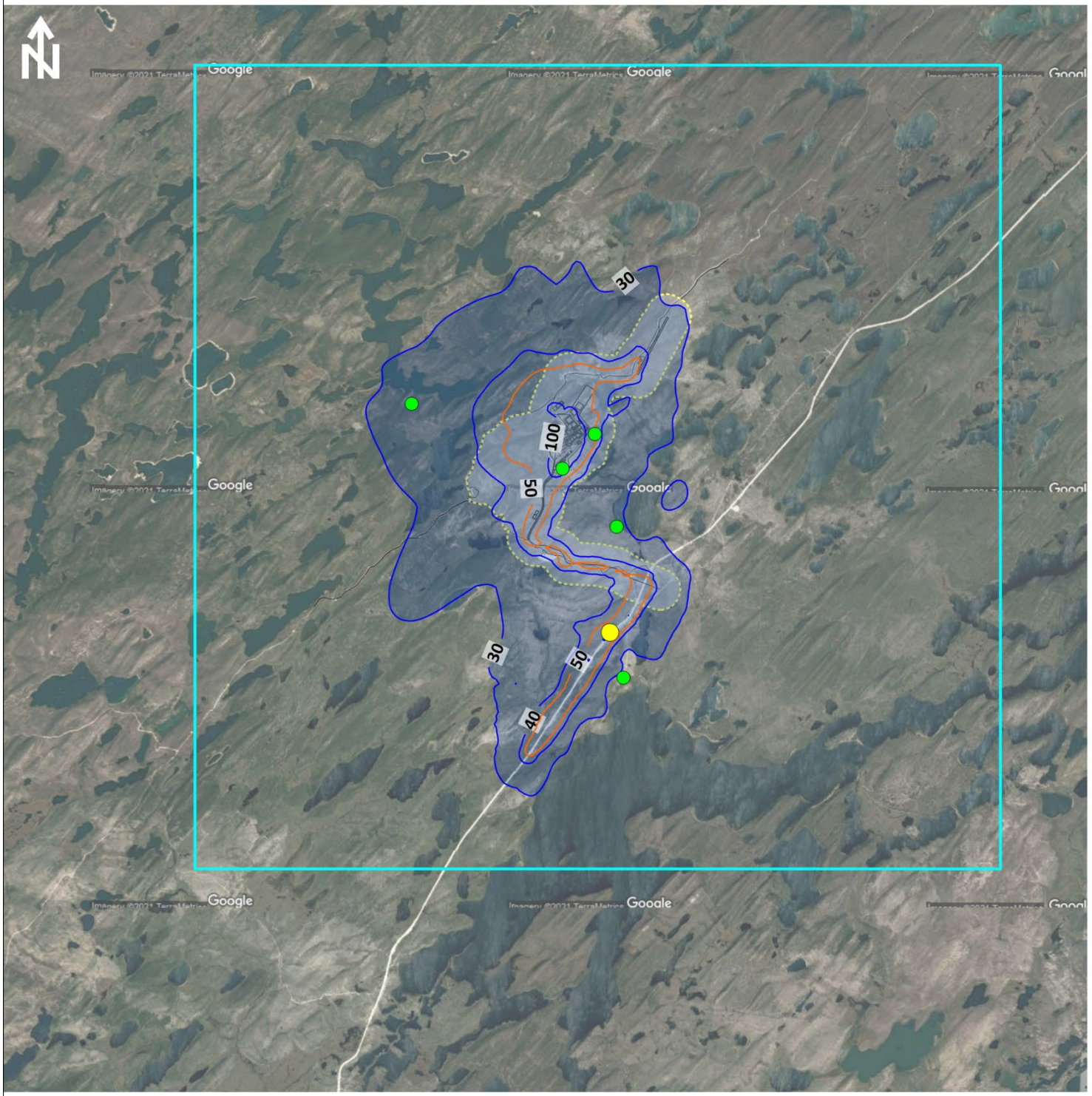
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
30-Day Dustfall (mg/cm²/30-days)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	3
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 23.1 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

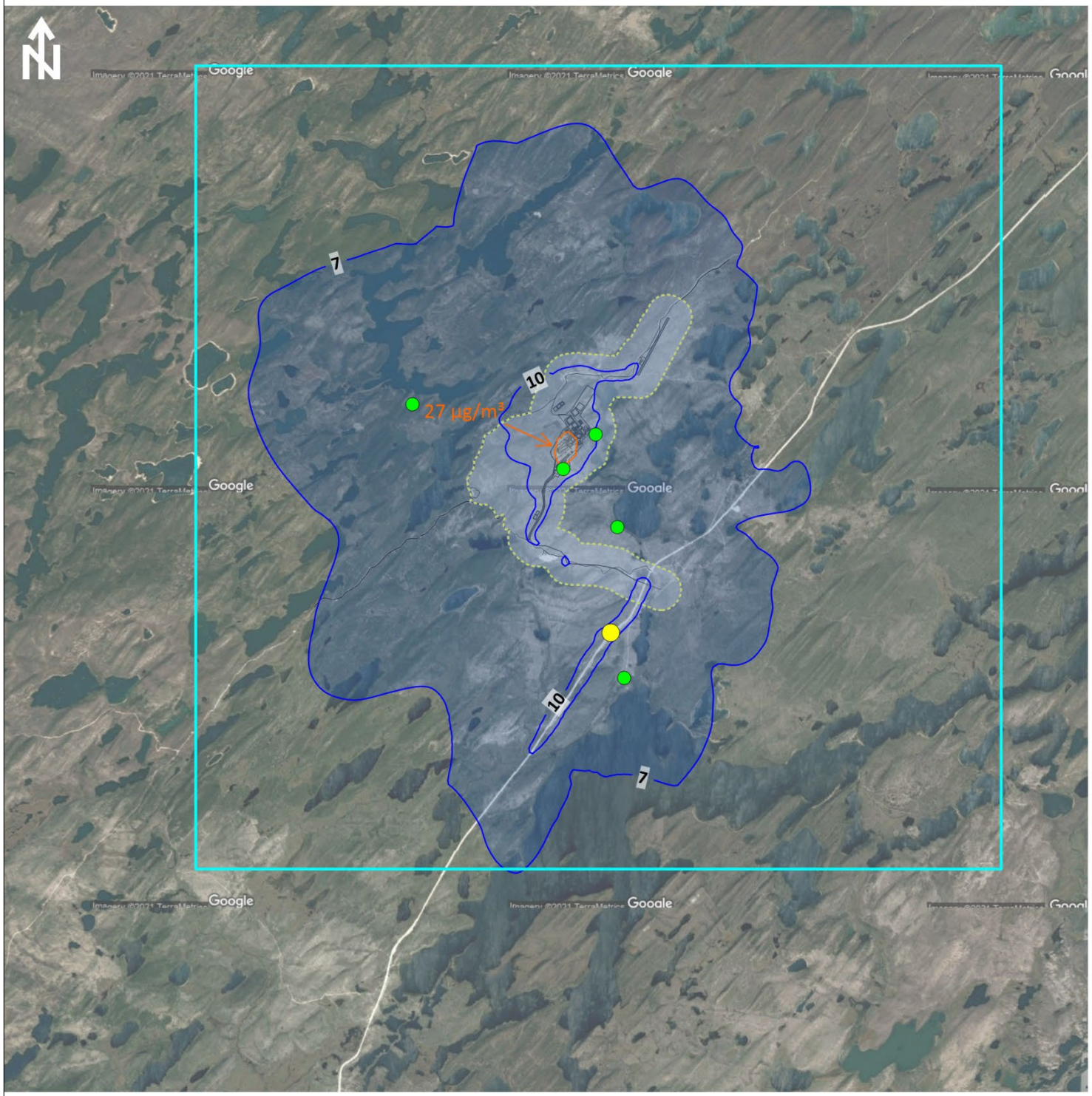
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour PM_{10} Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	4
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 6.5 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

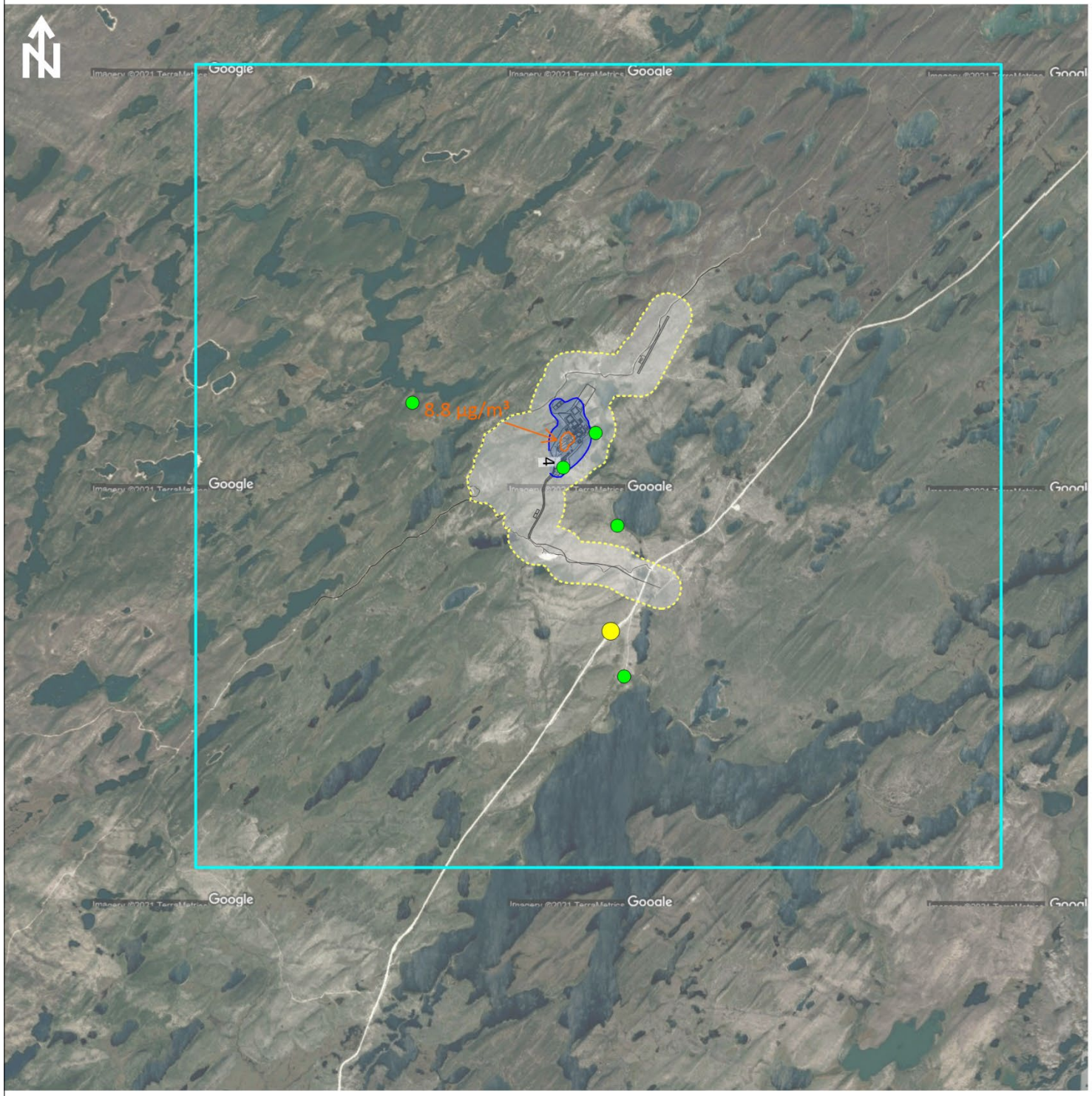
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	5
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.1 µg/m³.

SCALE:

0 km — 2.5 km — 5 km — 7.5 km

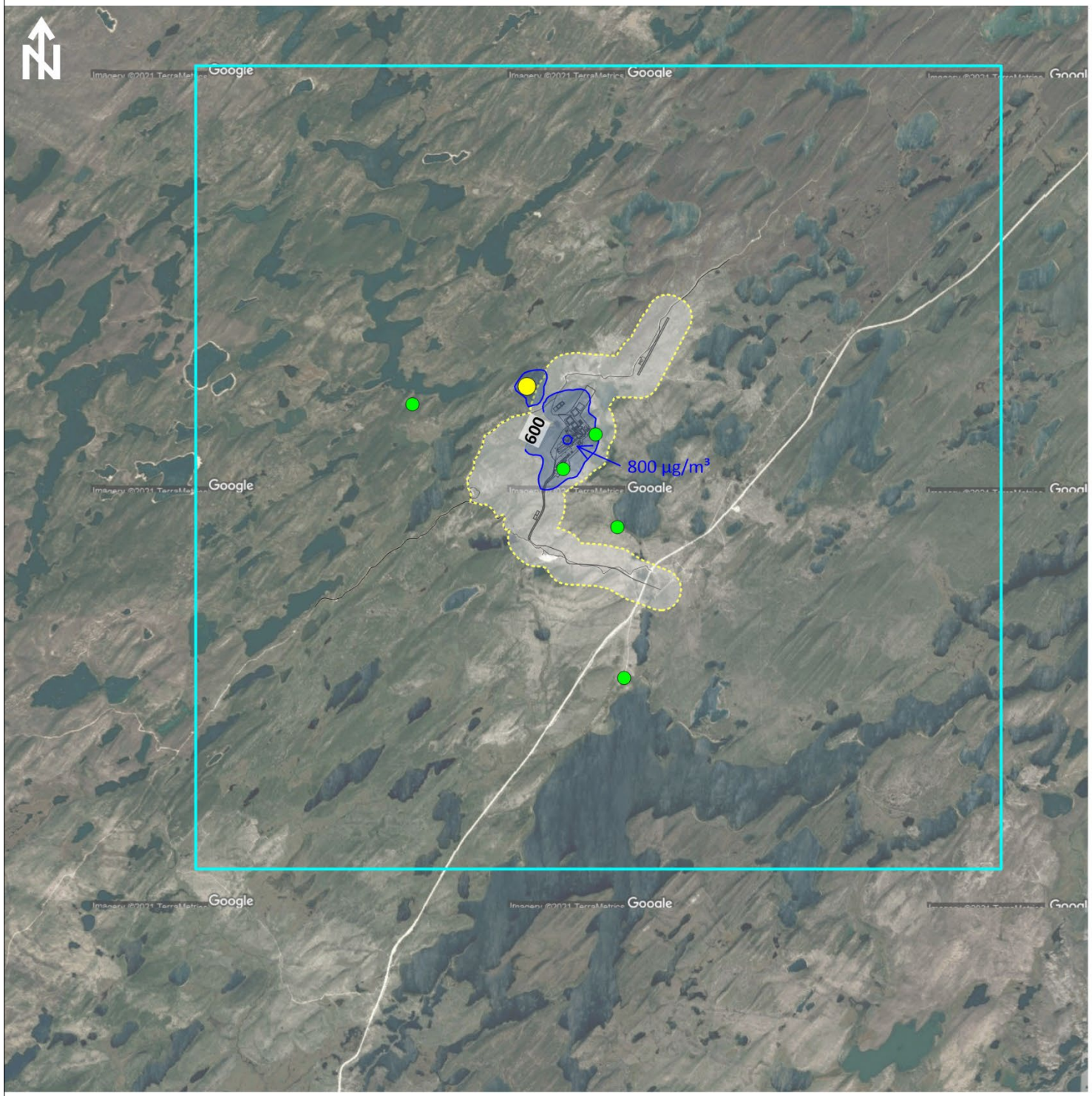
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum Annual $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	6
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km — 2.5 km — 5 km — 7.5 km

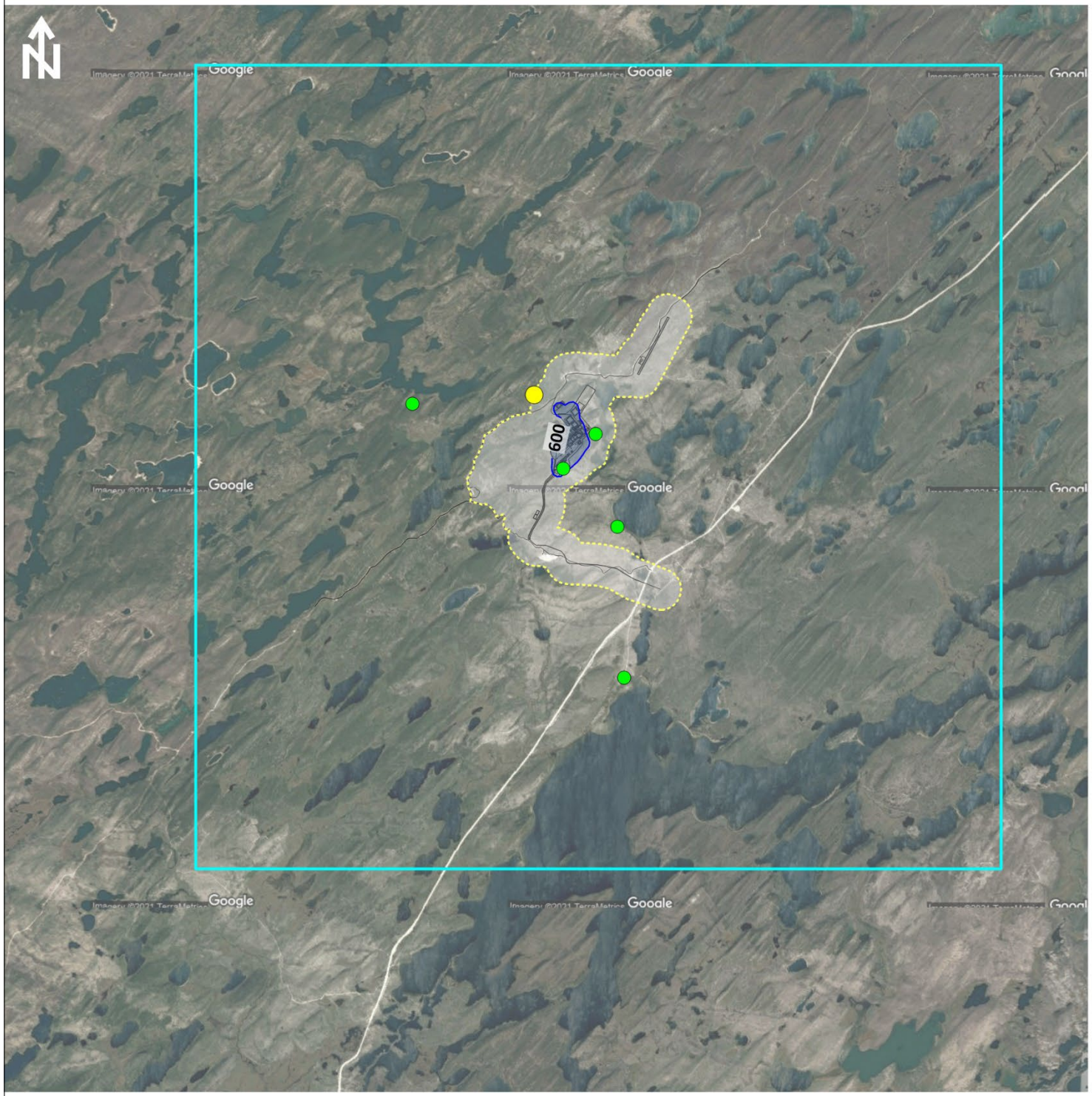
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 1-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	7
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km — 2.5 km — 5 km — 7.5 km

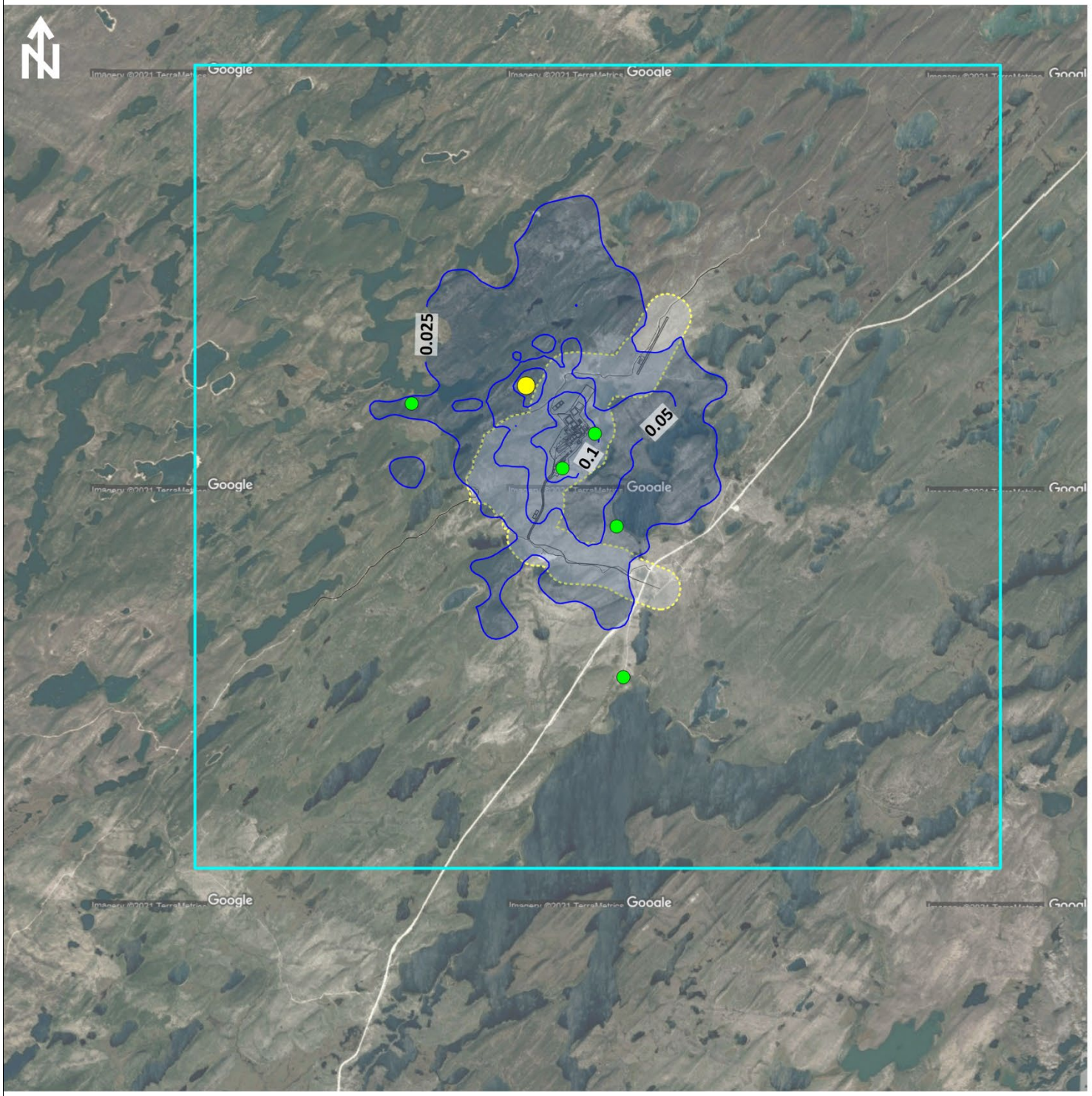
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 8-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	8
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

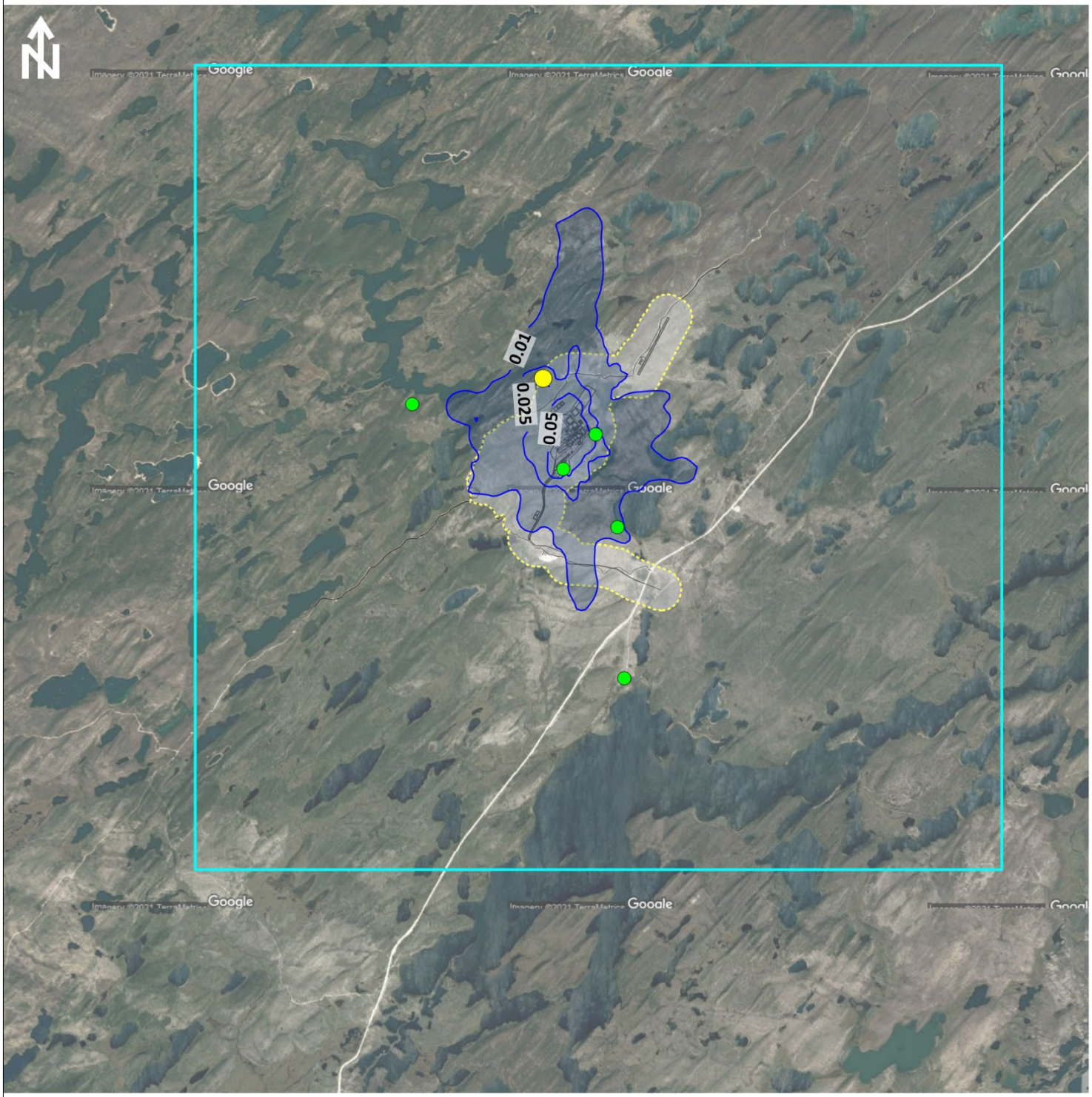
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
1-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	9
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

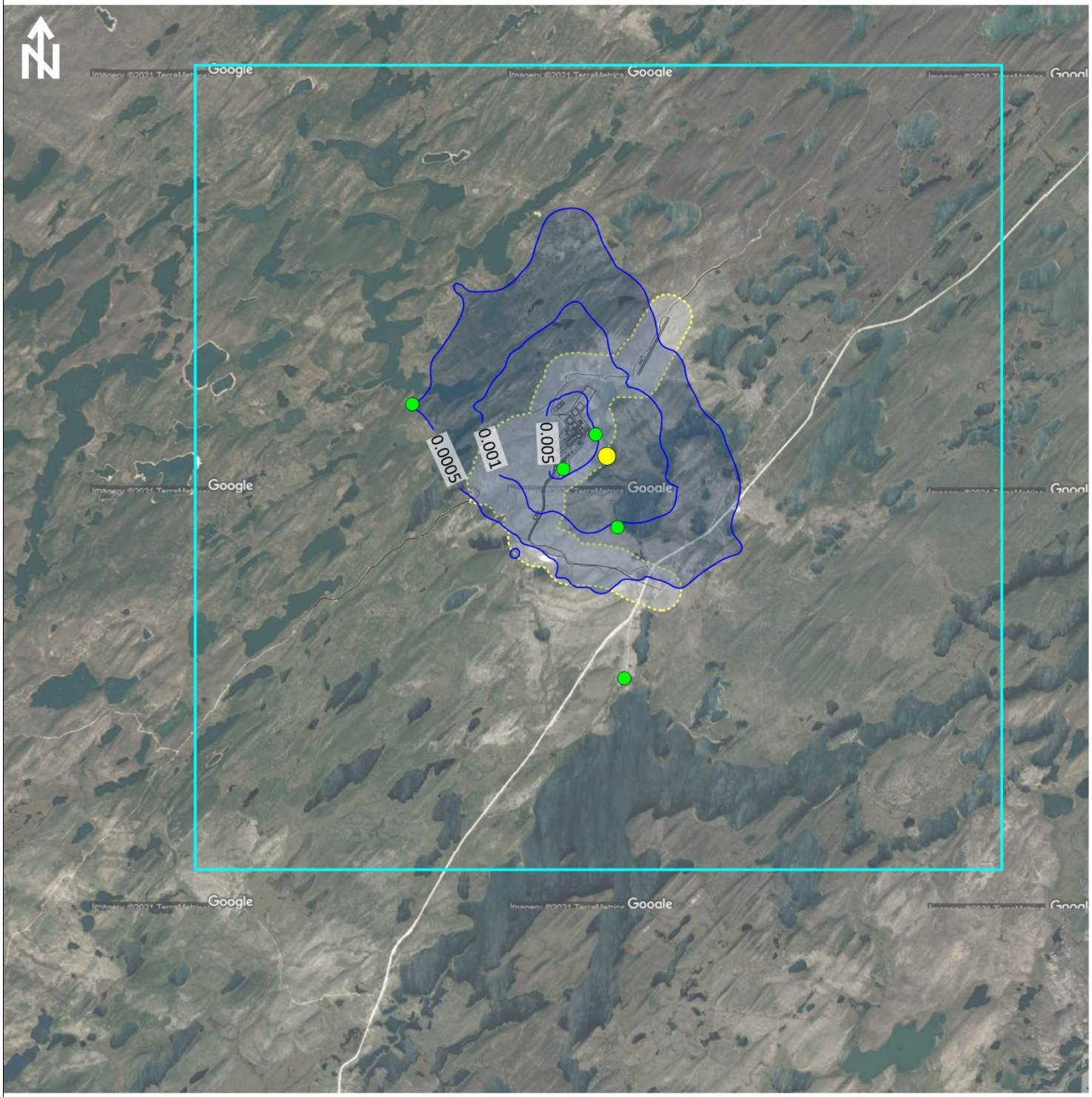
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
24-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	10
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

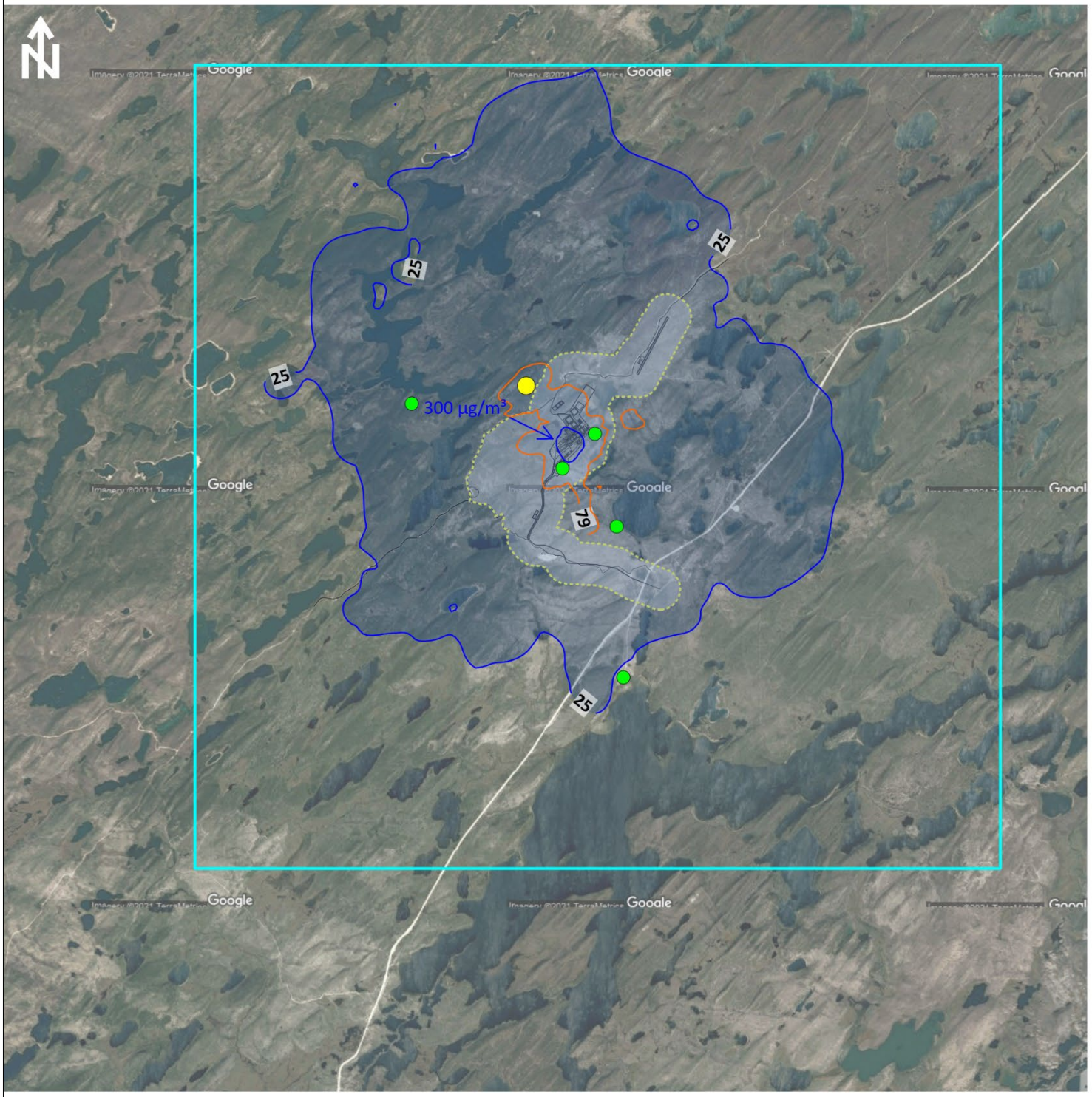
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Annual SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	11
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 11.3 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

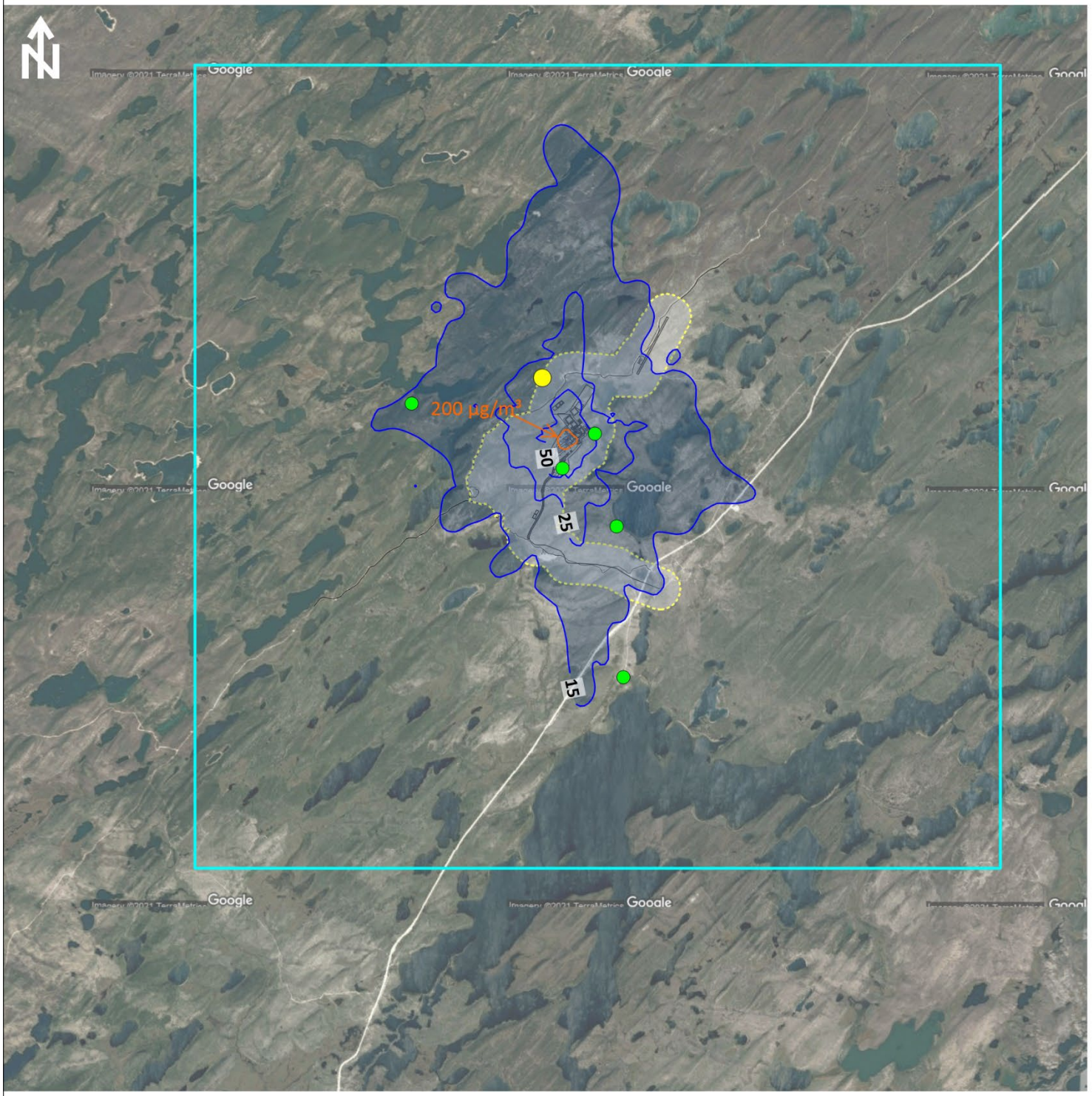
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 1-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	12
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 9.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

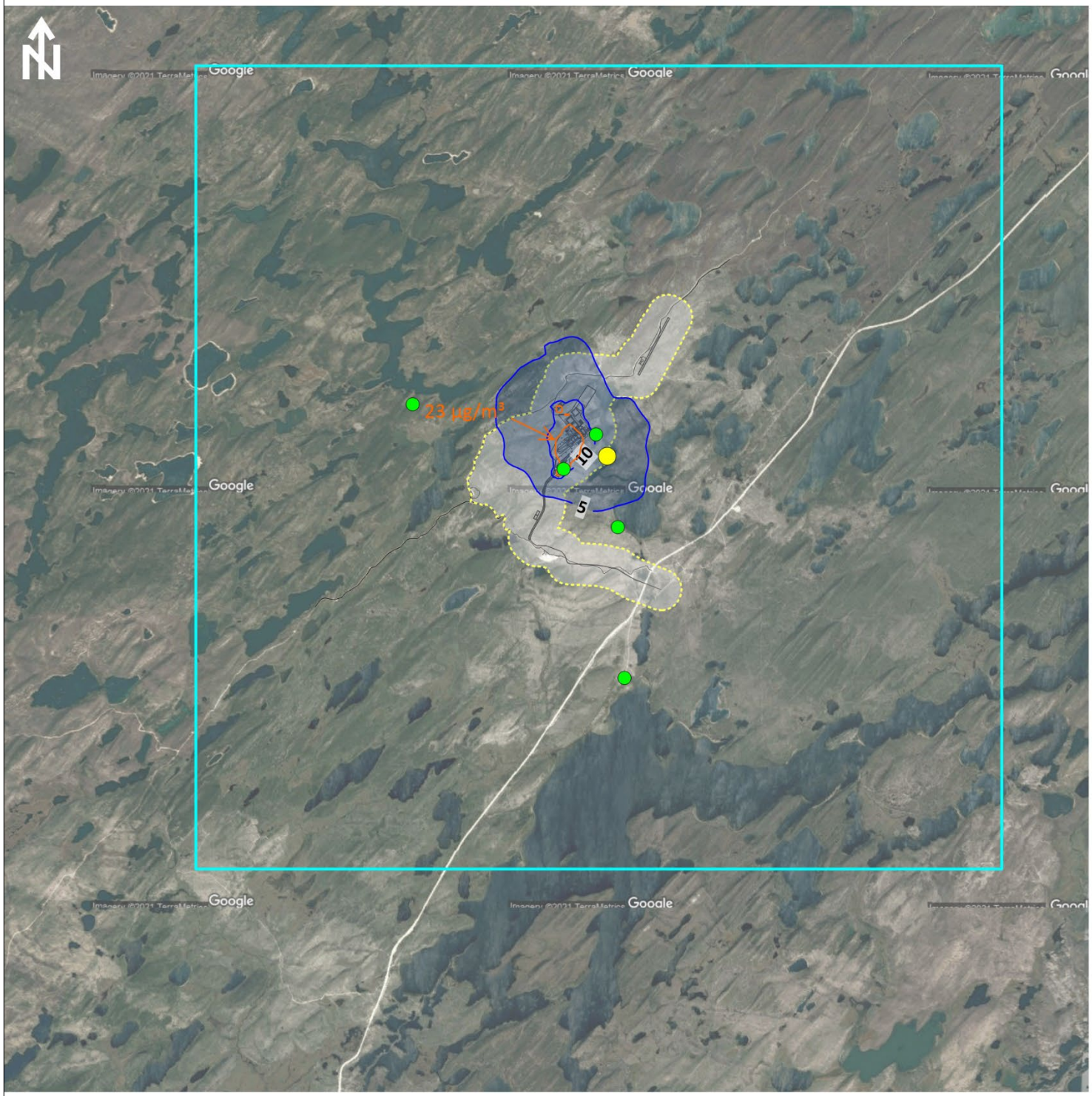
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	13
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.8 µg/m³.

SCALE:

0 km | 2.5 km | 5 km | 7.5 km

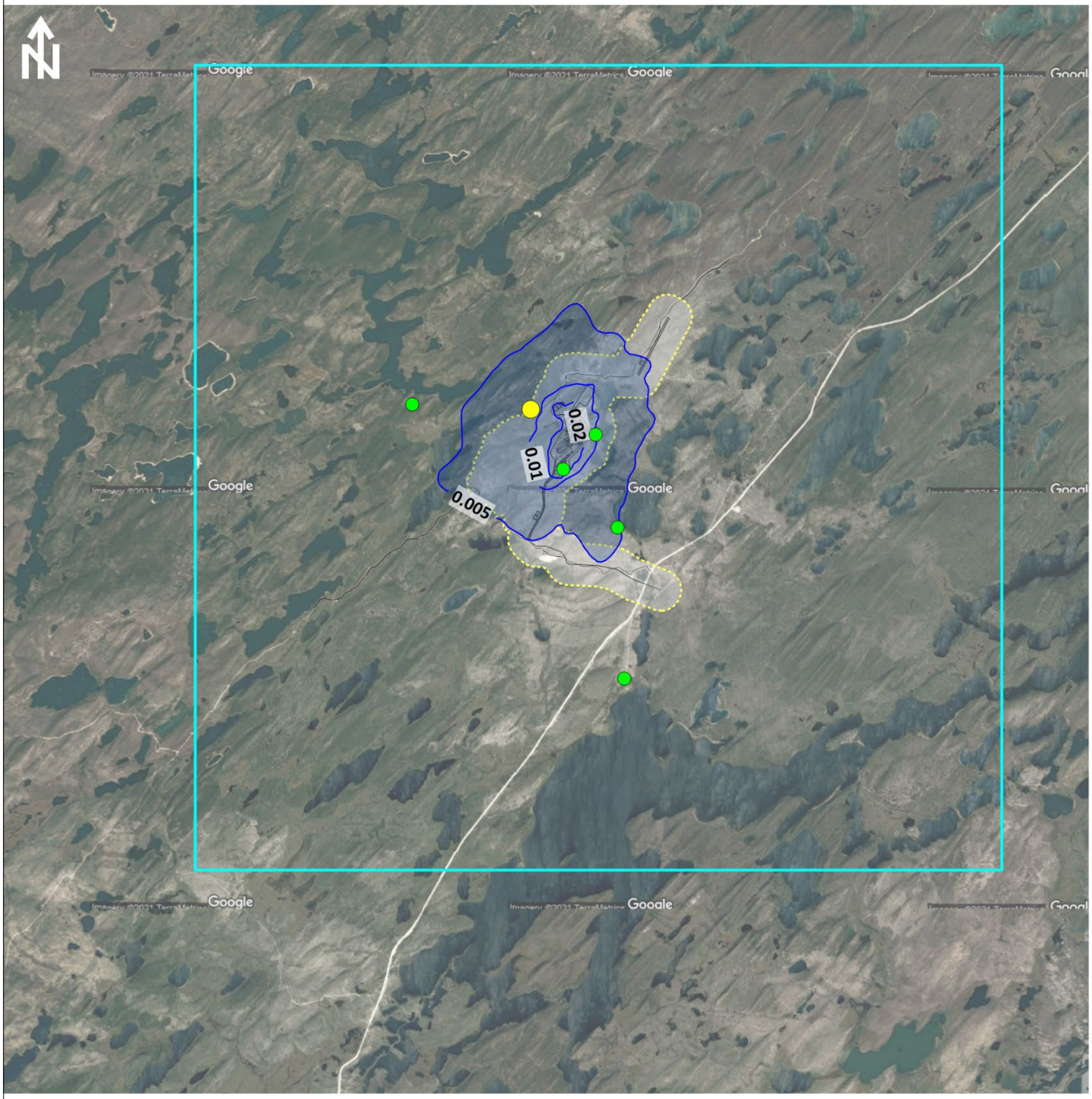
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum Annual NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	14
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.00E-03 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

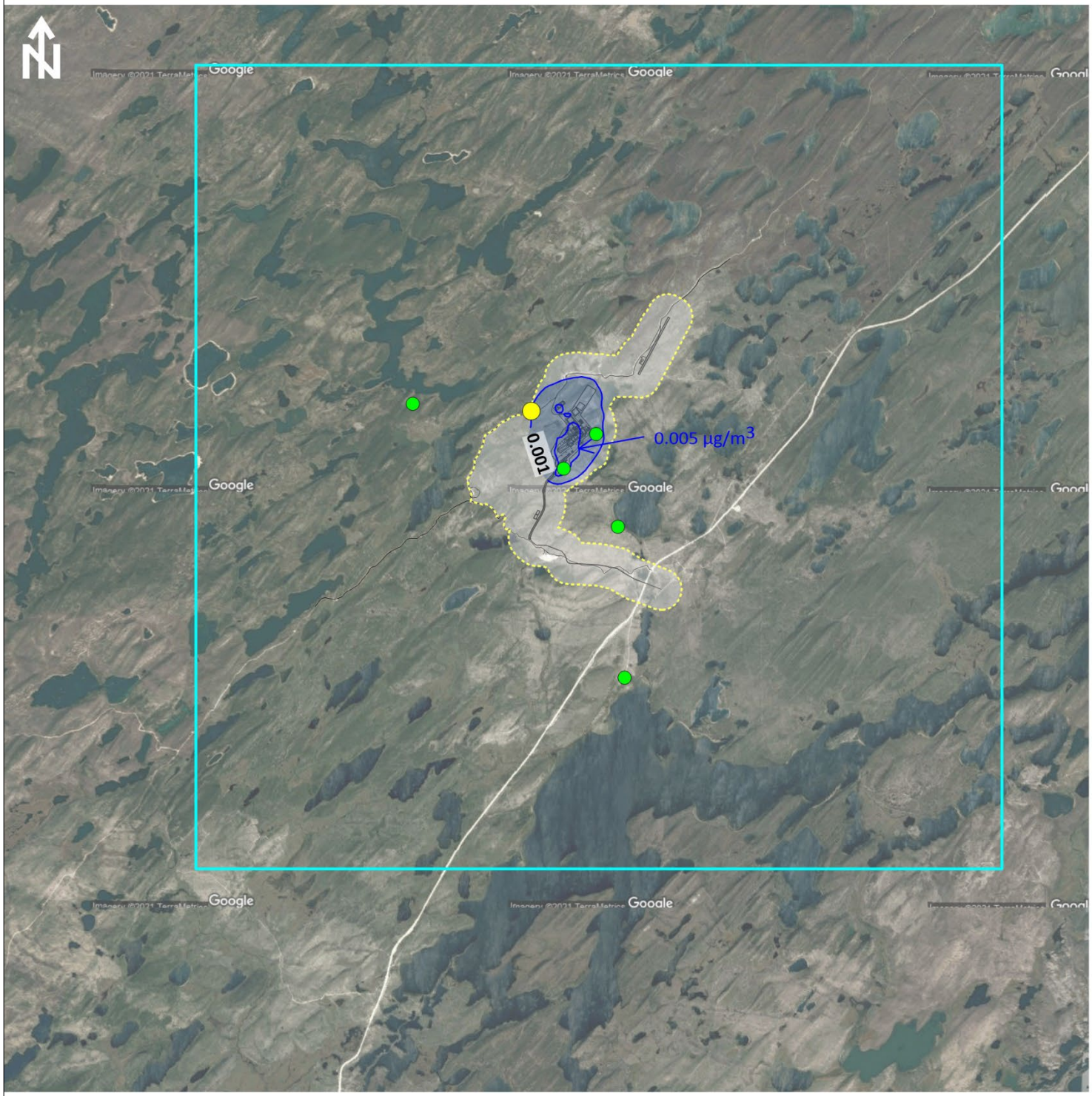
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour Uranium Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	15
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 6.00E-04 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

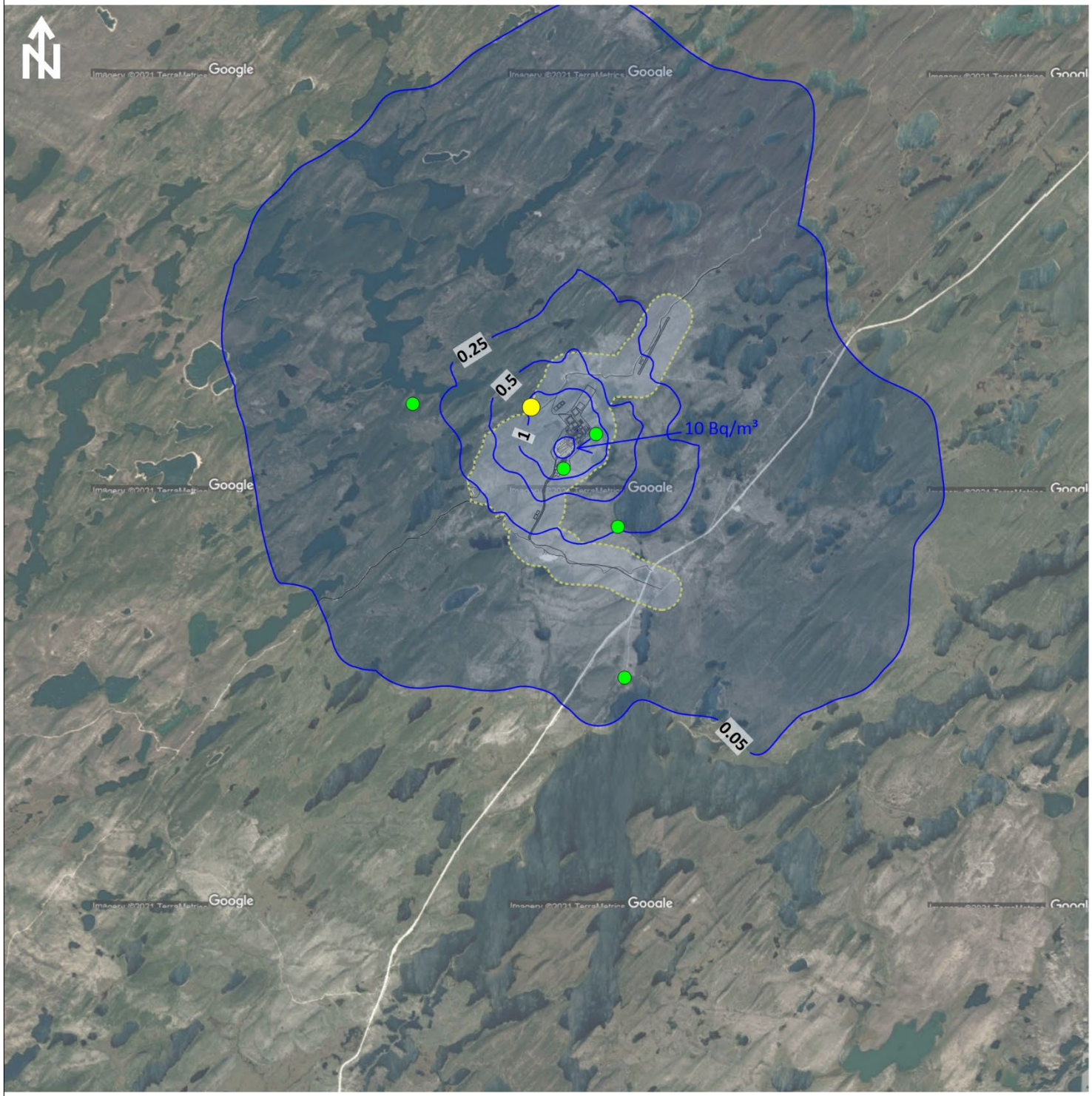
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum Annual Uranium Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	16
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (Bq/m³)
- Project Criteria (Bq/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 Bq/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Annual Radon Concentrations (Bq/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	17
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 46.2 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

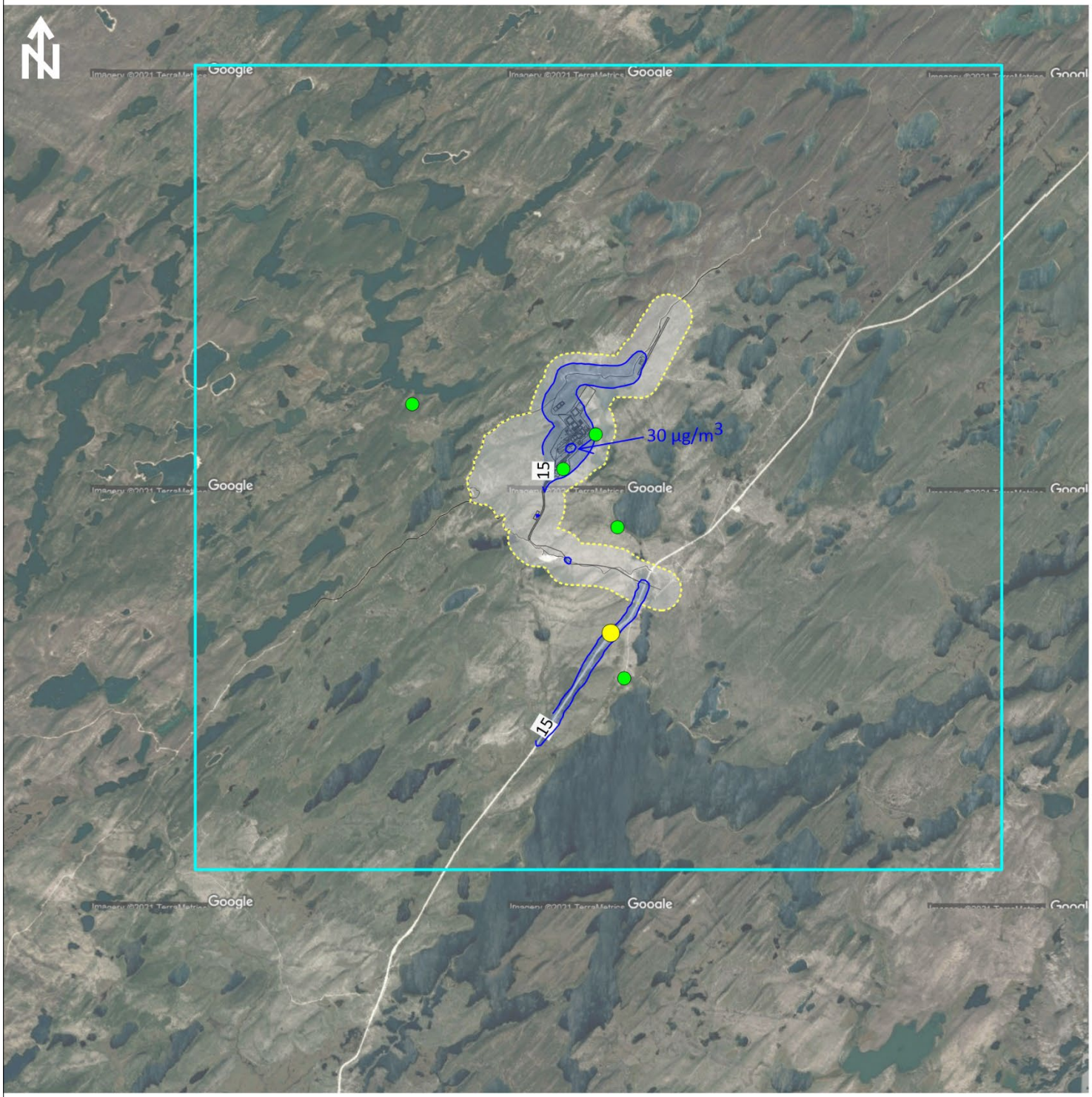
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	18
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 12.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum Annual TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	19
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Deposition (mg/cm²/30d)
- Project Criteria (mg/cm²/30d)
- Maximum off-property deposition location
- Risk Receptor

NOTES:

Dustfall includes the addition of a background value of 0.06 mg/cm²/30d.

SCALE:

0 km 2.5 km 5 km 7.5 km

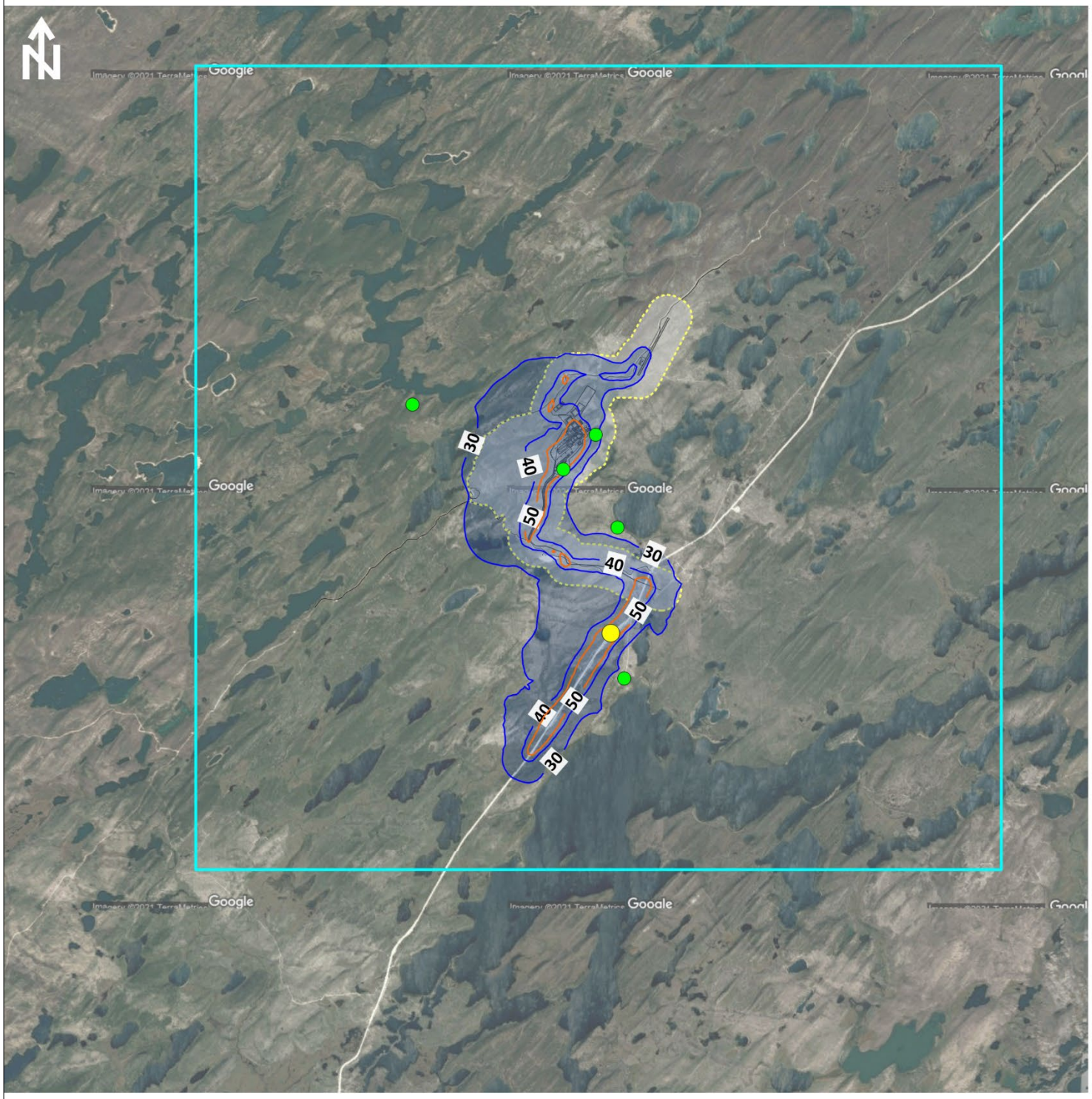
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
30-Day Dustfall (mg/cm²/30-days)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	20
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 23.1 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

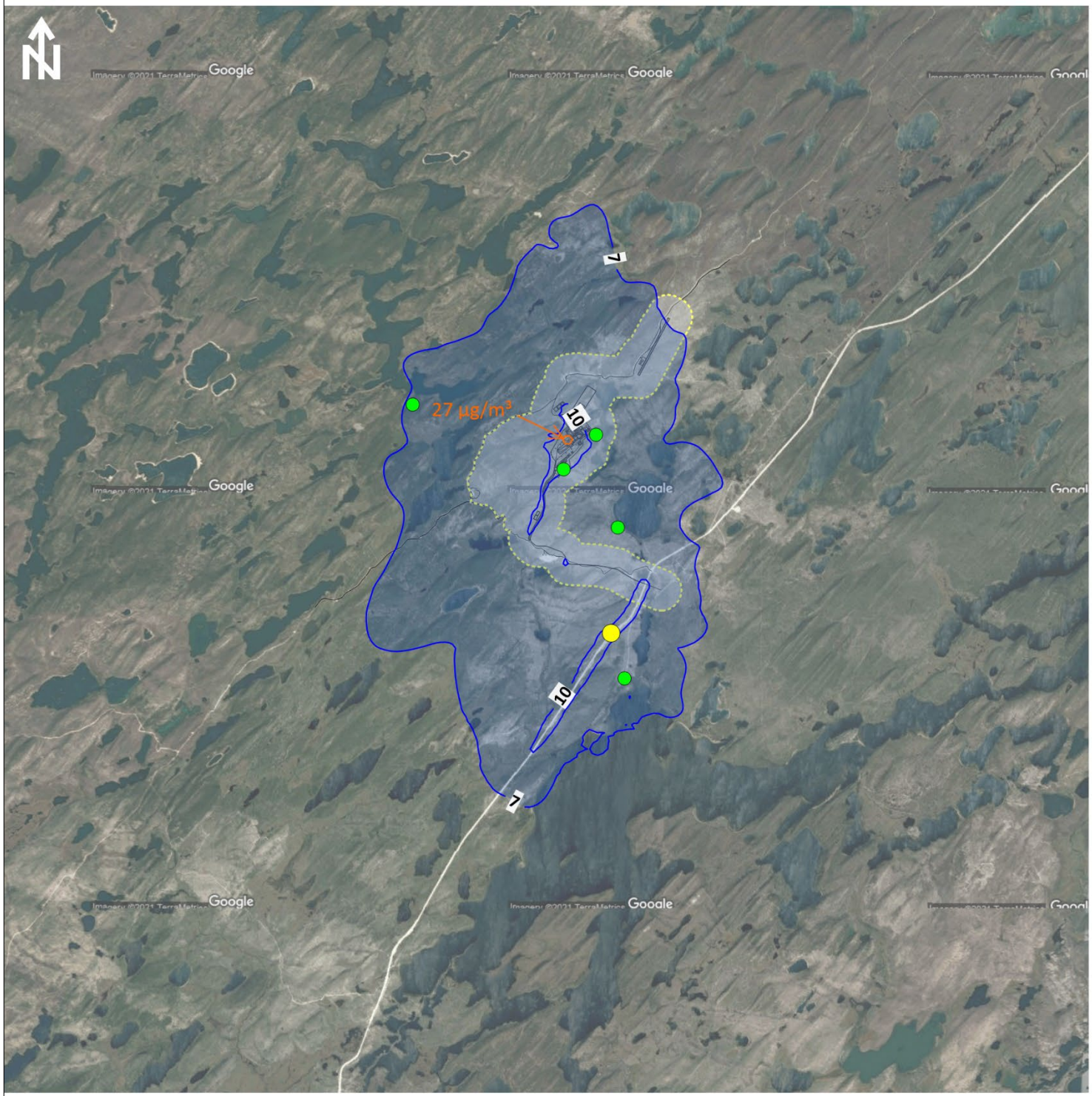
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour PM_{10} Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	21
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 6.5 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

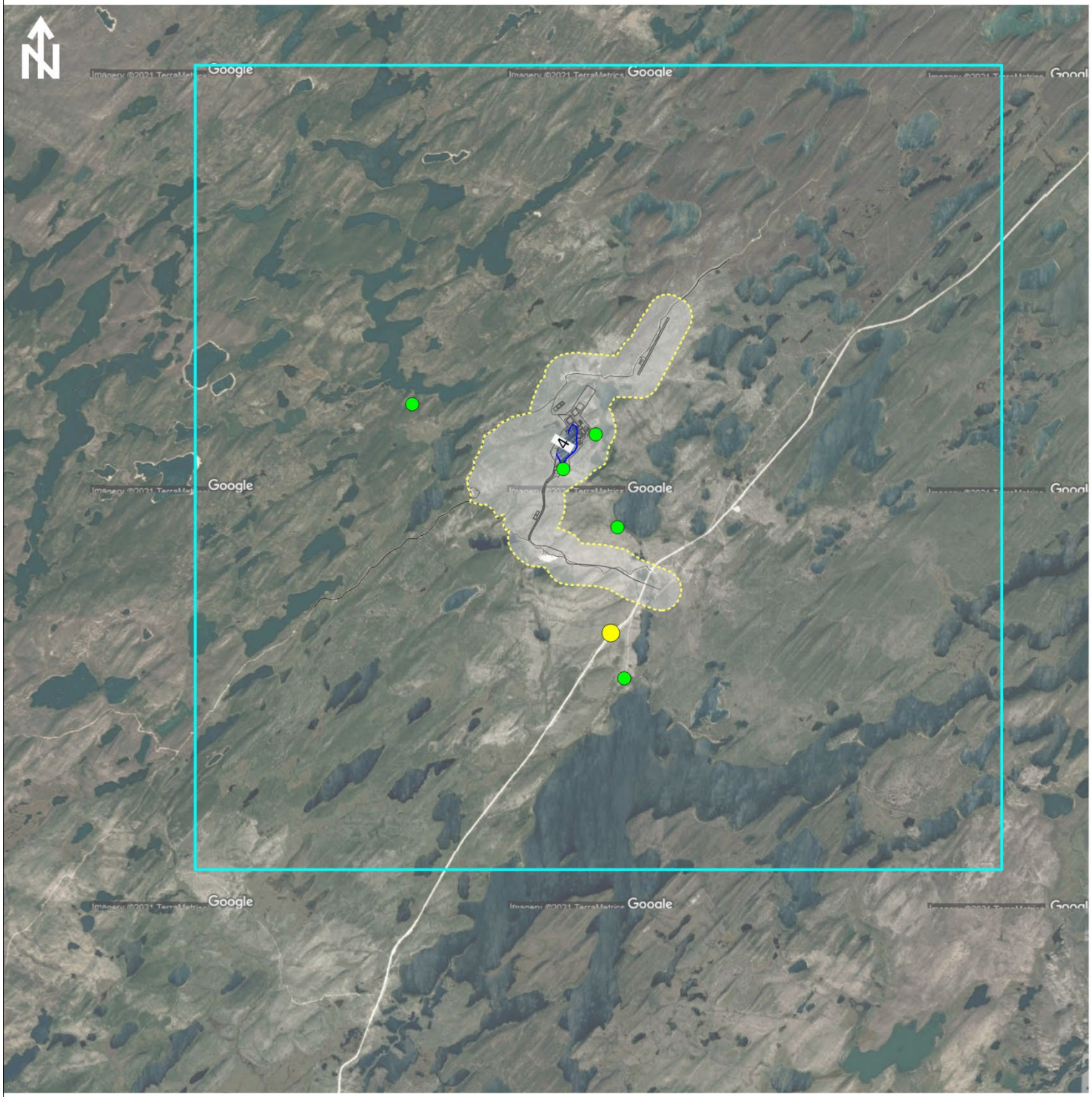
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	22
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.1 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

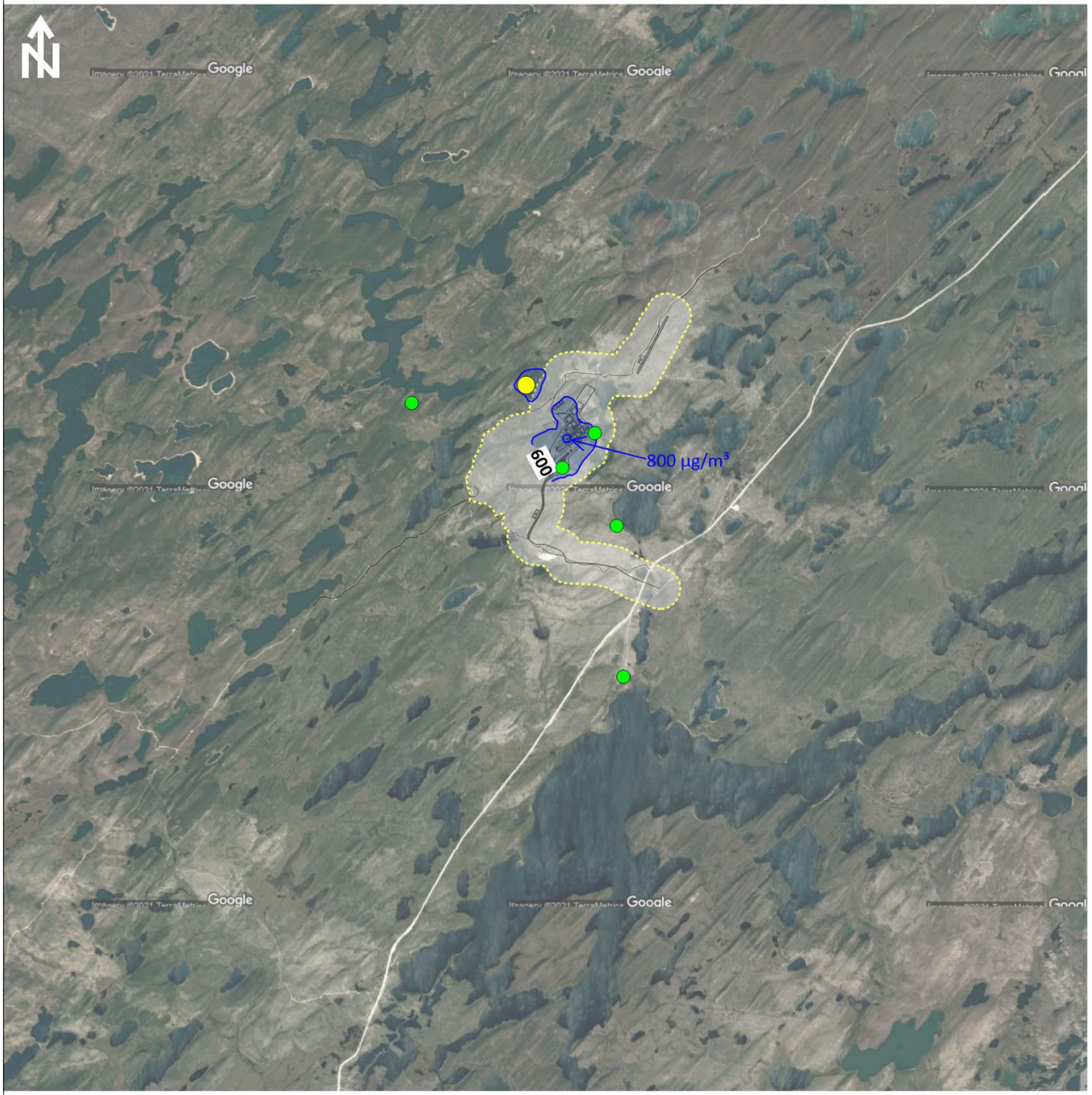
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum Annual $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	23
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

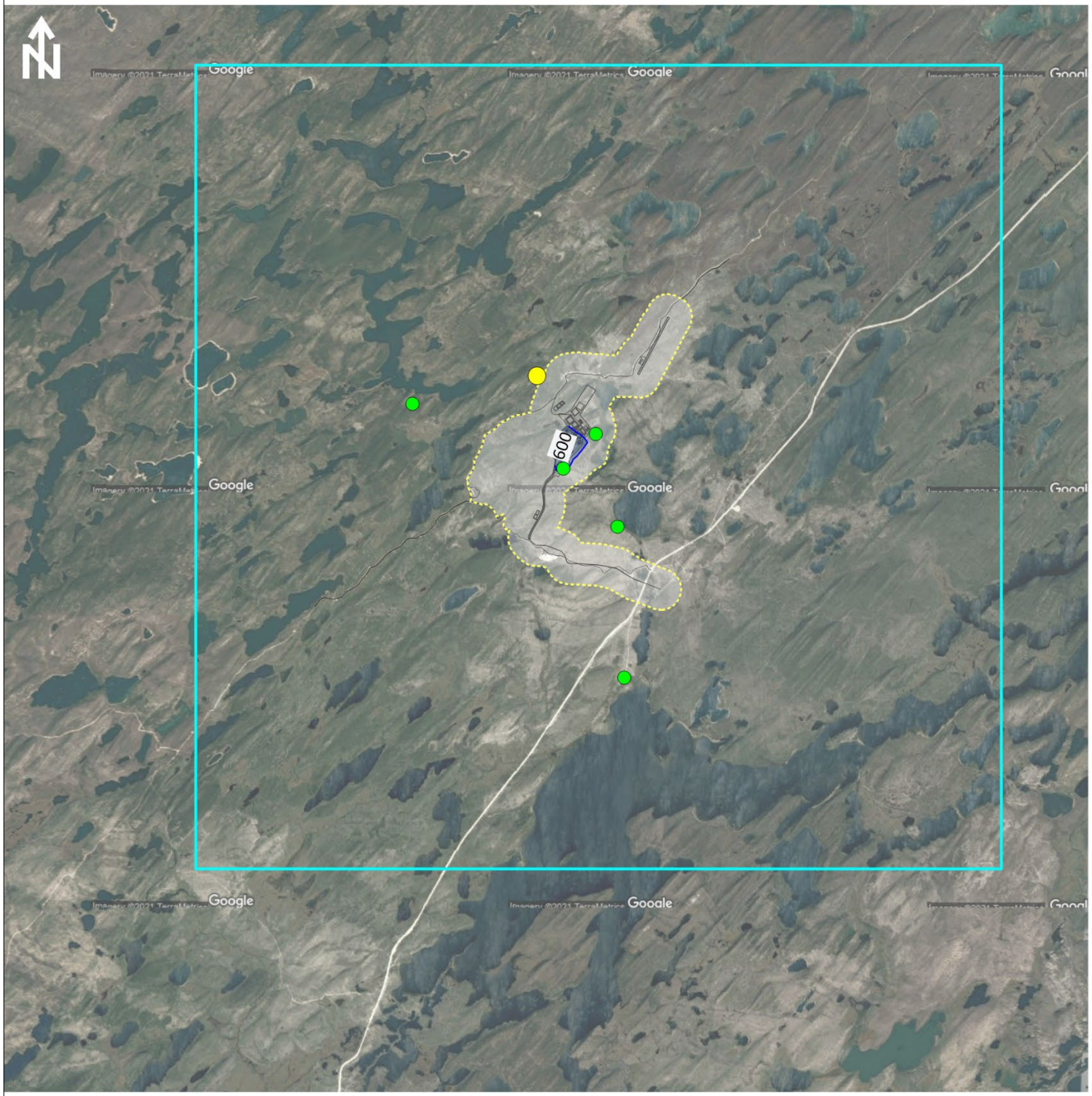
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 1-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	24
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

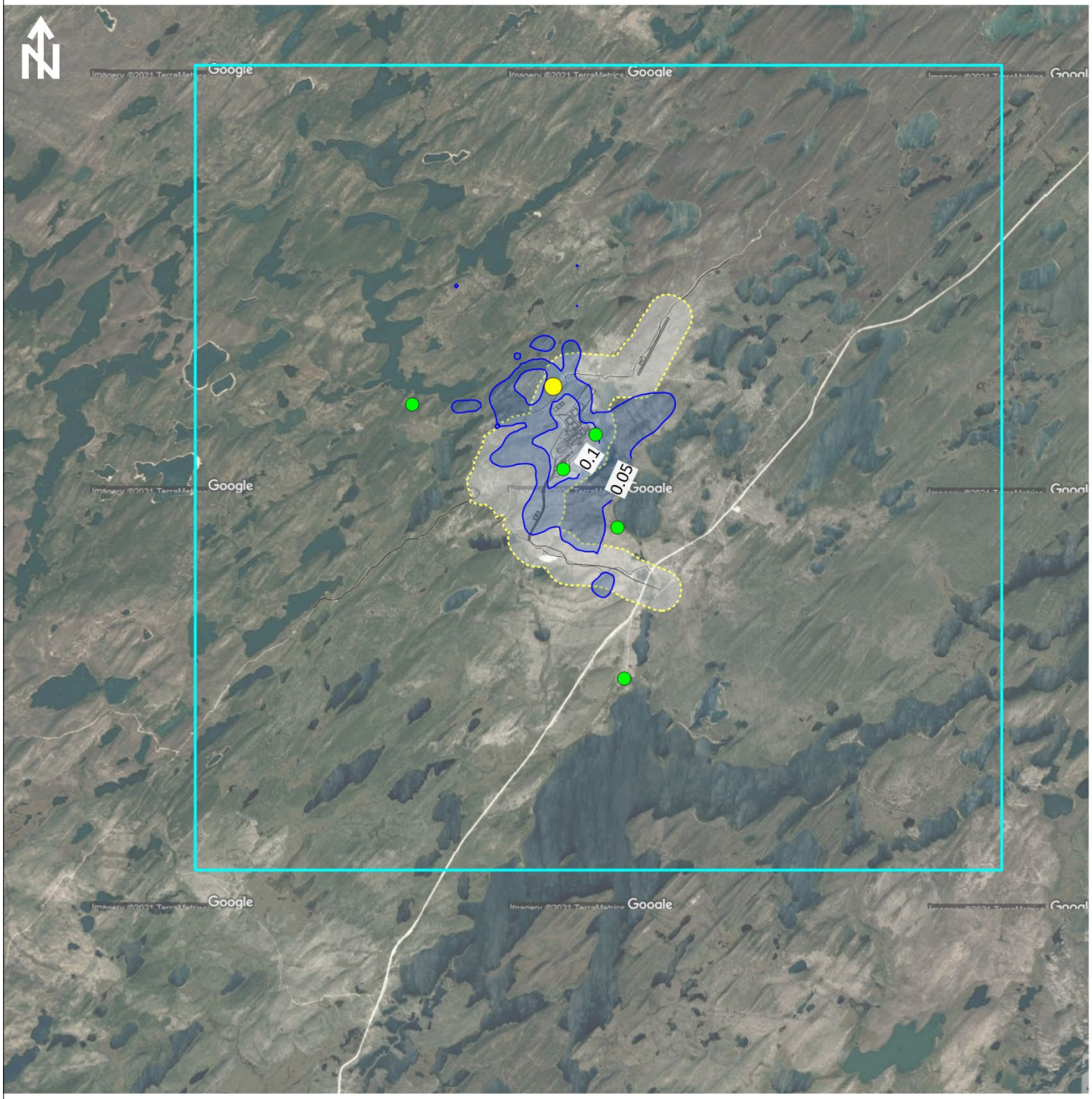
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 8-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	25
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

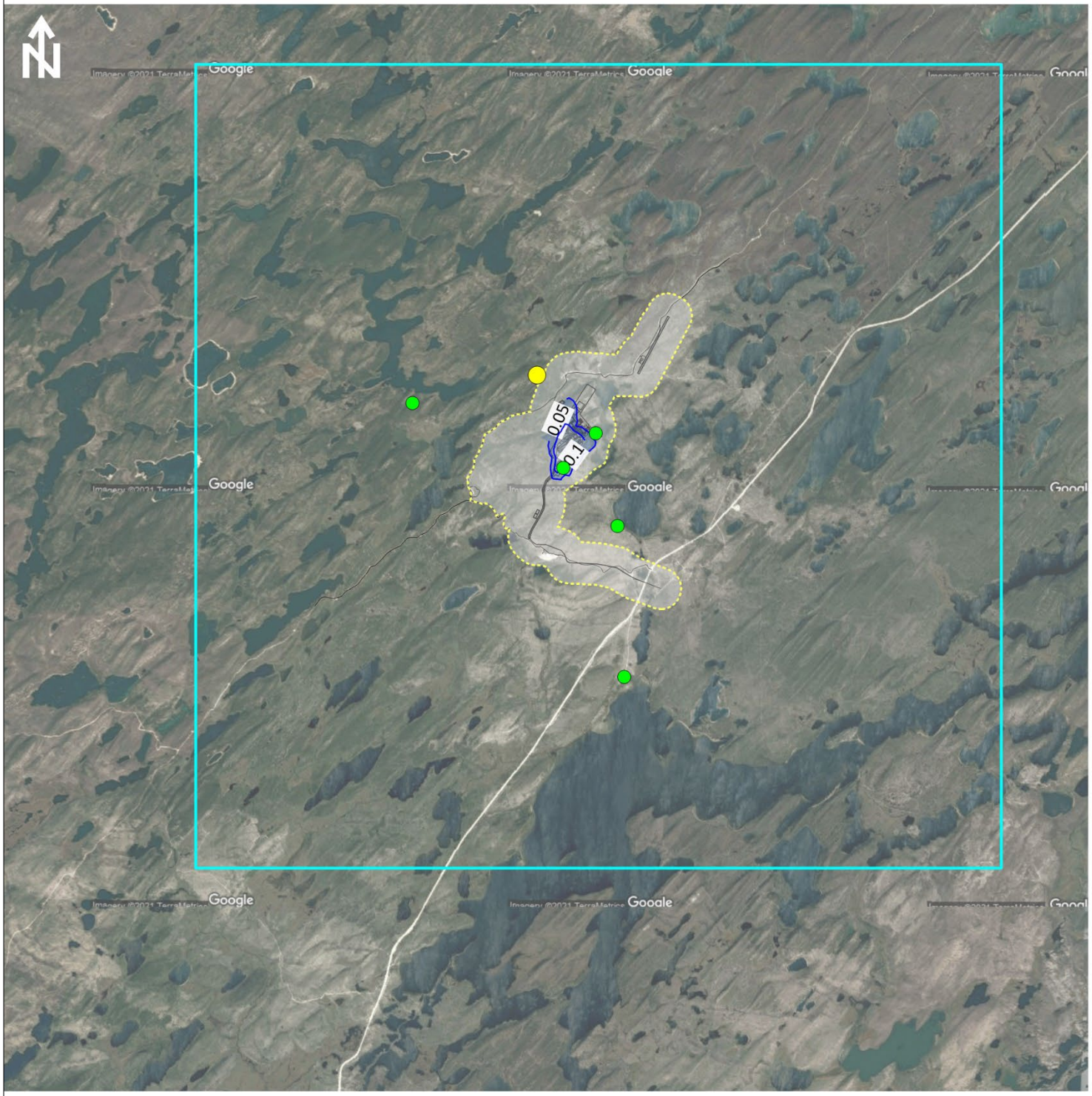
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
1-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	26
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
24-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	27
Date:	Project No.:	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

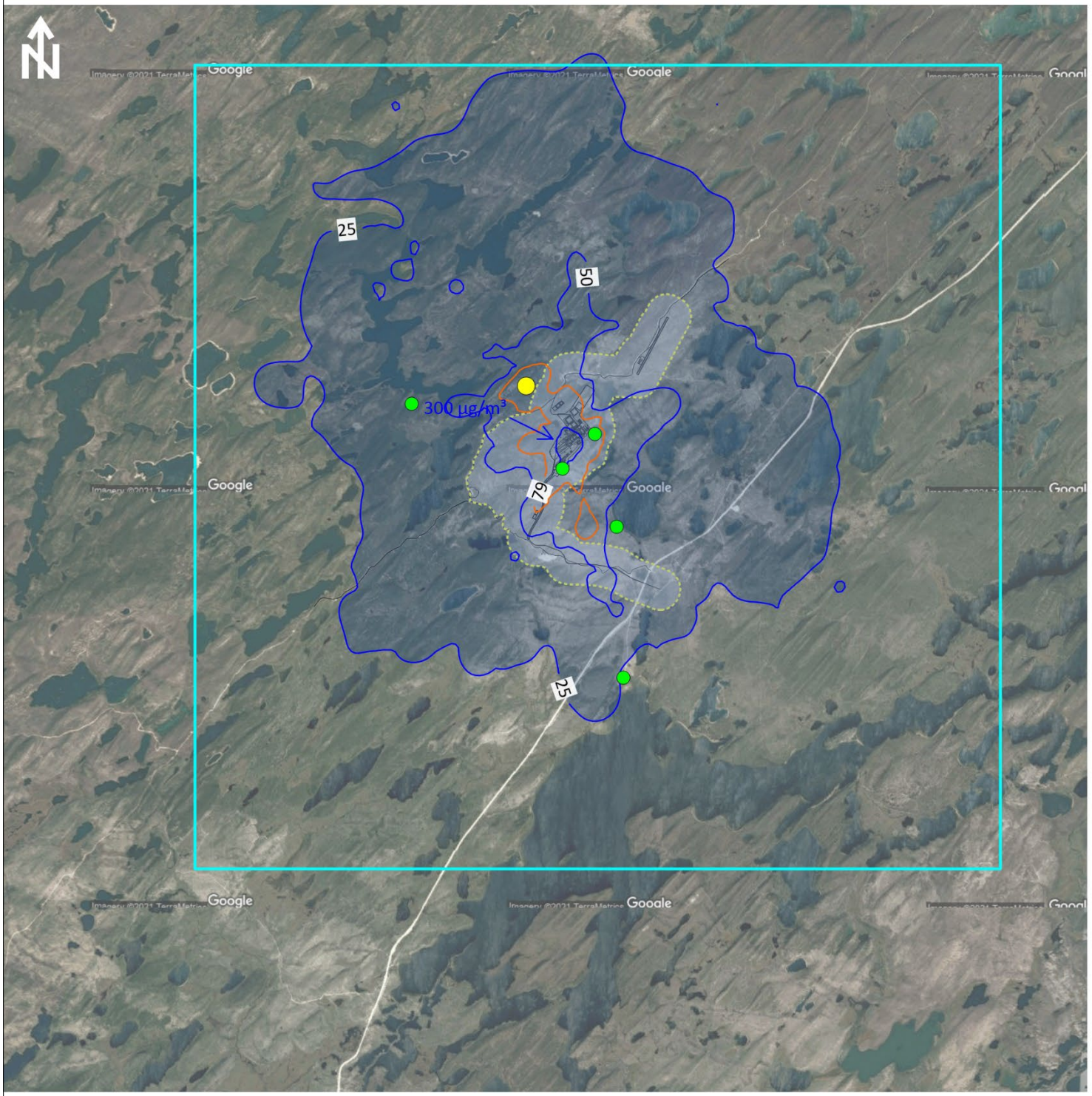
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Annual SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	28
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 11.3 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

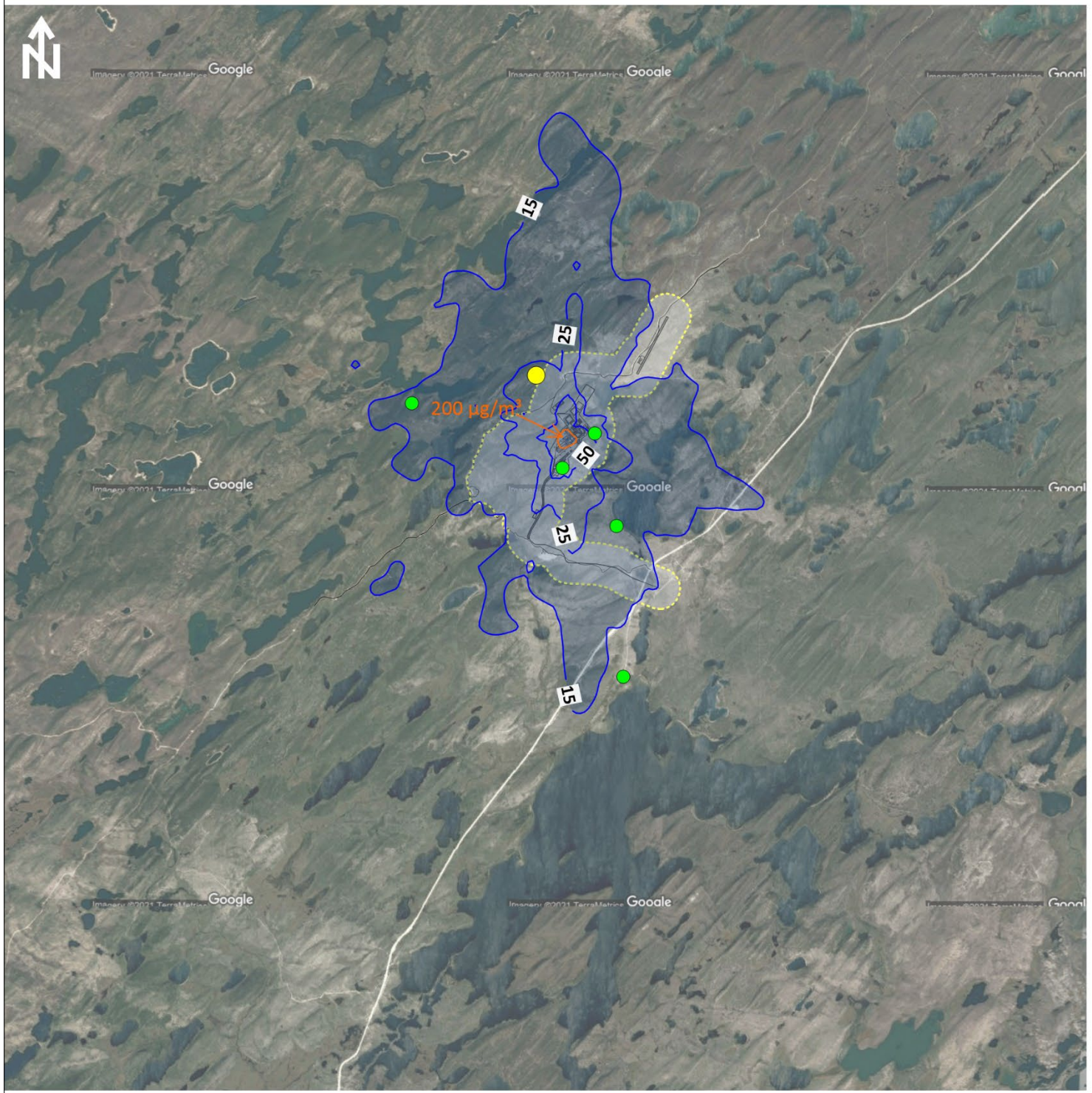
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 1-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	29
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 9.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	30
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.8 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

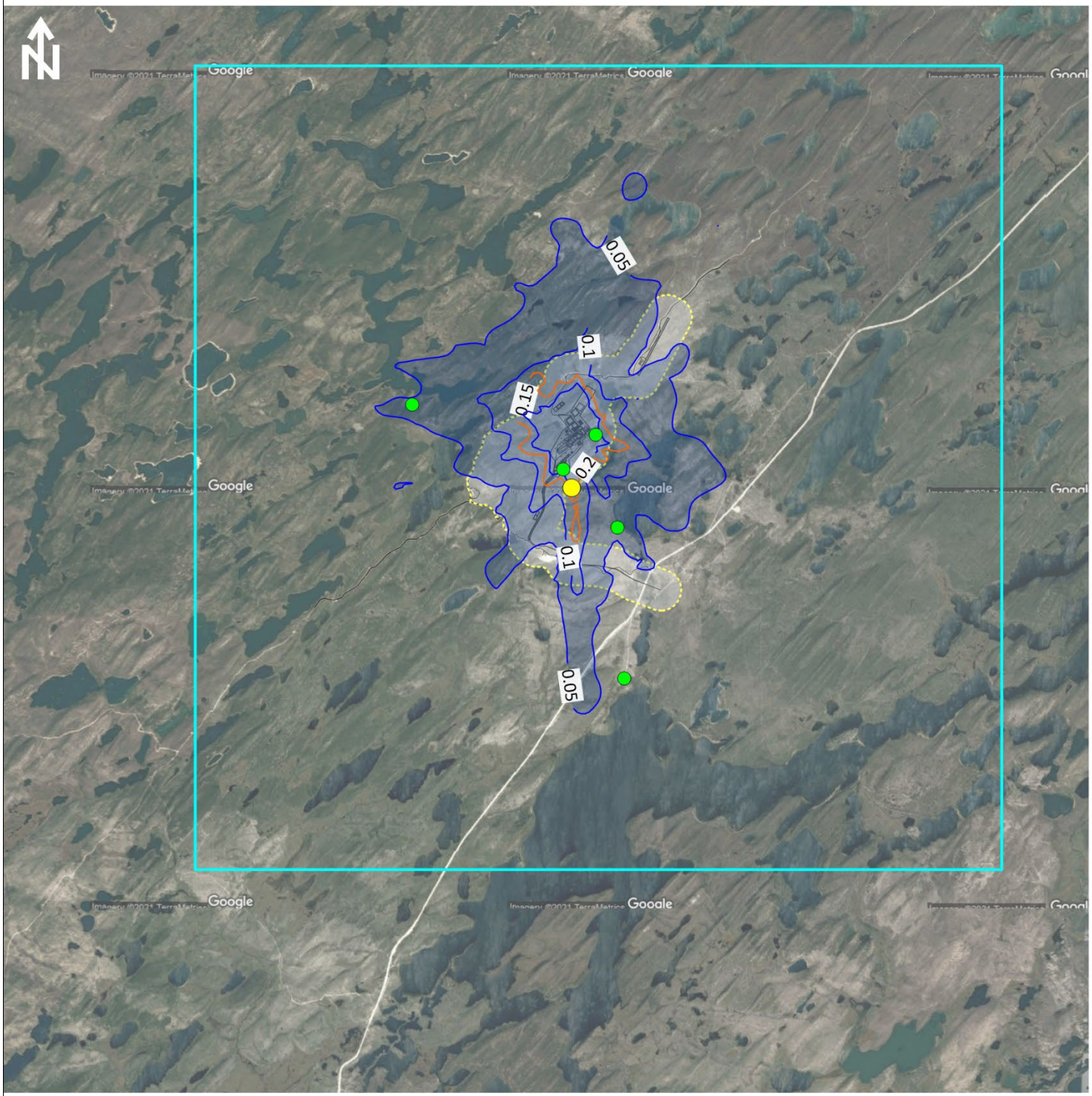
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum Annual NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	31
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.00E-03 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

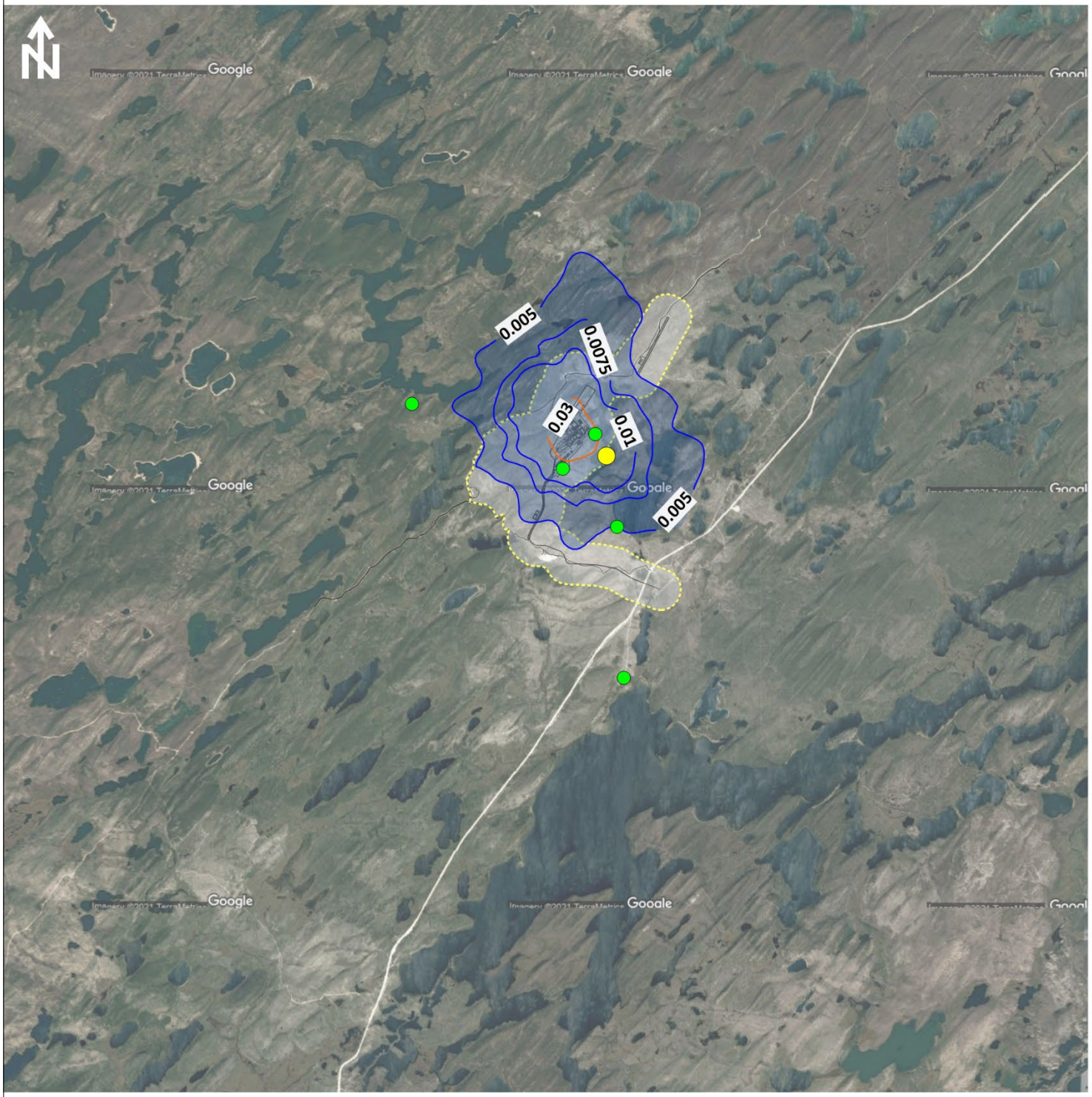
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour Uranium Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	32
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 6.00E-04 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

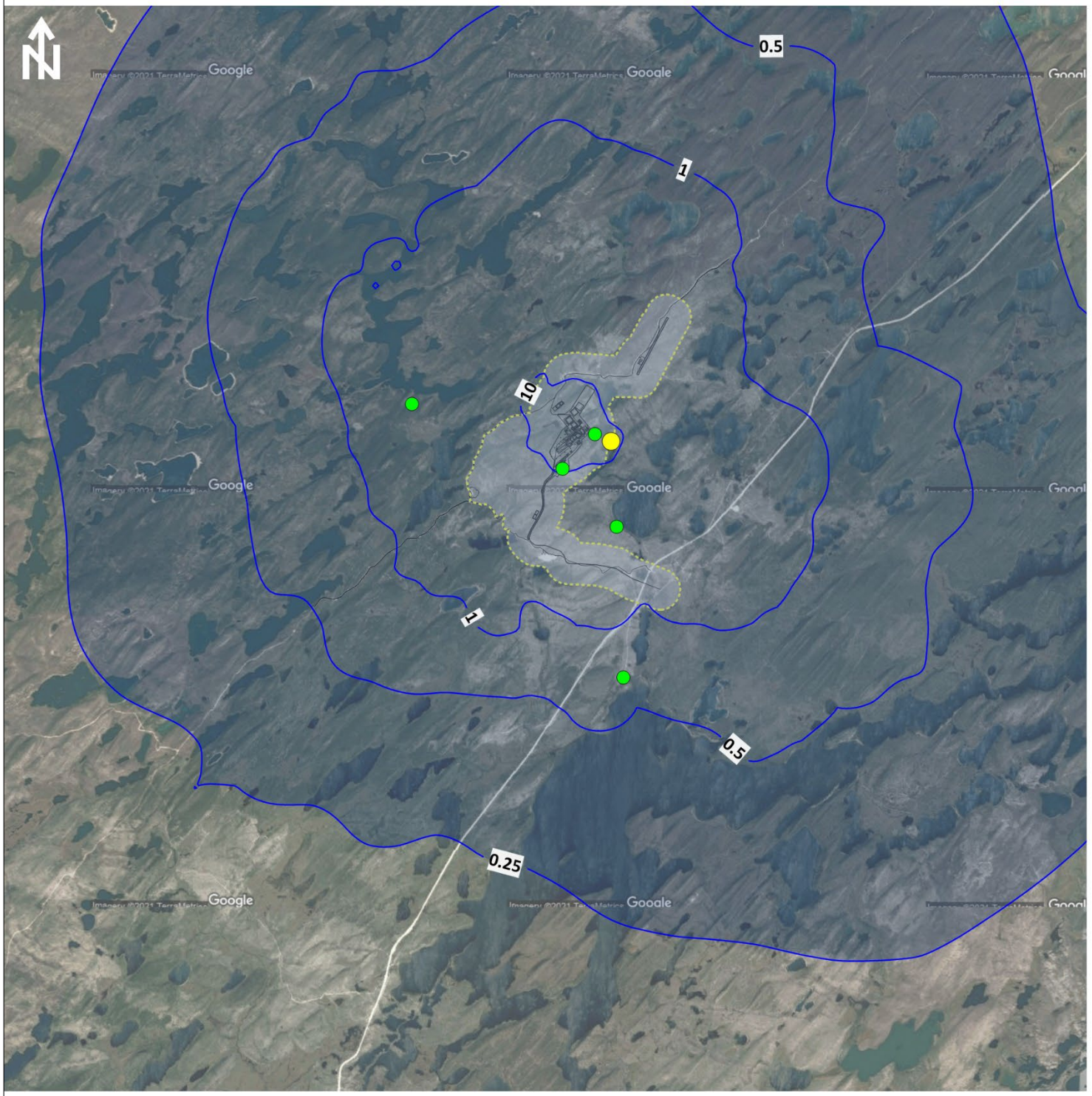
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum Annual Uranium Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	33
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (Bq/m³)
- Project Criteria (Bq/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 Bq/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

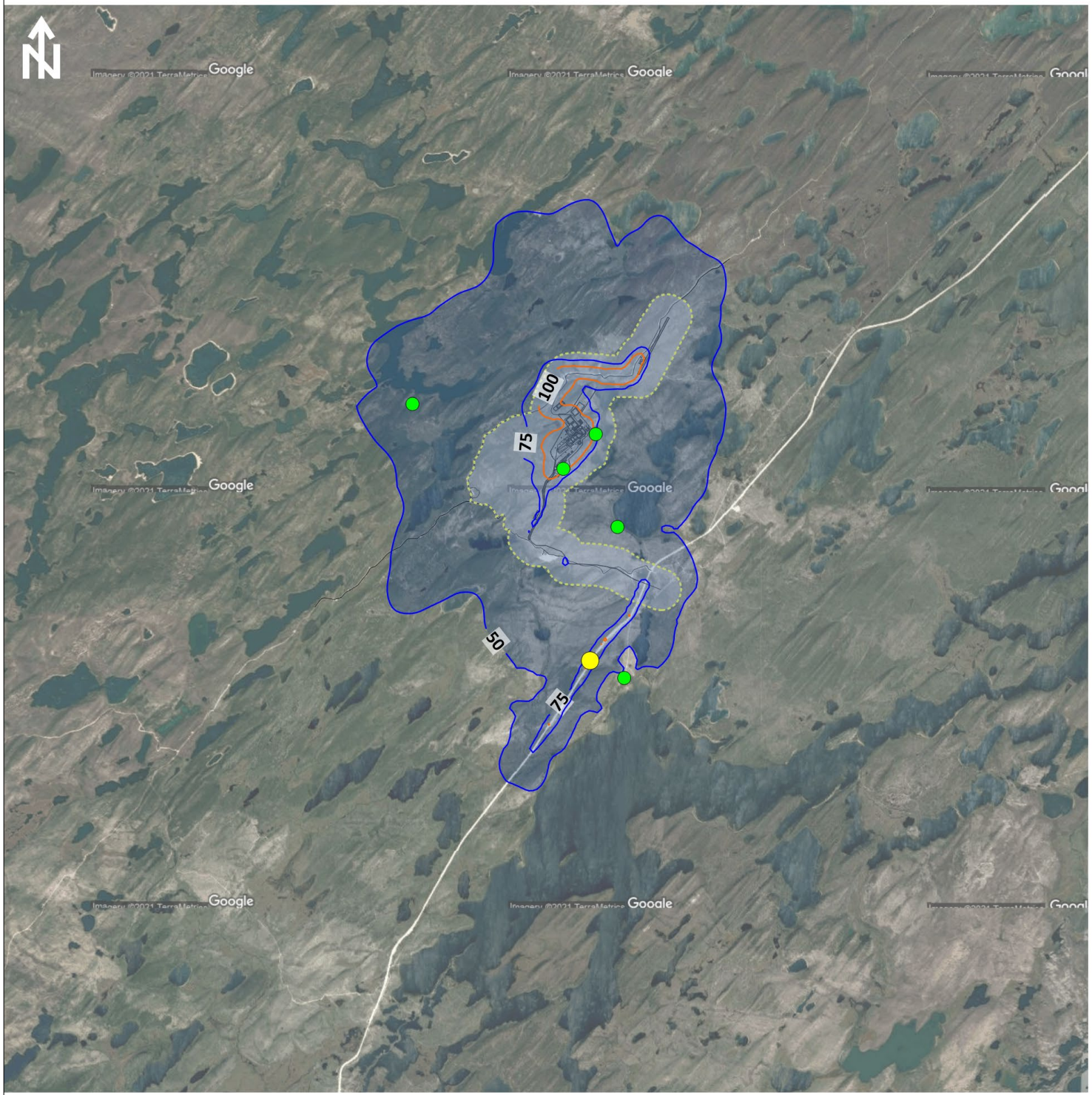
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Annual Radon Concentrations (Bq/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	34
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 46.2 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

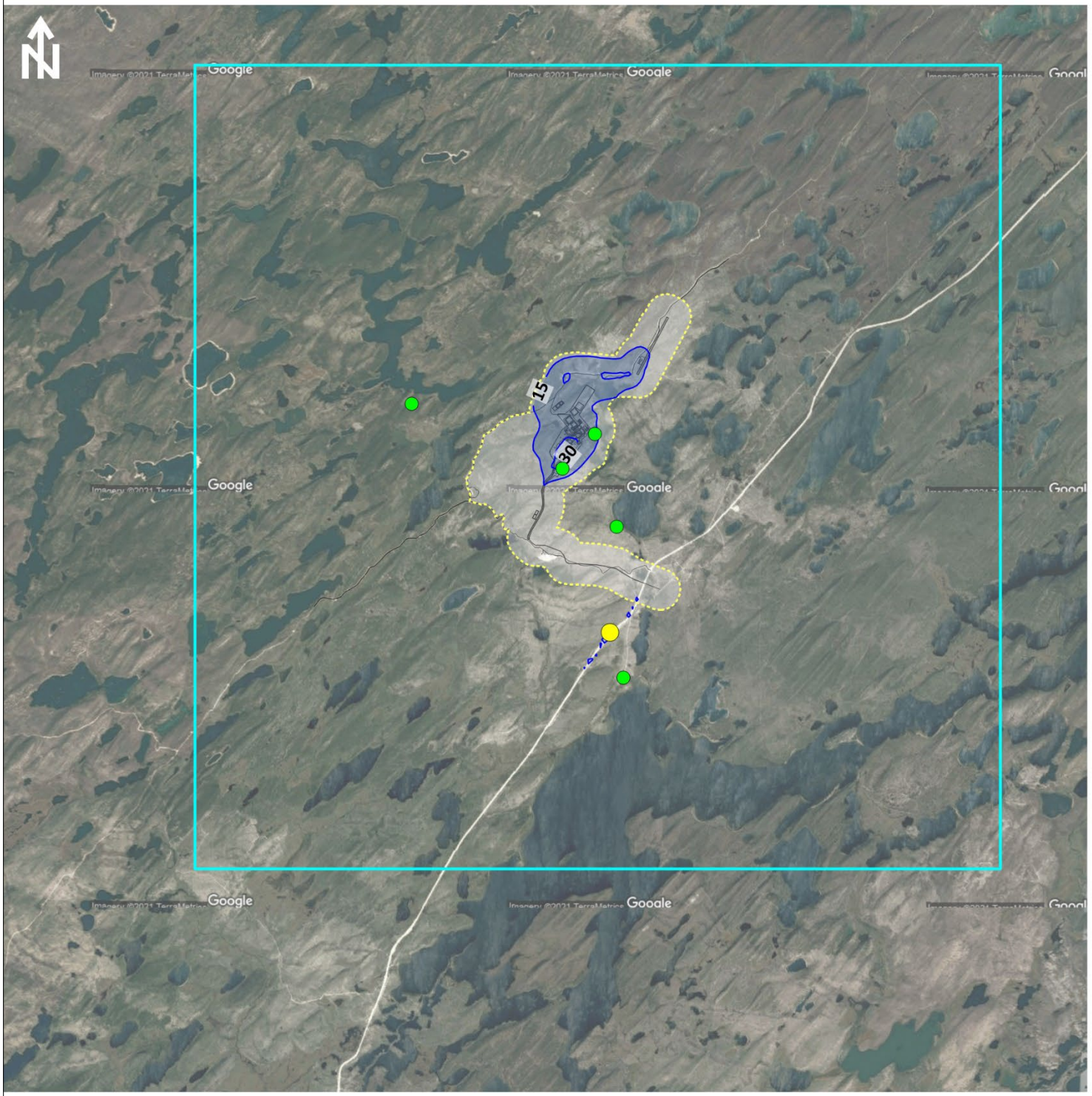
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 24-hour TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	35
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 12.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

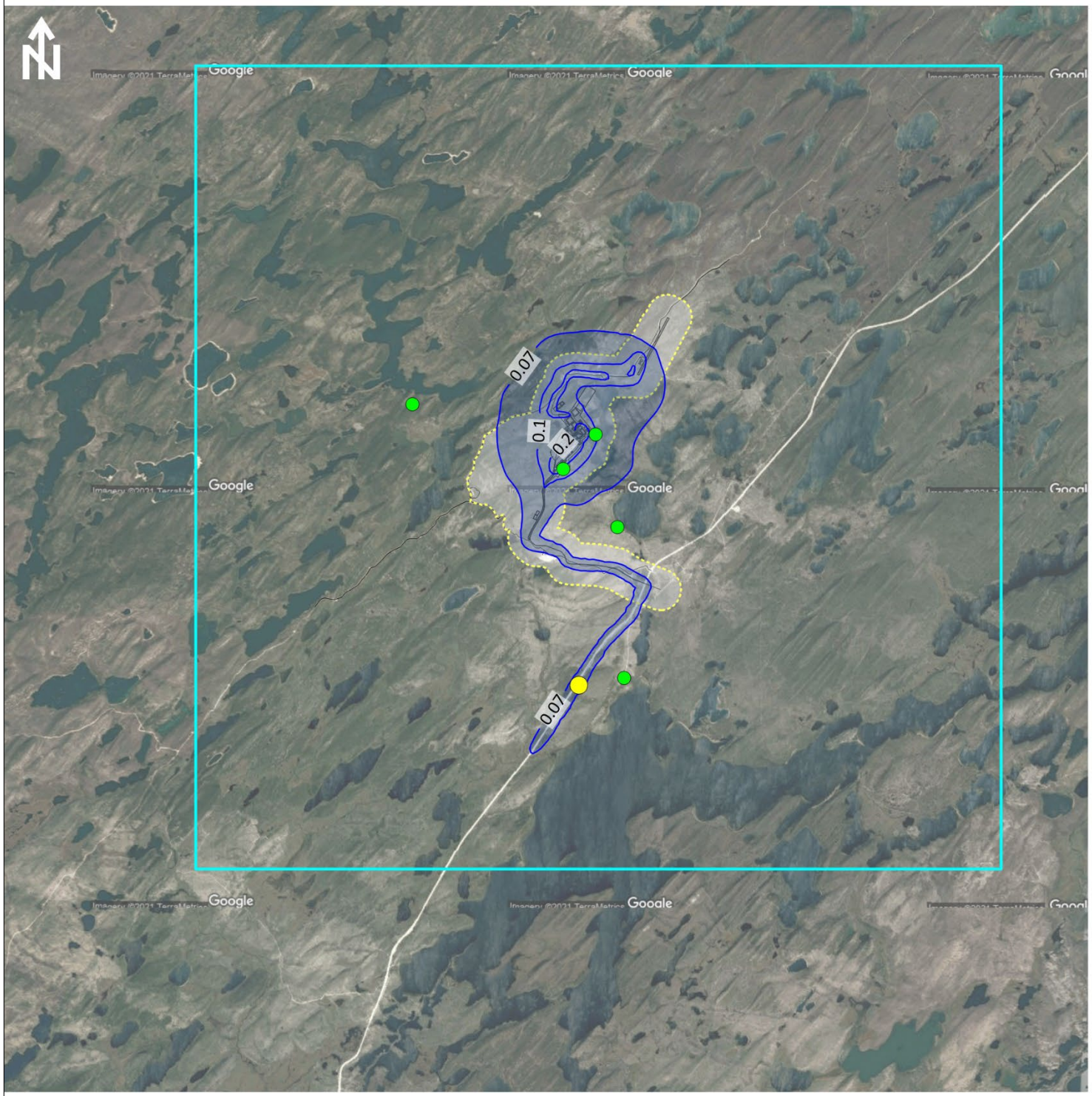
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum Annual TSP Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	36
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Deposition (mg/cm²/30d)
- Project Criteria (mg/cm²/30d)
- Maximum off-property deposition location
- Risk Receptor

NOTES:

Dustfall includes the addition of a background value of 0.06 mg/cm²/30d.

SCALE:

0 km 2.5 km 5 km 7.5 km

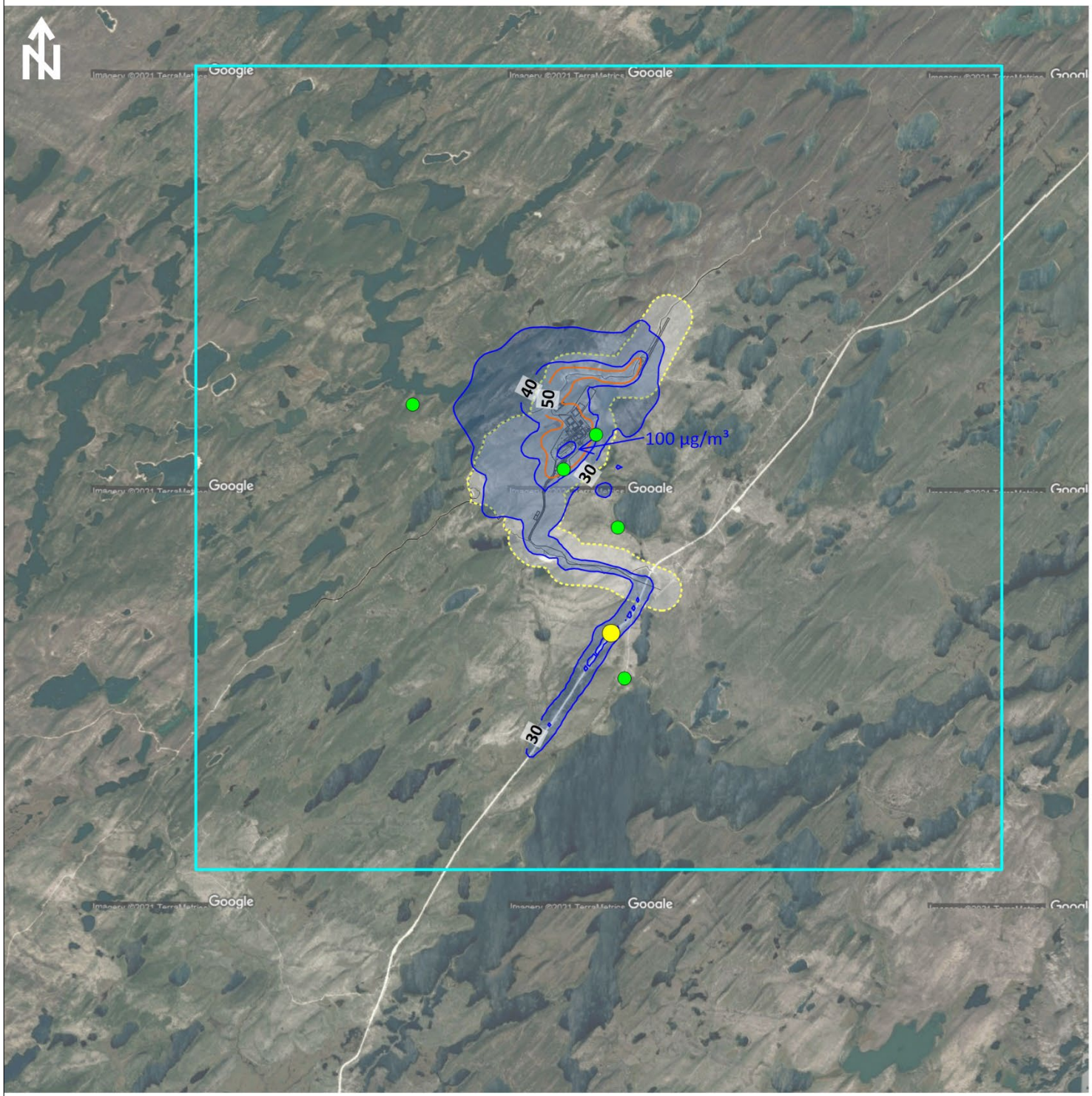
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
30-Day Dustfall (mg/cm²/30-days)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	37
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 23.1 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

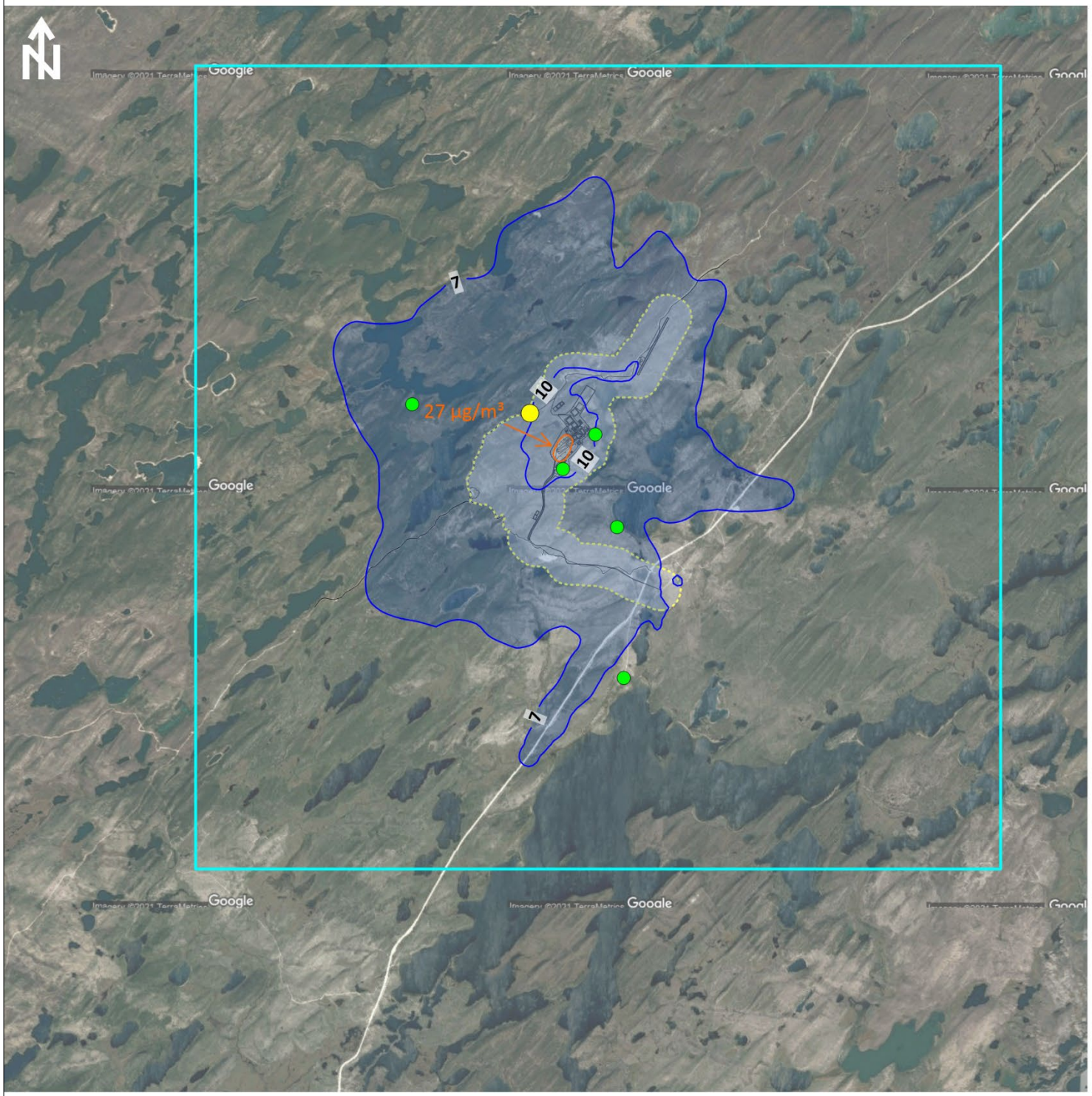
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 24-hour PM_{10} Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	38
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 6.5 µg/m³.

SCALE:

0 km — 2.5 km — 5 km — 7.5 km

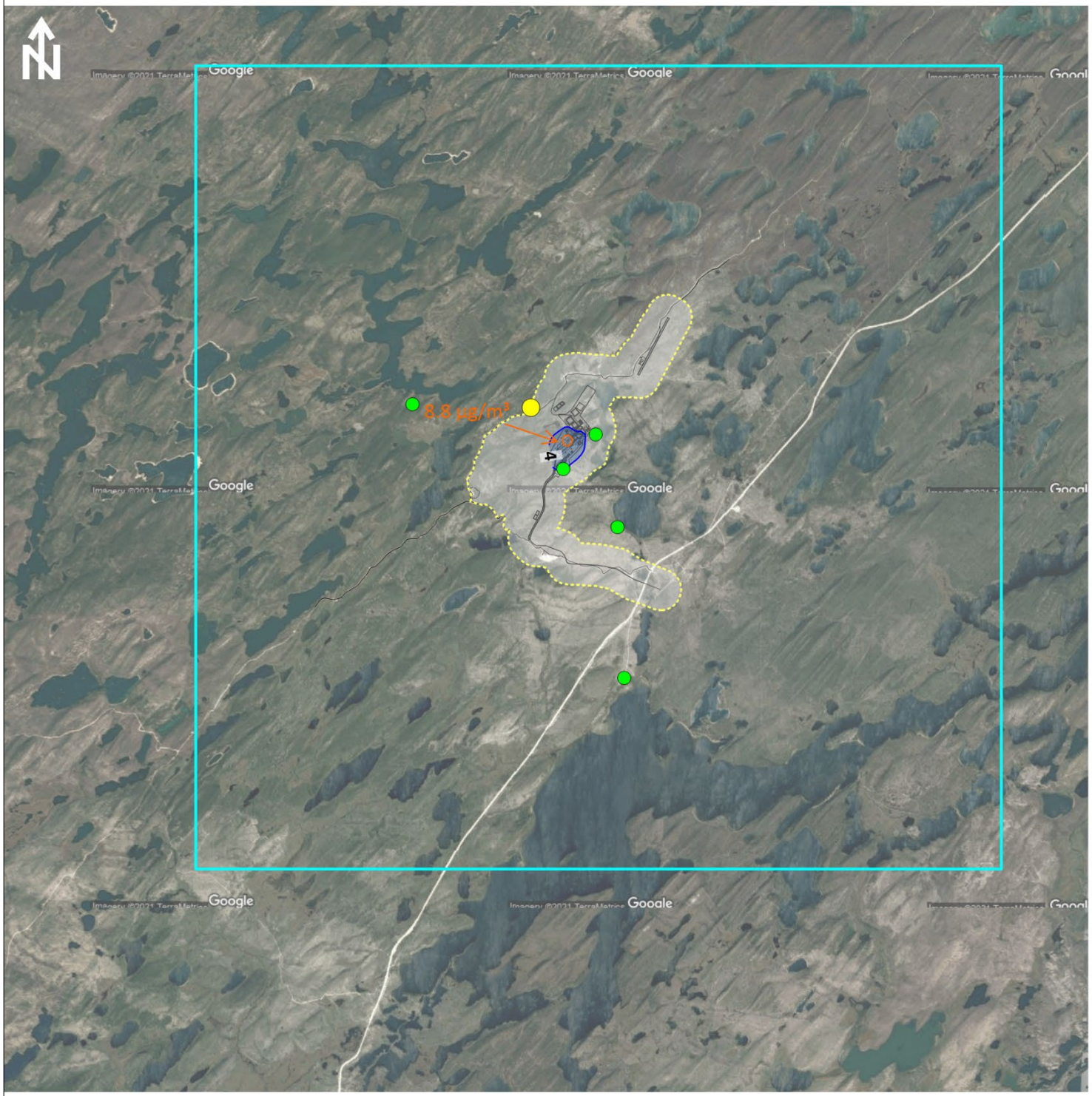
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 24-hour $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	39
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.1 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum Annual $PM_{2.5}$ Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	40
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

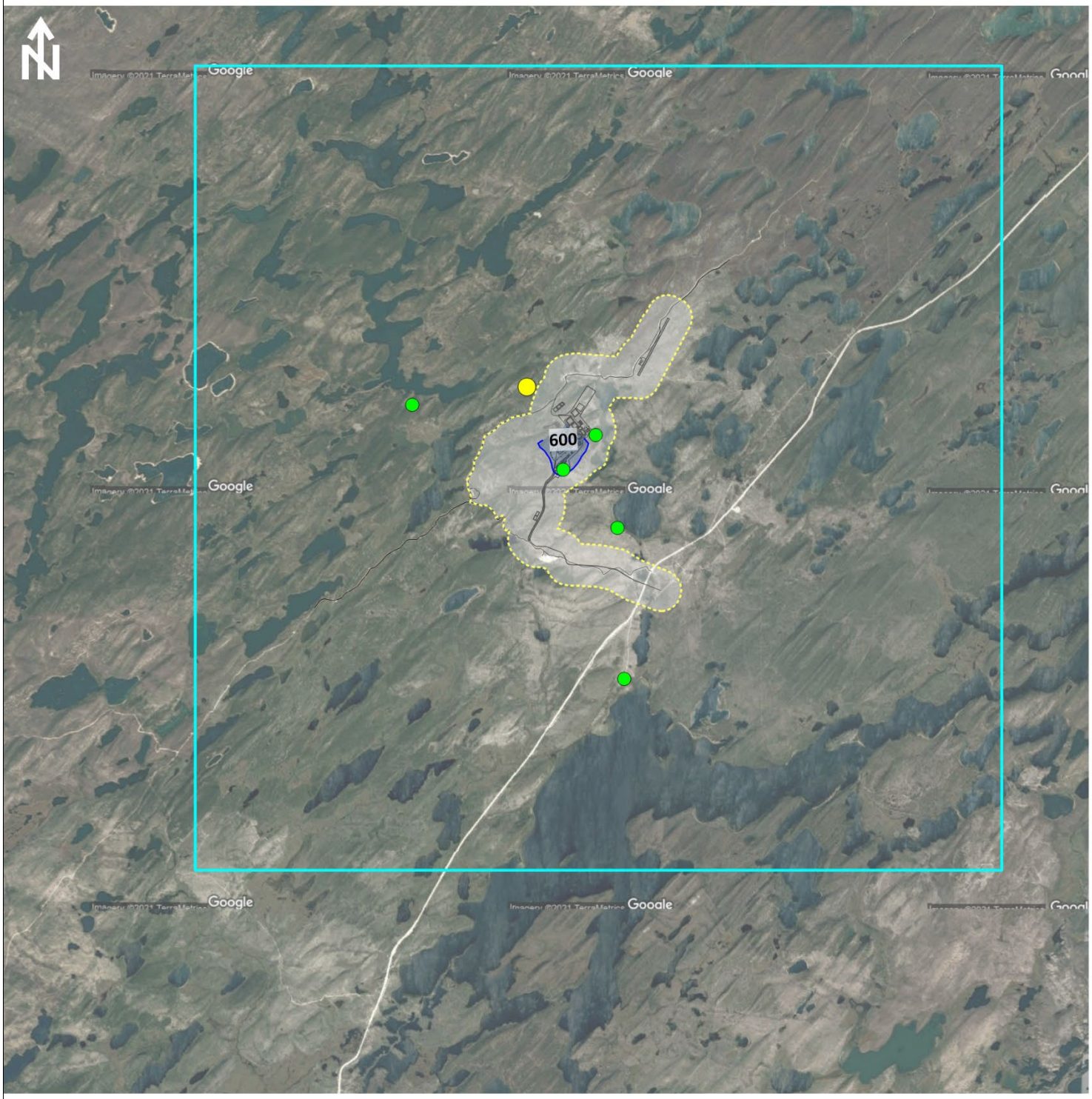
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 1-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	41
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 575 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 8-hour CO Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	42
Date:	Project No.:	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
1-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	43
Date:	Project No.:	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

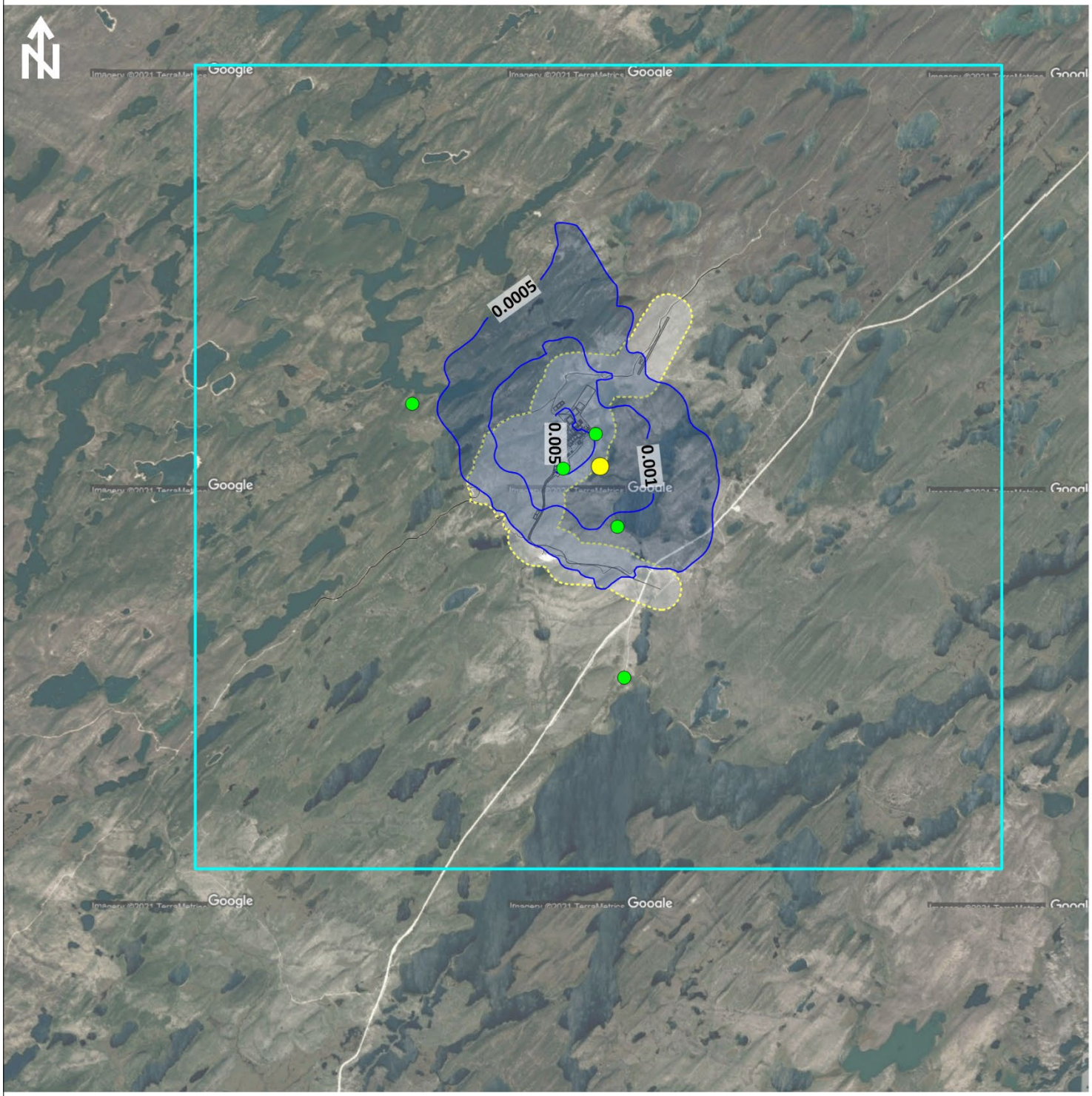
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
24-hour SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	44
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

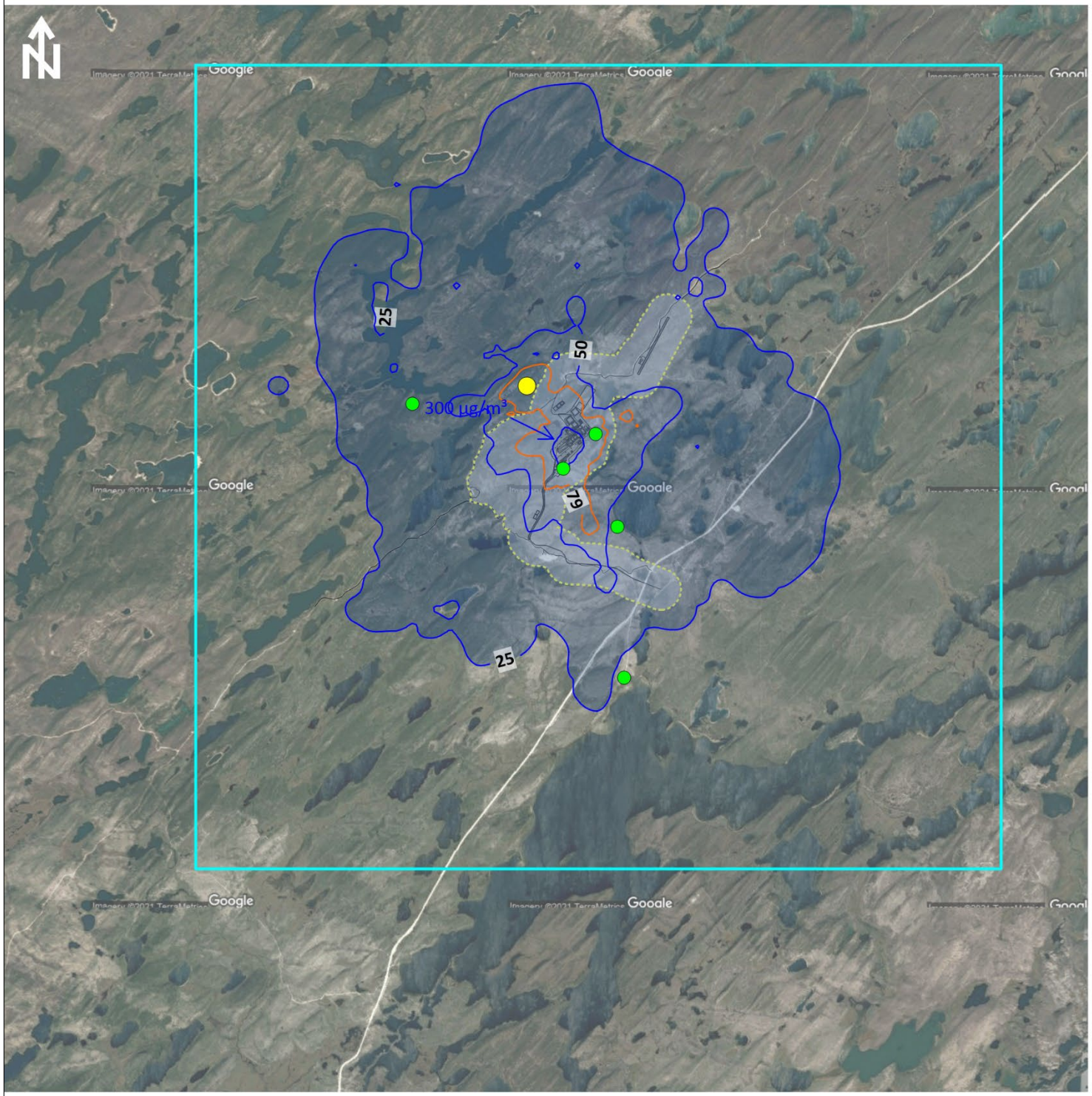
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Annual SO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	45
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 11.3 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

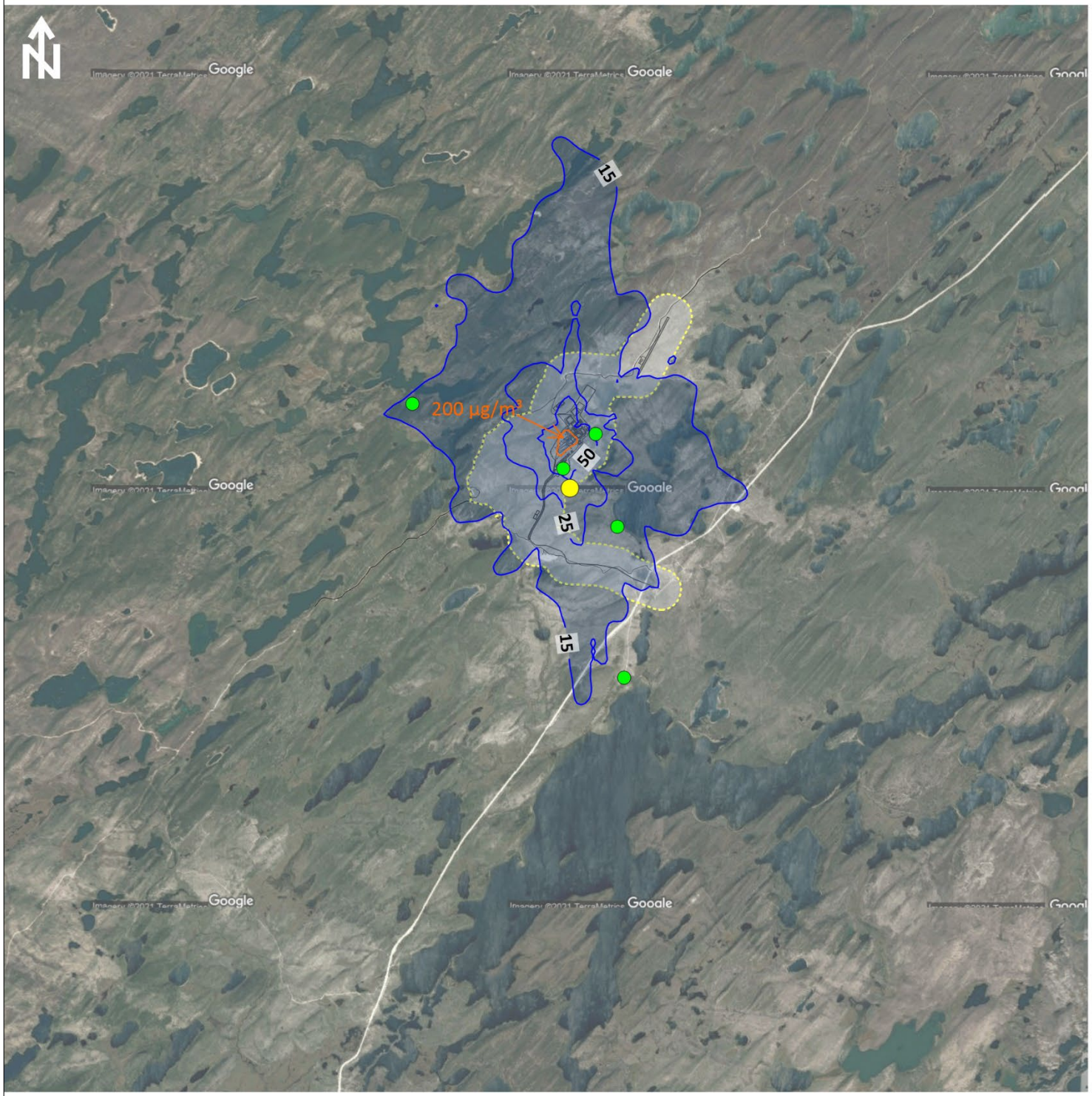
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 1-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	46
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 9.4 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

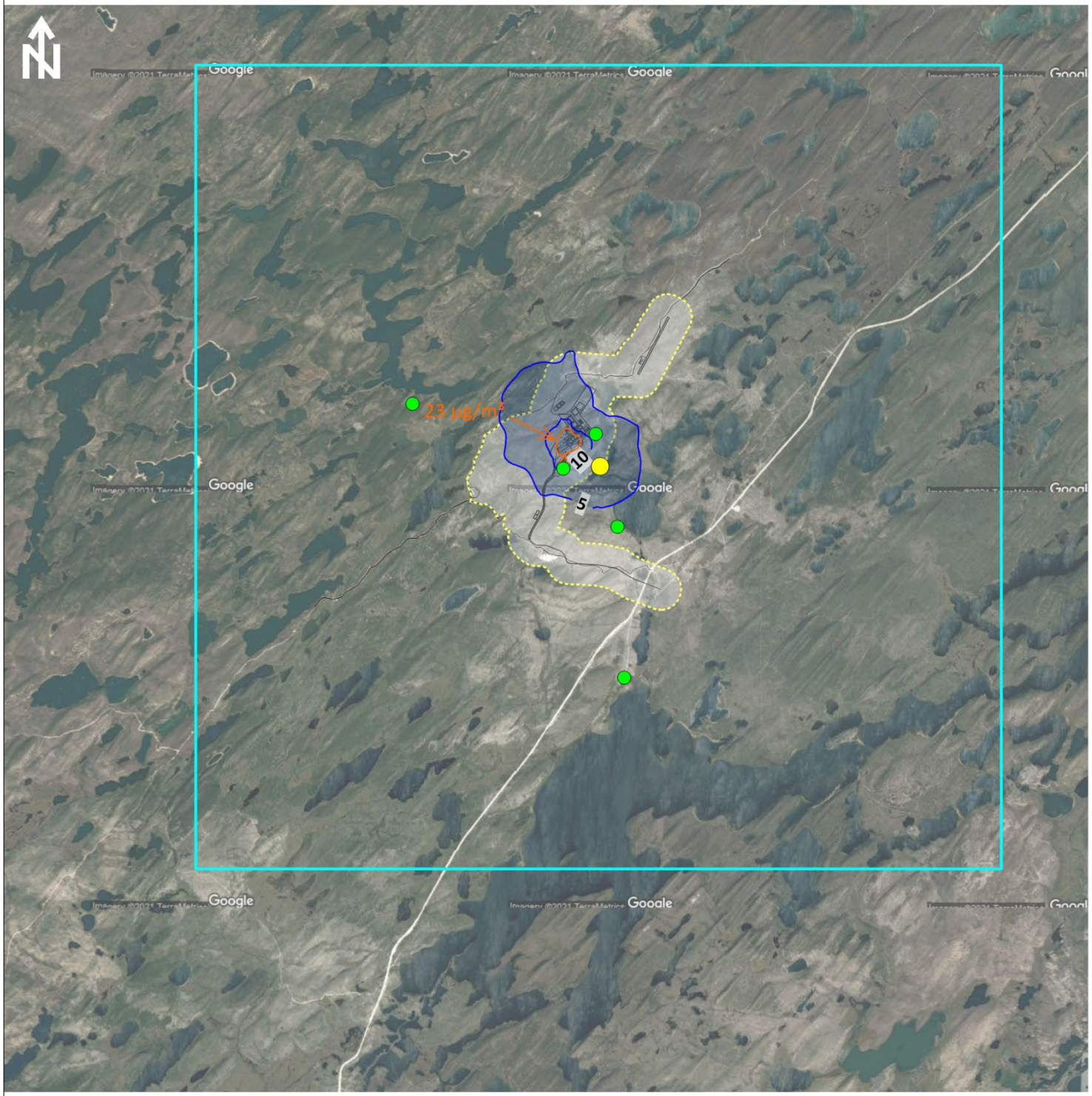
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 24-hour NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	47
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (µg/m³)
- Project Criteria (µg/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 3.8 µg/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

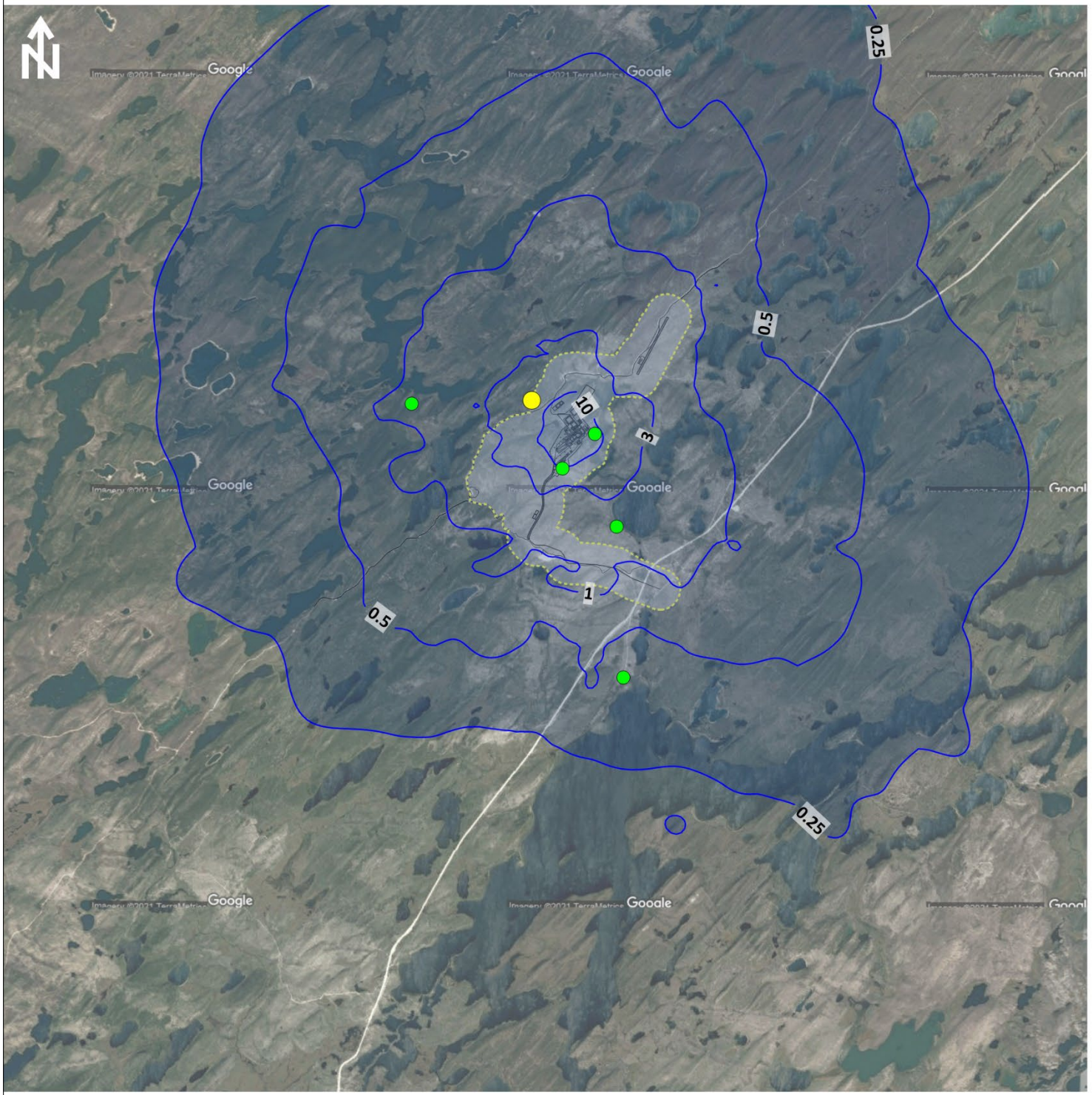
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum Annual NO_2 Concentrations (µg/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	48
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Concentration (Bq/m³)
- Project Criteria (Bq/m³)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

Concentrations include the addition of a background value of 0 Bq/m³.

SCALE:

0 km 2.5 km 5 km 7.5 km

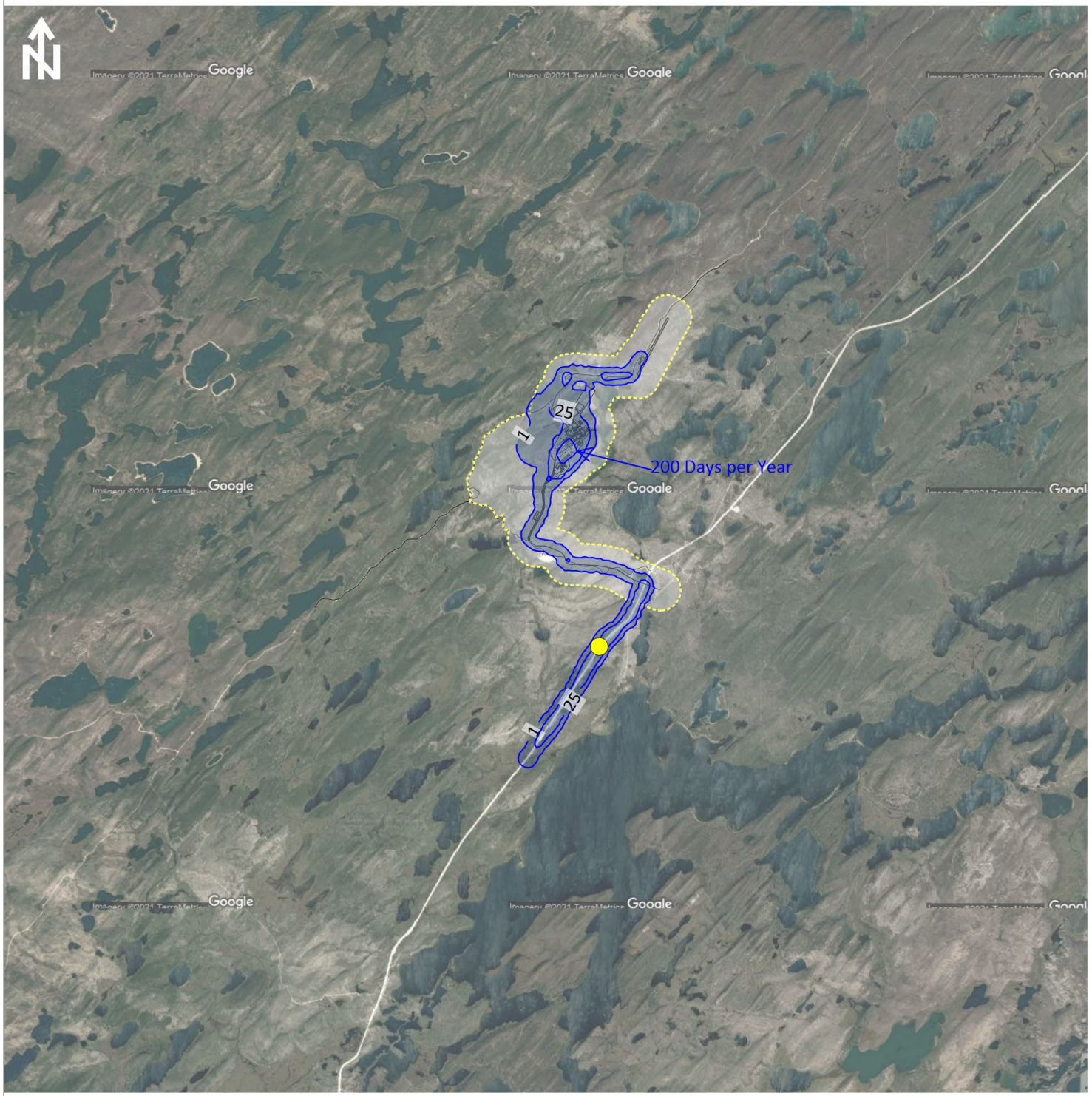
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Annual Radon Concentrations (Bq/m³)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	49
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

SCALE:

0 km 2.5 km 5 km 7.5 km

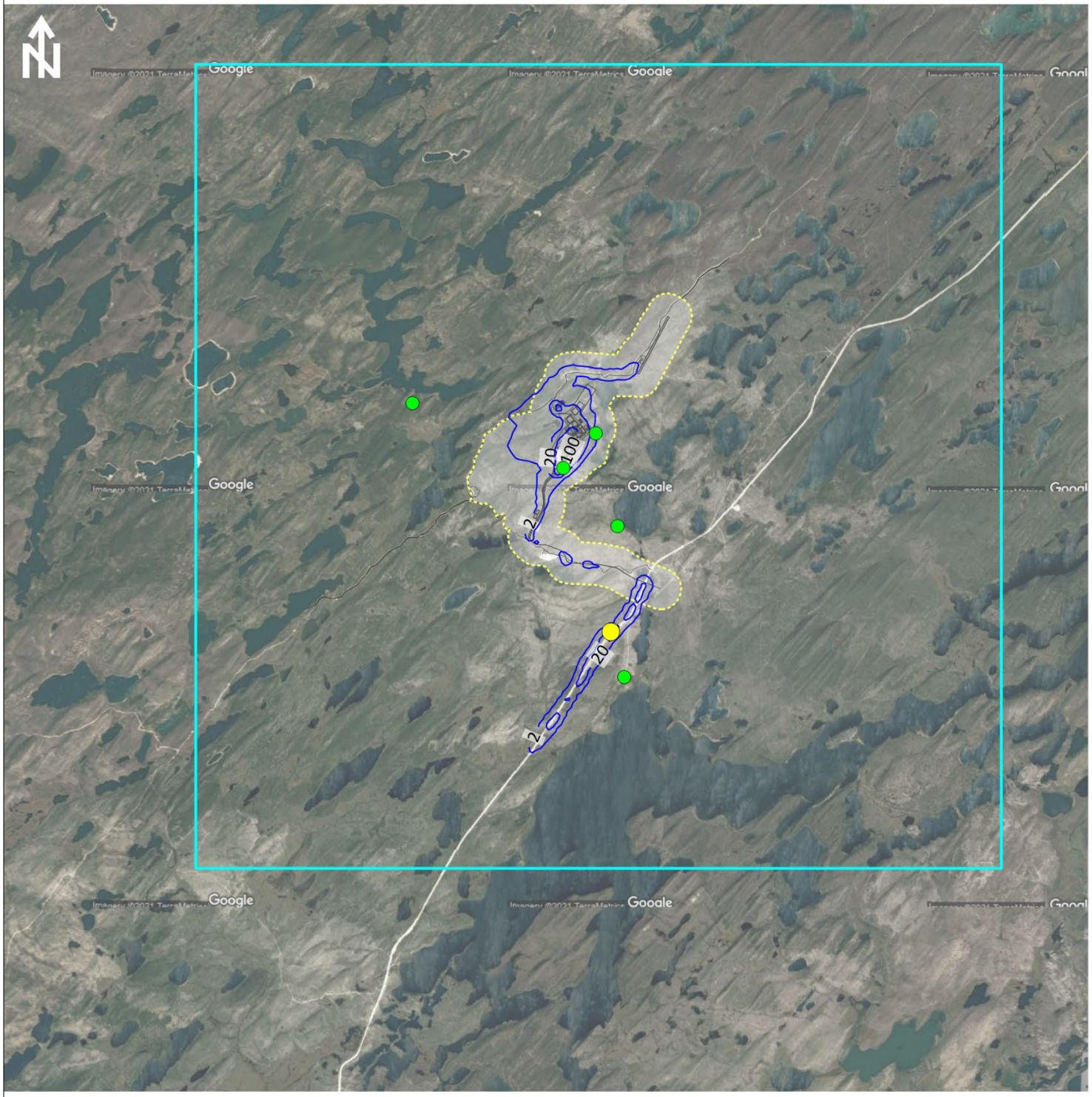
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour TSP Exceedances (days per year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	50
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

SCALE:

0 km 2.5 km 5 km 7.5 km

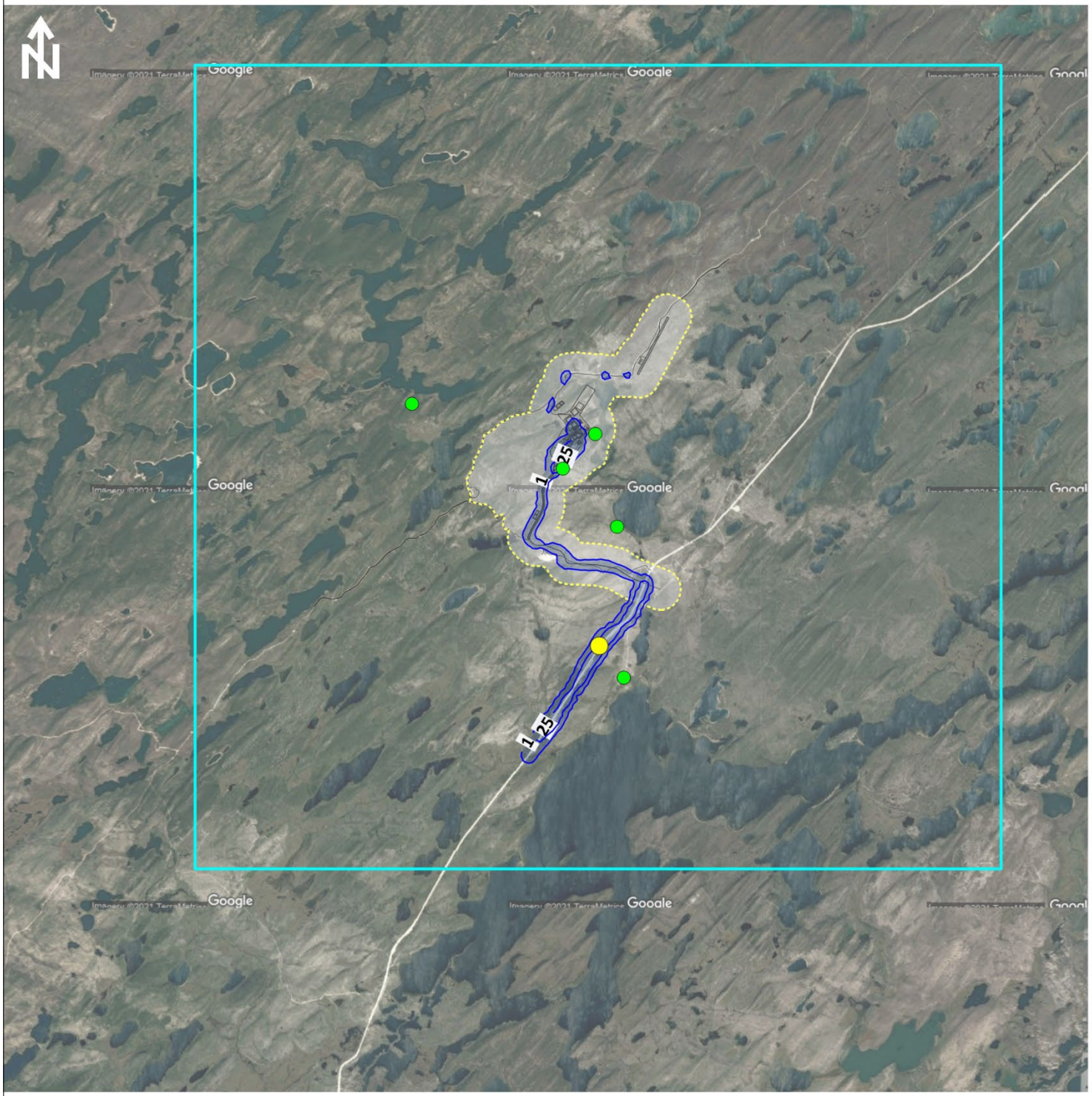
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Construction Scenario:
Maximum 24-hour PM_{10} Exceedances (Days per Year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	51
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

SCALE:

0 km 2.5 km 5 km 7.5 km

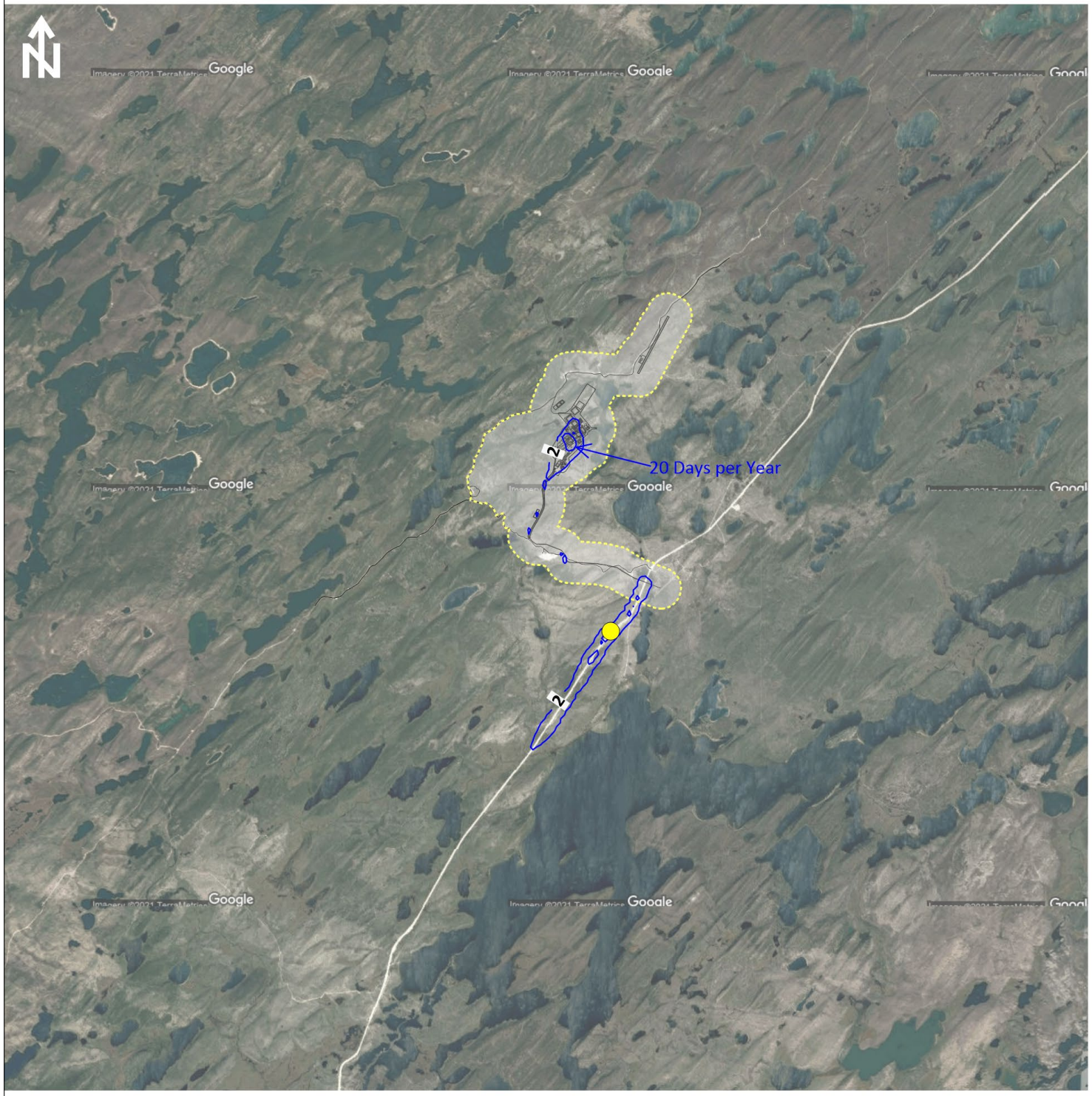
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour TSP Exceedances (Days per Year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	52
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

SCALE:

0 km — 2.5 km — 5 km — 7.5 km

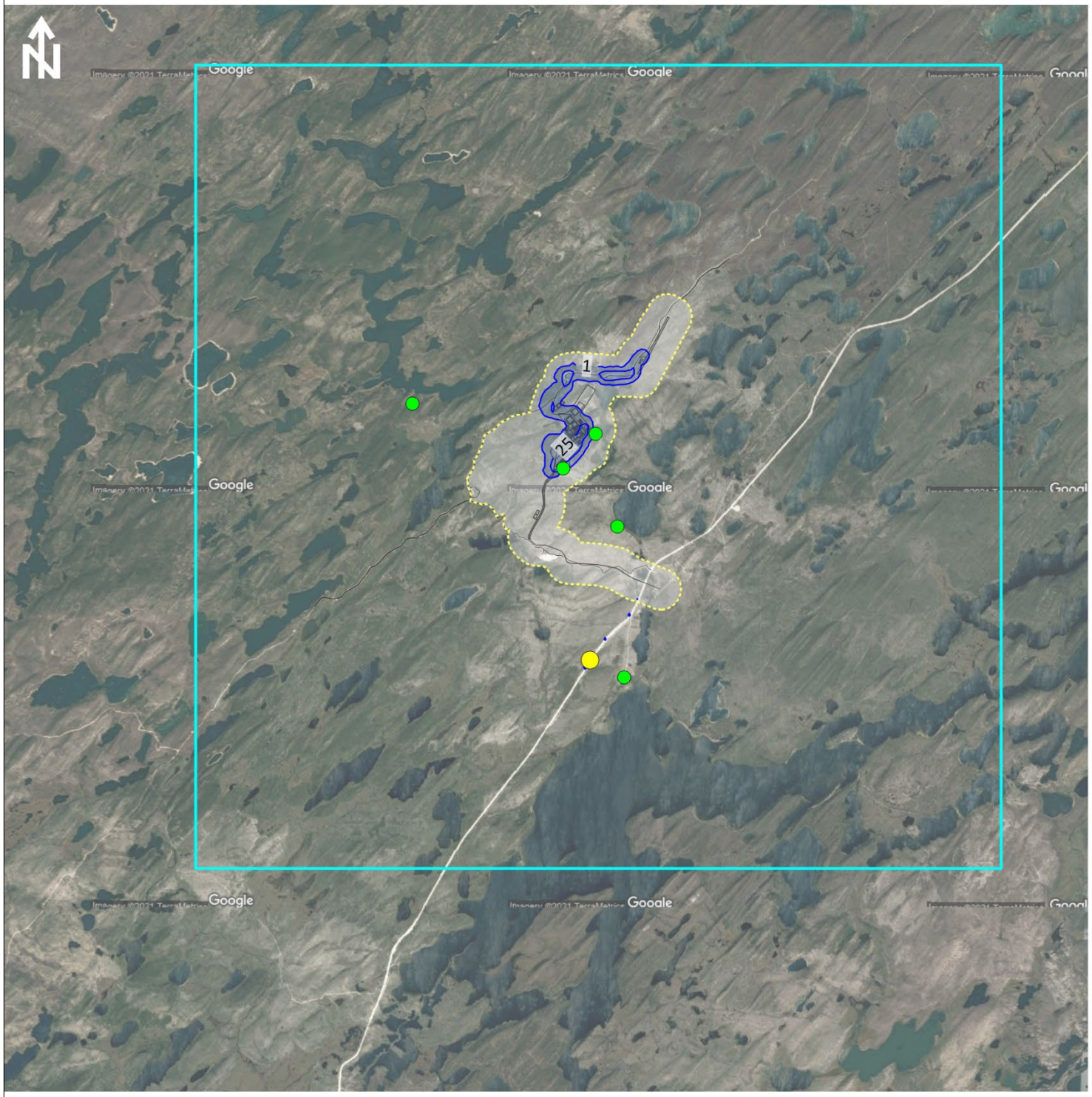
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour PM_{10} Exceedances (days per year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	53
Date:	**Project No.:**	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 24-hour TSP Exceedances (Days per Year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	54
Date:	**Project No.:**	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (hours per year)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 1-hour NO_2 Exceedances (Hours per Year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	55
Date:	Project No.:	
July 2022	SX19-0043	

LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (hours per year)
- Maximum off-property concentration location
- Risk Receptor

NOTES:

SCALE:

0 km 2.5 km 5 km 7.5 km

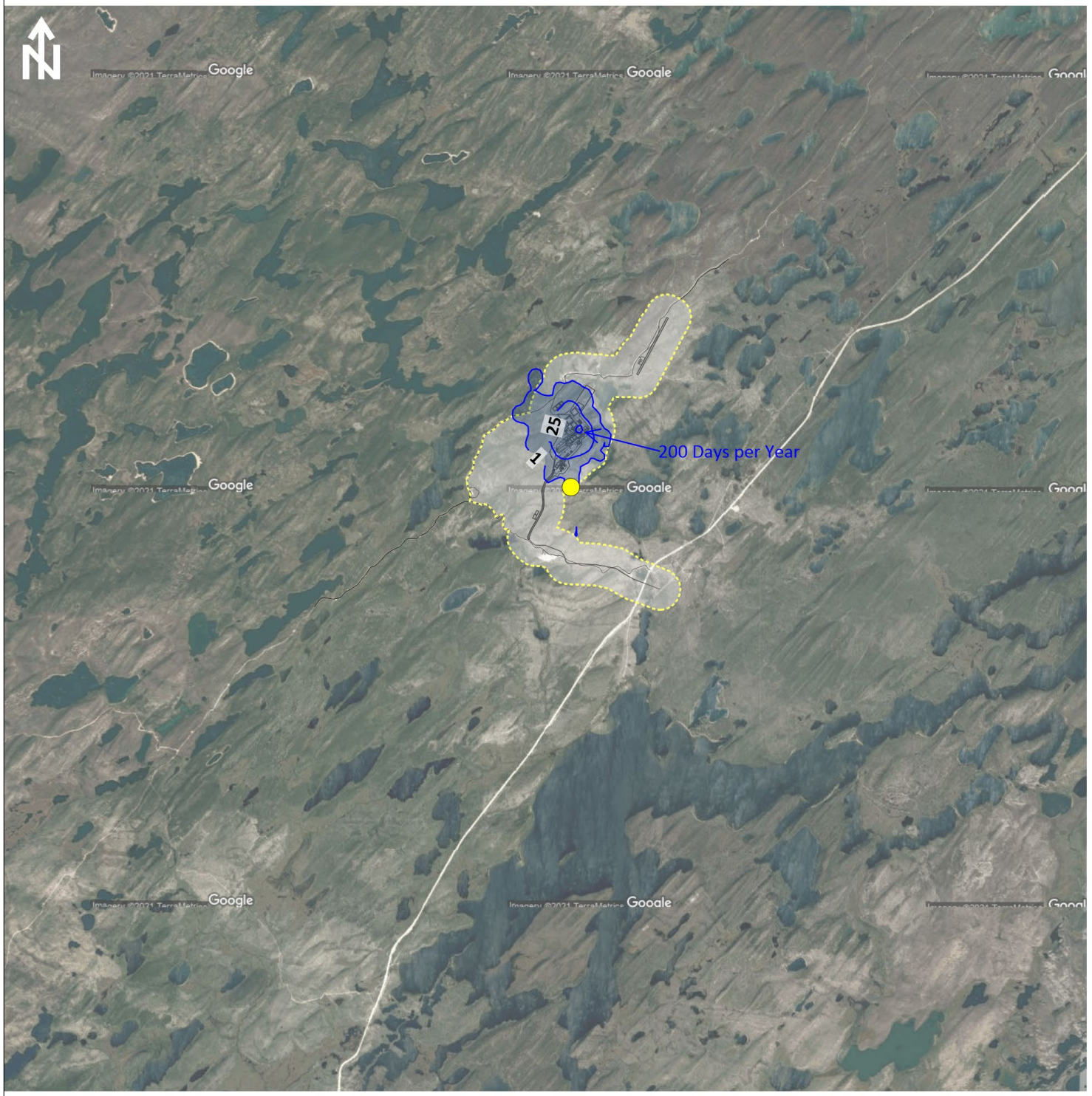
REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Decommissioning Scenario:
Maximum 1-hour NO_2 Exceedances (Hours per Year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	56
Date:	Project No.:	
July 2022	SX19-0043	



LEGEND:

- LSA
- Property Boundary
- Project Area
- Exceedances (days per year)
- Maximum off-property concentration location
- Risk Receptor

SCALE:

0 km 2.5 km 5 km 7.5 km

REFERENCE:

Basemap: Google Earth 2021
UTM Zone 13T, WGS84

Denison Mines Corp.
Wheeler River Project, SK

Operations Scenario:
Maximum 24-hour Uranium Exceedances (days/year)

Drawn By:	Approved By:	Figure No.:
JMH	PLK	57
Date:	**Project No.:**	
July 2022	SX19-0043	

Appendix A:

Air Emissions Inventory

Appendix A: Air Emissions Inventory

As discussed in the main body of the report, construction, operations, and decommissioning of the Project will result in COPC emissions to air. The significant sources of air emissions and expected COPC during each Project phase are summarized in Table A. 1. In general, the main air emission sources over the life of the Project can be categorized as follows:

- General construction,
- Wellfield drilling,
- Material handling,
- Grading,
- Bulldozing,
- Wind erosion,
- Batch plant operations,
- Unpaved road dust,
- Mobile and stationary fuel combustion, and
- Wellfield and ISR plant operations.

The emissions quantification methods for each of the above sources are discussed in more detail below. The production information and variables and assumptions that were used to calculate the air emissions are summarized in a series of tables provided at the end of this Appendix. For example, the production information to support the calculations for construction is provided in Table A. 2. These tables will be referred to throughout the discussion below.

Table A. 1: Summary of Expected Air Emission Sources and COPC

Primary Emissions Source	Secondary Emissions Source	Applicable Scenarios				Potential COPC					Reference	Notes
		Const.	Ops.	Decomm.	Post-Decomm.	Dust	Combustion Products	Uranium	Metals [1]	Radon		
General construction	Earthworks and cut/fill	x	x			x					Section A.1	Dozing, material handling, and wind erosion during construction captured under general construction.
Stationary diesel combustion	Fixed generators	x	x	x			x				Section A.11	
	Portable generators	x	x	x			x					
Stationary propane combustion	Comfort heating		x	x			x				Section A.12	
	Calciner thermal heater		x				x				Section A.13	
Mobile equipment/vehicle combustion	E.g., dozers, graders, trucks, etc.	x	x	x			x				Sections A.9 and A.10	
Unpaved road dust		x	x	x		x					Section A.2	Assume clean fill used to construct roads, so not a source of uranium, metals, or radon.
Grading	Road maintenance	x	x	x		x			x		Section A.5	For road maintenance/snow removal during operations and decommissioning.
Dozing		x		x		x		x	x		Section A.1 and A.6	
Drilling	ISR well field (freeze, injection, recovery)	x	x			x		x	x	x	Section A.7	Also see 'Wellfield' source.
	Monitoring wells	x				x						Minimal number of monitoring wells minimal during ops. /decomm.
	Fresh water wells					x						Minimal number of fresh waste and recharge wells and considered negligible.
	Recharge wells					x						
Concrete Production		x	x	x		x			x		Section A.8	
Borrow area	Wind erosion	x	x	x		x					Section A.4	Clean fill not a source of uranium or metals.
	Material handling	x	x	x		x					Section A.1 and A.3	
Clean waste pad	Wind erosion		x	x		x					Section A.4	Clean waste not a source of uranium, metals, or radon.
	Material handling		x	x		x					Section A.3	
	Radon emanation										Section A.16	
Special waste pad	Wind erosion		x			x		x	x		Section A.4	
	Material handling		x			x		x	x	x	Section A.3	
	Radon emanation		x							x	Section A.16	
Landfills (domestic/ construction)	Wind erosion	x	x	x		x					Section A.4	Domestic/construction waste not a source of uranium, metals, or radon.
	Material handling	x	x	x		x					Section A.1 and A.3	
	Radon emanation										n/a	

Primary Emissions Source	Secondary Emissions Source	Applicable Scenarios				Potential COPC					Reference	Notes
		Const.	Ops.	Decomm.	Post-Decomm.	Dust	Combustion Products	Uranium	Metals [1]	Radon		
Industrial landfill	Wind erosion	x	x	x		x					Section A.4	
	Material handling	x	x	x		x					Section A.1 and A.3	Radon emissions negligible. Consistent with worker exposure assumptions.
Industrial landfill	Radon emanation										n/a	
Storage Ponds	Contaminated runoff pond										n/a	Not expected to be a source of COPC.
	Industrial WWTP precipitate pond(s)		x	x						x	Section A.16	Minor source of radon. Material kept wet, therefore, no dust expected.
	Leachate collection pond										n/a	Not expected to be sources of COPC.
	Clean waste pond										n/a	
	Effluent monitoring or release pond(s)										n/a	
	Process water pond										n/a	
	Domestic wastewater pond										n/a	
	Process precipitates pond		x							x	Section A.16	Material kept wet, therefore, no dust or metals expected.
	Uranium rich solution holding area	x	x	x						x	Section A.16	
	Surge tank	x	x	x						x	Section A.16	
Wellfield	Wellfield Drilling	x	x			x		x	x	x	Sections A.7 and A.16	
	Freeze Drilling	x	x			x		x	x	x	Sections A.7 and A.16	
	Pump Houses		x				x				Section A.12	Radon captured in wellfield/piping. Only combustion COPC from propane heating in pump house.
	Wellfield piping		x	x						x	Section A.16	
	Core shack	x	x							x	Section A.16	
Freeze Plant			x	x			x					Only combustion COPC from propane heating.
ISR Plant	Dryer process gas stack		x			x		x	x		Section A.13	
	Calciner process gas stack		x			x	x	x	x			In this case, 'combustion products' refers to SO_2 from calciner.
	Hygiene scrubber stack		x			x		x	x			
	Calciner exhaust for thermal fluid heater		x				x					
	Reagent storage exhausts					x					n/a	Intermittent PM emissions when filling reagent tanks. Considered negligible.
	Water treatment exhausts										n/a	Not expected to be a source of COPC.
	Yellowcake precipitation area									x	Section A.16	Assume dust emissions captured in hygiene scrubber stack.
	Ra/Fe Precipitation exhausts		x							x		
	General exhausts (e.g., washrooms, shops, etc.)		x	x						x		
Silo loading	Lime		x	x		x					Section A.15	Intermittent dust emissions during deliveries. Lime silo will be connected to dust collection system.
Hazardous waste storage											n/a	Not a source of COPC.
Fuel storage (outdoor)											n/a	Not a source of COPC.
Welding						x			x		n/a	Assume welding emissions sporadic and negligible.
Airstrip						x					n/a	Assume flights are infrequent enough that emissions can be considered negligible.

A.1 Construction

Fugitive dust is emitted from earthworks activities during construction including clearing and grubbing, grading, dozing, material stockpiling, building construction, etc. Emissions of dust from general construction was estimated using the Level 2 calculation method from the Western Regional Air Partnership (WRAP) Fugitive Dust Handbook [21], Table 3-2, which breaks construction emissions into two parts:

Dust from general construction activities:

$$EF\ (PM_{10}) = 0.11 \frac{\frac{ton}{acre}}{month} \text{ (for average conditions)}$$

Dust from cut/fill activities:

$$EF\ (PM_{10}) = 0.059\ ton/yd^3$$

The $PM_{2.5}/PM_{10}$ ratio factor of 0.1 from the WRAP Handbook was applied. TSP emission factors were developed by scaling the general construction TSP emission factor from U.S. EPA AP-42 Chapter 13.2.3 [22] to the Level 1 (i.e., worst-case) PM_{10} emission factor from the WRAP Handbook. For example, the TSP emission factor for general construction was calculated as follows:

$$EF\ (\text{TSP}) = 0.11 \frac{\frac{ton}{acre}}{month} \times 1.2 \frac{\frac{ton}{acre}}{month} \div 0.42 \frac{\frac{ton}{acre}}{month} = 0.314\ \frac{\frac{ton}{acre}}{month} = 0.70\ \frac{\frac{tonnes}{ha}}{month}$$

To estimate dust emissions from general construction, the construction area is required and for emissions from cut/fill activities, the volume of material is required (see Table A. 2). The duration of construction is also required for both calculations. For this assessment, the construction area is estimated to be about 170 ha and it was conservatively assumed that construction activities occur year-round. The volume of material handled is expected to be about 1.3 million m³ over a one-year period. It was also assumed that fugitive dust emissions will be mitigated through watering during the summer months (i.e., May to October), and a control factor of 50% was applied to construction emissions. During the winter months (November to April), it was assumed a natural mitigation factor of 90% was applied to account for snow cover and frozen conditions [23].

Dust emissions from unpaved road dust, wind erosion, grading, drilling, and concrete batching during construction are captured in the individual calculations for these sources (see Sections A.2, A.4, A.5, A.7, and A.8), while combustion emissions are discussed in Sections A.9 to A.12.

A.2 Unpaved Road Dust

Dust is emitted from unpaved roads by the action of vehicle wheels against the surface and by the turbulent wake created behind a moving vehicle. Emissions of unpaved road dust were estimated using the emission factor equation for industrial roads from U.S. EPA AP-42 Chapter 13.2.2 [24]:

$$EF = 281.9 \times k \times \left(\frac{s}{12}\right)^a \times \left(\frac{W}{3}\right)^{0.45}$$

Where:
EF = emission factor in lb/VKT
k = particle size multiplier (TSP = 4.9; PM_{10} = 1.5; $PM_{2.5}$ = 0.15)
s = silt content (%)
W = vehicle weight (tons)
a = constant (TSP = 0.7; PM_{10} and $PM_{2.5}$ = 0.9)
VKT = vehicle kilometres travelled

To estimate emissions from unpaved roads, silt content, average vehicle weight, and the number of vehicle kilometres travelled (VKT) is required. As shown in Table A. 2, a silt content of 8.3% was used, based on default data from U.S. EPA AP-42 [8]. Traffic information, including vehicle weights and VKT are provided in Table A. 3.

Emissions of road dust can be mitigated through operational practices such as watering or applying chemical dust suppressants. For the summer months, a control of 70% was applied to the roads to account for the application of water at least twice per day [25]. In the winter, a control of 90% was applied, which is based on the findings of a study completed at the De Beers diamond mine in northern Ontario [23]. An additional 44% control was applied in both seasons to the mine roads to account for vehicle speeds under 40 km/h as per the WRAP Handbook [21]. The mine roads are expected to have an average speed limit of 30 km/h (Table A. 2).

A.3 Material Handling

Emissions of dust from material handling during construction are captured in the general construction emissions discussed in Section A.1. During operations and decommissioning, emissions of dust will be generated when materials are added to or removed from a storage area. Material handling emissions were estimated using the emission factor equation from U.S. EPA AP-42 Chapter 13.2.4 [26]:

$$EF = k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4}$$

Where:
EF = emission factor in kg/tonne
k = particle size multiplier (TSP = 0.74; PM_{10} = 0.35; $PM_{2.5}$ = 0.053)
U = wind speed (m/s)
M = material moisture content (%)

To estimate emissions from material handling, wind speed, material moisture content, and the amount of material (e.g., wellfield cuttings) handled is required. The mean annual wind speed in the vicinity at the Project site is 3.4 m/s (Table A. 2), which is based on data from the meteorological data set (see Appendix B). The assumed moisture content of the waste rock is 11% (Table A. 2), based on default data from U.S. EPA AP-42 [26]. Finally, material handling rates are provided in Table A. 5.

A.4 Wind Erosion

Material storage areas like the clean waste storage pad and special waste pad are susceptible to wind erosion. Wind erosion emissions were estimated using the emission factor equation presented in the WRAP Handbook [21]:

$$EF = k \times 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{f}{15}\right)$$

Where:
EF = emission factor in kg/ha/day
k = particle size multiplier (TSP = 1.0; PM_{10} = 0.5; $PM_{2.5}$ = 0.075)
s = silt content (%)
f = percentage of the time with the unobstructed wind speed greater than 5.4 m/s in percent (%)

To estimate emissions from wind erosion, the following variables are required: material silt content; the frequency of winds greater than 5.4 m/s; and the surface area of the storage area. As shown in Table A. 2, a silt content of 20% was assumed for wellfield cuttings, while a silt content of 12% assumed for sand/aggregate materials. The frequency term 'f' was calculated to be 6.5% based on data from CALMET (see Appendix B). The calculated surface areas of the storage areas subject to wind erosion are outlined in Table A. 6.

A control of 90% was applied to winter emissions to account for natural mitigation of dust from snow and ice cover [3]. In summer, storage areas that will be actively watered (i.e., the clean waste and special waste pads) were controlled by 50%. For the short-term emissions scenarios, no emissions control was applied to the remaining piles; however, for the annual emissions scenario, storage areas not actively mitigated by watering were controlled by 47% due to natural mitigation from rainfall.

A.5 Grading

For this assessment, it was assumed that the mine site roads and the access road will be maintained with grading. Emissions of dust from grading were estimated using the emission factor equation in U.S. EPA AP-42 Chapter 11.9 [27]:

$$EF\ (TSP) = 0.0034 \times S^{2.5}$$

$$EF\ (PM_{10}) = 0.60\ \times 0.0056 \times S^{2.0}$$

$$EF\ (PM_{2.5}) = 0.031 \times 0.0034 \times S^{2.5}$$

Where:
EF = emission factor in kg/VKT
S = grader speed in km/h
VKT = vehicle kilometres travelled

The above equation requires an estimate of the grader speed (assumed to be 10 km/h) as well as the number of kilometres travelled, which was calculated based on the length of road and the number of gradings, which was assumed to be two passings in a day for one day of the week. Note that grading was assumed to occur only during the summer months.

A.6 Dozing

Emissions of dust from dozing during construction are captured in the general construction emissions discussed in Section A.1. For this assessment, it was assumed that a bulldozer will be used during decommissioning for

reclamation activities in the wellfield and storage pads. Emissions of dust from bulldozing were estimated using the emission factor equation in U.S. EPA AP-42 Chapter 11.9 [27]:

$$EF\ (TSP) = 2.6 \times s^{1.2} \times M^{-1.3}$$

$$EF\ (PM_{10}) = k \times 0.75\ \times 0.45 \times s^{1.5} \times M^{-1.4}$$

$$EF\ (\mathrm{PM}_{2.5}) = 0.105 \times 2.6 \times s^{1.2} \times M^{-1.3}$$

Where:
EF = emission factor in kg/hour
s = material silt content in percent (%)
M = material moisture content in percent (%)

The above equation requires the silt and moisture content of the material being bulldozed, as well as the number of operating hours. The silt and moisture content were assumed to be 20% and 11%, respectively (Table A. 2). There are two bulldozers that were assumed to be used 8 hours a day in each location. For the annual emissions scenario, it was also assumed that dozing occurs during the summer months only.

A.7 Drilling

For the Project's ISR mining process, freeze wells, injection wells, recovery wells, and monitoring wells are drilled. Emissions of dust from wellfield drilling were estimated using the emission factors from the Environment and Climate Change Canada's (ECCC) guidance document for pits and quarries [28]:

$$EF\ (TSP) = 0.59\ kg/hole$$

$$EF\ (PM_{10}) = 0.31\ kg/hole$$

$$EF\ (\mathrm{PM}_{2.5}) = 0.31\ kg/hole$$

The above emission factors simply require the number of holes drilled, which are summarized in Table A. 7 for each assessment scenario. The emission factors assume wet drilling; therefore, no additional controls were applied.

A.8 Batch Plant

Concrete will be required for foundations and pads, and cement will be needed for wellfield casings. Emissions from batch plant operations were estimated using the emission factors provided in U.S. EPA AP-42 Chapter 11.12 [29], which are summarized in the following table:

Activity	Emission Factor (kg/tonne material)		
	TSP	PM_{10}	$PM_{2.5}$
aggregate transfer (controlled by 30%)	1.14E-03	5.52E-04	1.70E-04
sand transfer (controlled by 30%)	2.73E-04	1.27E-04	4.10E-05
cement unloading to storage silo	6.10E-05	2.07E-05	9.15E-06
cement supplement to silo	8.16E-05	4.35E-05	1.22E-05
weigh hopper loading (controlled by 30%)	1.49E-03	7.45E-04	2.23E-04
truck loading	6.87E-03	1.84E-03	1.03E-03

The volume of concrete required for each assessment scenario is 3,000 m^3 for construction, and 1,000 m^3 for operations and decommissioning. The default concrete composition from U.S. EPA AP-42 was then applied to determine the concrete production rates by weight:

Material	Material Density		% Of Concrete
	lb / yd^3	kg / yd^3	
coarse aggregate	1,865	846	46%
sand	1,428	648	35%
cement	491	223	12%
cement supplement	73	33	2%
water	167	76	4%
concrete product	**4,024**	**1,825**	-

A.9 On-Road Mobile Combustion Emissions

On-road mobile combustion sources include any vehicles permitted to drive on public roads (e.g., delivery/shipping trucks). To calculate exhaust emissions from on-road mobile combustion sources, U.S. EPA Tier 2 emission factors (which apply to vehicles for model years 2004-2009) were conservatively used and are summarized in the table below.

Emission Factors for On-Road Vehicles Conforming to U.S. EPA Tier 2 Standards (Model Years 2004-2009)

Vehicle Type	Fuel Type	Technology Type	Emission Factors				Units
			HC	CO	NOx	PM	HC
Light Duty Vehicle (LDV)	Gasoline	Tier 2	0.09	4.20	0.07	0.01	g/mile
	Diesel	Tier 2	0.09	4.20	0.07	0.01	g/mile
Medium Duty Vehicle (MDV)	Gasoline	Tier 2	0.09	4.20	0.07	0.01	g/mile
	Diesel	Tier 2	0.09	4.20	0.07	0.01	g/mile
Heavy Duty Vehicle (HDV)	Gasoline	Tier 2	0.14	15.50	0.20	0.01	g/bph-hr
	Diesel	Tier 2	0.14	15.50	0.20	0.01	g/bph-hr

Emission factors for light- and medium-duty on-road vehicles depend on the number of vehicle kilometers travelled (VKT), whereas emission factors for heavy-duty vehicles depend on the engine size and number of operating hours. Equipment information is summarized in Table A. 4, while VKT is provided in Table A. 3.

Instead of emission factors, SO_2 emissions from on-road mobile sources were calculated using a mass balance approach based on the fuel sulphur content:

$$SO_2\left(\frac{g}{s}\right) = FC \times FD \times sox \times 0.01 \times 2.00$$

Where:
FC = fuel consumption in L
FD = fuel density in g/L
sox = fuel sulphur content in %
0.01= conversion from percent to fraction
2.00 = the mass ratio of sulphur dioxide to sulphur (assumes 100% oxidation of sulphur)

Fuel consumption data was calculated based on the vehicle fuel economy and VKT data (Table A. 4 and Table A. 3). The fuel sulphur content for diesel and gasoline was based on the *Sulfur in Diesel Fuel Regulations* [30] and *Sulphur in Gasoline Regulations* [31], which specify sulphur contents of 15 parts per million (ppm) and 30 ppm, respectively, for diesel and gasoline.

A.10 Non-Road Combustion

Non-road or off-road combustion sources at the Project site include heavy equipment (e.g., dozers, graders, loaders) and vehicles (e.g., haul trucks) that are not permitted to travel on public roads. In general, emissions for these sources were calculated as follows:

$$ER\left(\frac{g}{s}\right) = EF\left(\frac{g}{hp-hr}\right) \div BSFC\left(\frac{lb\ fuel}{hp-hr}\right) \times FC\left(\frac{lb\ fuel}{yr}\right) \div 365\left(\frac{days}{yr}\right) \div 24\left(\frac{hr}{day}\right) \div 3600\left(\frac{s}{hr}\right)$$

Where:
ER = emission rate
EF = emission factor
BSFC = brake-specific fuel consumption
FC = annual fuel consumption

The emission factors and brake-specific fuel consumption (BSFC) values were obtained from the U.S. EPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition* [32]. For non-road diesel combustion, Tier 4 emission factors were assumed. All the emission factors used in the assessment are summarized in the table below while engine horsepower data are provided in Table A. 4. SO_2 emissions were calculated using the same methodology described above in Section A.9.

Emission Factors for Off-Road Vehicles Conforming to U.S. EPA Tier 2 Standards (Model Years 2004-2009)

Equipment Type	Engine Tier	Fuel Type	BSFC	Steady State Emission Factor (g/hp-hr)			
				HC	CO	NOx	PM
Water truck	Tier 2	Diesel	0.367	0.1669	0.8425	4.3351	0.1316
Grader	Tier 2	Diesel	0.367	0.3384	0.8667	4.1	0.18
Haul truck	Tier 2	Diesel	0.367	0.1669	1.3272	4.1	0.1316
Dozer	Tier 2	Diesel	0.367	0.1669	0.7642	4.1	0.1316
Forklift	Tier 2	Diesel	0.367	0.3384	0.8667	4.1	0.18
Man lift	Tier 2	Diesel	0.408	0.2789	1.5323	4.7279	0.3389
Wheel loader	Tier 2	Diesel	0.367	0.3384	0.8667	4.1	0.18
Skid steer	Tier 2	Diesel	0.408	0.2789	1.5323	4.7279	0.3389
Flat deck truck	Tier 2	Diesel	0.367	0.1669	0.8425	4.3351	0.1316
Vacuum truck	Tier 2	Diesel	0.367	0.1669	0.8425	4.3351	0.1316
Crane	Tier 2	Diesel	0.367	0.3085	0.7475	4	0.1316
DR drill rig	Tier 2	Diesel	0.367	0.1669	0.8425	4.3351	0.1316
Mud rotary drill rig	Tier 2	Diesel	0.367	0.1669	0.8425	4.3351	0.1316

A.11 Diesel Generator Emissions

To estimate emissions from the stationary diesel generators, emission factors from manufacturer's specifications were applied. For the smaller, portable generators, emission factors from U.S. EPA AP-42, Chapter 3.3, Gasoline and Diesel Industrial Engines [13] were used. The generator emission factors are summarized in the following table:

Emission Factors for Diesel Generators

Type	Description	No. Units	Fuel Consumption	TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NOx	Units
C3512	Diesel, 1.1 MW	2	356.8 L/h	0.32	0.32	0.32	1.74	-	11.96	g/kW-h
C15	Diesel, 450 kW	2	106.1 L/h	0.00	0.00	0.00	0.80	-	6.17	g/kW-h
Portable	Diesel, <600 hp	2	16.1 L/h	5.1	5.1	5.1	15.6	-	72.6	g/L

Notes:
Assumes TSP = PM_{10} = $PM_{2.5}$

SO_2 emissions were calculated using the same methodology described above in Section A.9. The fuel consumption rates required to estimate SO_2 are provided in the above table.

For the Construction scenario, two (2) C3512 generators and two (2) portable generators were assumed to operate continuously, year-round. For the Operations and Decommissioning scenarios, the maximum short-term emission rates assumed that two (2) C3512 generators and two (2) C15 generators operate continuously, while two (2) portable generators operate 12 hours per day. For average annual emission rates, the expected operating hours were used, which is 2 hours per day for one C3512 unit and 12 hours per day for one portable generator.

A.12 Propane Combustion Emissions

Propane combustion sources include propane heaters for comfort heating and cooking appliances for supporting infrastructure (e.g., camp). To estimate emissions from propane sources, U.S. EPA AP-42 emission factors were used. The propane combustion emission factors are summarized in the following table:

COPC	Emission Factor [1]	Units
TSP	0.024	kg/m³
PM_{10}	0.024	kg/m³
$PM_{2.5}$	0.024	kg/m³
SO_2	0	kg/m³
CO	0.899	kg/m³
NOx	1.558	kg/m³

Notes:
[1] Source: [33]

The fuel consumption rates required to estimate emissions from propane combustion are provided in Table A. 8 for each assessment scenario.

A.13 ISR Plant Stacks

The calciner, dryer, and hygiene exhaust stacks in the ISR plant will be sources of particulate (and its constituents). In addition, the calciner stack will also be a source of SO_2, while the calciner burner exhaust will be a source of combustion products. The calciner, dryer, and hygiene stacks will be equipped with scrubber systems to control emissions of COPC.

To estimate emissions from the ISR stacks, in-stack concentrations based on a preliminary engineering study [14] were used, which are summarized in the following table:

Source Description	In-Stack Concentration						Actual Flow Rate
	TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NOx	
	mg/dNm³	mg/dNm³	mg/dNm³	mg/dNm³	ppm	mg/dNm³	DNm³/s
Dryer scrubber stack	10	10	10	0.0	0.0	0.0	
Calciner scrubber stack	10	10	10	0.0	26	0.0	
Hygiene scrubber stack	10	10	10	0	0.0	0	
Calciner burner exhaust	13	13	13	144	0.0	250	

Notes:
Assume TSP = PM_{10} = $PM_{2.5}$

Expected flow rates from the same engineering study [14], were applied to the above emission limits to estimate the emission rates using to the following equations:

$$Max\ ER\left(\frac{g}{s}\right) = Flow\ Rate\left(\frac{dNm^3}{s}\right) \times COPC\ Conc.\left(\frac{mg}{DNm^3}\right) \div 1000\left(\frac{mg}{g}\right)$$

$$Average\ ER\left(\frac{g}{s}\right) = Flow\ Rate\left(\frac{dNm^3}{s}\right) \times COPC\ Conc.\left(\frac{mg}{DNm^3}\right) \div 1000\left(\frac{mg}{g}\right) \times Plant\ Availability\ (95\%)$$

A.14 Uranium and Metals in TSP

Emission rates of uranium and metals were calculated based on the composition of the parent material from which dust is emitted. Emissions were conservatively based on TSP. The specific calculation is:

$$Uranium\ or\ Metal\ \left(\frac{g}{s}\right) = TSP\ \left(\frac{g}{s}\right) \times uranium\ or\ metal\ content\ (\%)$$

The uranium grade and metal content of the various material types are outlined in Table A. 9.

A.15 Lime Silo

Lime will be used in the ISR water treatment process and will be stored inside of a silo in the ISR plant, equipped with a dust collection system exhausting to the atmosphere by its own stack. Dust emissions will be generated when lime is transferred to the storage silo.

Emissions for loading of the lime silo were estimated using the emission factors provided in U.S. EPA AP-42 Chapter 11.19 [9], which are summarized in the following table:

Activity	Emission Factor (kg/tonne)		
	TSP	PM_{10}	$PM_{2.5}$
Lime transfer to storage silo	0.0055	0.0008	0.0003

During operations, 66,240 tonnes of lime will be used on an annual basis (181 tonnes per day). For the decommissioning phase, it was assumed that half that amount will be required for ongoing water treatment.

A.16 Radon Emissions

Radon emissions are expected from various Project elements; however, the primary source of radon emissions will be wellfield operations and restoration. The following sections described how radon emissions were estimated for the air quality assessment. Note that for all calculations, equilibrium between radium-226 (Ra-226) and radon gas (Rn-222) is assumed unless otherwise specified.

A.16.1 Wellfield Development

For the Construction and Operations scenarios, radon gas will be released during wellfield drilling from radium-bearing ore cuttings. The amount of radon gas available for release can be estimated using the following equation from Appendix D of the U.S. NRC document *Standard Review Plan for In Situ Leach Uranium Extraction Lease Applications* [15]:

$$Rn_{nw} = 10^{-12}\ E\ L\ [Ra]\ T\ M\ N$$

A description of the variables and the values that will be used in the wellfield drilling calculations are summarized in Table A. 10.

Radon gas will also be released when groundwater containing dissolved radon gas is pumped to the surface during wellfield development. To estimate radon from groundwater pumping, the following mass balance approach was used:

$$Rn_{gw} = V\ w\ C\ \times 3.2 \times 10^{-8}\ \frac{s}{yr}$$

Where:
Rn_{gw} = radon emissions from groundwater pumping (g/s)
V = average water volume per well (m^3) = 60 m^3/well
w = number of injection/recovery wells (see Table A. 7*)*
C = Rn-222 concentration in groundwater (Bq/L) = 6 million Bq/L

A.16.2 Wellfield Production

In an ISR wellfield, radon released from the ore body is removed by the process water or recovered mining solution moving through the production wellfield. Radon gas is then released to the atmosphere wherever the recovered mining solution is vented. In the case of the Project, a portion of the radon is expected to be released in the wellfield from occasional venting from the wellheads and leaking transport piping. Majority is assumed to be released when the process water arrives at the surge tank, with a minor amount released from the recovered solution pond, which is open to the atmosphere. Per discussions with Denison staff, purge or bleed in the production wellfield is not expected, so radon emissions from purge water are assumed to be zero.

The amount of radon gas released from wellfield venting (Rn_{vent}) and the surge tank (Rn_{tank}) was estimated using the following equations:

$$C_{Rn} = \frac{10^6\ [Ra]\ A\ D\ P\ E\ L\ f}{(L + v)\ V + \ F_p + \ F_i}$$

$$Rn_{vent} = 3.65 \times 10^{-10}\ v\ C_{Rn}$$

$$Rn_{tank} = 3.65 \times 10^{-10}\ F_i\ C_{Rn}$$

A description of the variables and the values that will be used in the above equations are summarized in Table A. 11.

The amount of radon gas released from the recovered solution pond (Rn_{pond}) was estimated using the following equation as described in [34]:

$$Rn_{pond} = Ra_{pond} \times 1000\ \times D \times SA\ \times 2.1 \times 10^{-6}$$

Where:
Rn_{pond} = radon emissions from the recovered solution pond pumping (g/s)
Ra_{pond} = Ra-226 concentration in the recovered solution pond (Bq/L) = 3,700 Bq/L [35]
1000 = conversion from litres to m^3
D = wave depth (m) = assumed 1 m
SA = surface area (m^2) = 2,500 m^2 (see Table A. 6*)*
2.1E-06 = decay constant (Bq Rn/s per Bq Ra-226)

During the Construction scenario, pump tests may also be completed towards the end of the construction phase for up to six months. Emissions from these pump tests can be estimated using the same above equations. For the assessment, it was conservatively assumed that pump tests would occur concurrently with all other construction activities.

A.16.3 Wellfield Restoration

For the Decommissioning scenario, wellfield restoration will be a source of radon gas. The mechanisms for release are similar to the production wellfield, therefore, the same equations outlined in Section A.16.2 are used. A description of the variables and the values that will be used in the wellfield restoration calculations are summarized in Table A. 12.

A.16.4 Other Sources

Other radon sources expected from the Project include:

- the core shack,
- the special waste pad,
- the process precipitates storage pad,
- the gypsum storage pad; and
- the ISR plant
    - recovered solution feed (in the process precipitates removal area)
    - process precipitates cake (in the process precipitates removal area)
    - yellowcake precipitation circuit
    - water treatment area.

For the storage areas, and the process precipitates cake in the ISR plant, the methods used by Ecometrix in support of the Worker Health assessment (EIS Section 10) and outlined in the International Atomic Energy Agency (IAEA) Technical Report Series No. 474 [17], were followed. The equation used to estimate radon gas from these sources is:

$$Rn = F_{Rn}\, A\, \frac{dw}{fw}\, S$$

Where:
Rn = radon emissions (g/s)
F_{Rn} = flux of Rn-222 (Bq/m²/s per Bq/g Ra-226)
A = activity concentration Ra-226 (Bq/kg)
dw/fw= dry weight to fresh weight ratio
S = surface area (m²)

The values that were used in the calculations are summarized in Table A. 13. Note that most variables in were selected by Ecometrix in support of the Worker Health assessment.

Radon emissions from the recovered solution feed, yellowcake precipitation circuit, and water treatment area in the ISR plant were calculated following the method recommended by Ecometrix and outlined in the U.S. Nuclear Regulatory Commission (NRC) document *Risk Assessment of Radon in Drinking Water* [16]. The equation used to estimate radon gas from these sources is:

$$Rn = \frac{10^3 \, C_{Rn} F \, T}{3600}$$

Where:
C_{Rn} = Ra-226 Concentration (Bq/L)
10^3 = conversion from L to m³
F = solution feed (m³/hour)
T = transfer efficiency = 0.55 (dimensionless)
3600 = conversion from hours to seconds

The Ra-226 activity levels were selected by Ecometrix and are 3,000 Bq/L, 1,350 Bq/L, and 610 Bq/L for the recovered mining solution, the yellowcake precipitate solution, and wastewater treatment solution, respectively. The solution feed rate was assumed to be 30 m³/hour.

One exception to the above methods is during the Decommissioning scenario when special waste will be removed from the storage pad and placed in the industrial landfill. To estimate radon emissions from special waste handling, the following equation was used:

$$Rn = \frac{10^6 \, M \, C_{Rn}}{3.15 \times 10^7}$$

Where:
M = material handling rate (tonnes/year)
C_{Rn} = Ra-226 concentration (Bq/g)
10^6 = conversion from tonnes to g
3.15E+07 = conversion from year to seconds

Further, it was assumed that the special waste will be removed over the summer months or 184 days.

Table A. 2: Production and Miscellaneous Data

Parameter	Units	Value	Notes	Comments/Questions
Operating Days per Year	number	345	[1]	95% plant availability = 345 operating days
Peak Production Rate - annual	lbs U_3O_8/year	12,000,000	[1]	
Average Production Rate - annual	lbs U_3O_8/year	8,955,000	[1]	
Production Rate - average daily	lbs U_3O_8/day	27,897	[1]	
ISR Plant Availability	%	95%	[1]	
Process plant feed rate (UBS solution) - avg. LOM	m^3/year	262,800	[1]	
Process plant feed rate (UBS solution) - avg. LOM	m^3/h	30	[1][2]	
Process Plant feed grade - avg. LOM	g/L	20	[1]	
Process plant U_3O_8 recovery	%	98.5	[1]	
Total disturbed area	Ha	169.6	[1]	For construction calculations. Total disturbed footprint for clearing/grubbing.
Construction cut/fill volume	m^3/year	1,325,904	[1]	Total cut/fill quantity
Material density - Mineralized drill cuttings	kg/m^3	3,600	[3]	Used average.
Material density - non-Mineralized drill cuttings	kg/m^3	3,600	[3]	Used average.
Material density - Aggregate (sand/gravel from borrow areas)	kg/m^3	1,650		Assumed.
Moisture content - Mineralized drill cuttings	%	11	[4]	Assumed.
Moisture content - non-Mineralized drill cuttings	%	11	[4]	Assumed.
Moisture content - Aggregate (sand/gravel from borrow areas)	%	11	[4]	Assumed.
Silt content - Ore cuttings	%	20		Assumed based on other projects in Saskatchewan.
Silt content - Special waste	%	20		Assumed based on other projects in Saskatchewan.
Silt content - Aggregate (sand/gravel from borrow areas)	%	12	[4]	Assumed.
Silt content - Roads	%	8.3	[5]	Assumed.
Mean wind speed	m/s	3.4		CALMET model output.
% of time wind speed >5.4 m/s	%	6.5		CALMET model output.

Parameter	Units	Value	Notes	Comments/Questions
Number of frozen days per year	Days	281	[6]	Key Lake Climate Normals. 84 frost-free days.
Number of days with rainfall > 0.2mm	Days	86		CALMET model output.
Control efficiency - natural (storage pads, unpaved roads) (winter)	%	90	[7]	
Control efficiency - watering (storage pads) (summer)	%	50	[8]	
Control efficiency - watering (outdoor material handling) (year-round)	%	0		Assume no control of fugitive dust.
Control efficiency - watering (unpaved roads) (summer)	%	70	[8][11]	Assumed. Controls on Highway 914 and onsite roads will achieve 70% through watering and/or chemical dust suppression. Assumes watering will occur at least 2+ times per day.
Control efficiency - speed <40 km/h (unpaved roads) (year-round)	%	44	[8]	
Diesel - fuel sulphur	%	0.0015	[9]	
Gasoline - fuel sulphur	%	0.0012	[10]	
Diesel - density	kg/L	0.85		
Gasoline - density	kg/L	0.74		
Vehicle speed - Grader	km/h	10		
Speed limit	km/h	30		

Notes:

[1] Design Basis Document. *20201012_WRE_EIS_Design Basis File freeze wall REV 1.xlsx.*

[2] Confirmed during teleconference call with Denison 22 June 2021.

[3] Site specific data provided by Denison.

[4] US EPA AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles, Table 13.2.4-1 [26]

[5] US EPA AP-42 Chapter 13.2.2 Unpaved Roads, Table 13.2.2-1 [24]

[6] Environment and Climate Change Canada (ECCC). Canadian Climate Normals 1981-2010 Station Data, Key Lake, Saskatchewan. Available at: https://climate.weather.gc.ca/

[7] Golder Associates. Determination of Natural Winter Mitigation of Road Dust Emissions from Mining Operations in Northern Canada, 2012 [3].

[8] Countess Environmental. 2006. Western Regional Air Partnership (WRAP) Fugitive Dust Handbook. September [4].

[9] Government of Canada. 2017. Sulphur in Diesel Fuel Regulations, SOR/2002-254 [30].

[10] Government of Canada. 2020. Sulphur in Gasoline Regulations, SOR/99-236 [31].

[11] ECCC Road dust emissions from unpaved surfaces: guide to reporting [25].

Table A. 3: Traffic Data

Road ID	Description	Start	End	Length (m)	Speed (km/h)	MaxPERF Truck	Crew Van	Loader	Haul Truck	Pick-up Trucks	Ambulance	Fire Truck	Delivery/Freight	Weight (tonnes)	Height (m)	Width (m)	Total Daily VKT
Construction Max Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	1	0	0	0	20	0	0	53	25	2.7	2.4	740
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	1	0	0	0	20	0	0	53	25	2.7	2.4	763
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	100	0	0	27	11	2.2	2.1	337
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	10	50	30	64	100	0	0	27	22	2.9	2.7	505
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	20	30	10	0	0	0	30	3.5	3.3	659
Construction Average Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	1	0	0	0	20 [2]	0	0	6	14	2.3	2.1	270
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	1	0	0	0	20 [2]	0	0	6	14	2.3	2.1	278
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	100	0	0	3	8	2.1	2.0	291
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	5	50	15	32	100	0	0	3	17	2.6	2.5	369
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	10	15	10	0	0	0	25	3.2	3.0	423
Operations Max Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	1	0	0	0	0	0	0	58	31	3.0	2.5	590
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	1	0	0	0	0	0	0	58	31	3.0	2.5	608
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	50	1	1	29	13	2.3	2.1	249
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	10	50	20	0	50	1	1	29	13	2.5	2.2	290
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	0	0	50	1	1	0	8	2.0	2.0	583
Operations Average Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	1	0	0	0	0	0	0	8	31	3.0	2.5	90
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	1	0	0	0	0	0	0	8	31	3.0	2.5	93
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	50	1	1	4	8	2.1	2.0	202
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	10	50	20	0	50	1	1	4	10	2.4	2.1	245
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	0	0	50	1	1	0	8	2.0	2.0	583
Decommissioning Max Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	0	0	0	0	0	0	0	17	31	3.0	2.5	170
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	0	0	0	0	0	0	0	17	31	3.0	2.5	175
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	50	1	1	9	9	2.1	2.0	211

Road ID	Description	Start	End	Length (m)	Speed (km/h)	MaxPERF Truck	Crew Van	Loader	Haul Truck	Pick-up Trucks	Ambulance	Fire Truck	Delivery/Freight	Weight (tonnes)	Height (m)	Width (m)	Total Daily VKT
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	0	50	0	64	50	1	1	9	27	2.9	3.1	315
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	0	30	50	1	1	0	25	2.8	2.9	866
Decommissioning Average Daily Traffic (One-Way Traffic)																	
HWY914	Highway 914	HWY914	ACCESS	5000	80	0	0	0	0	0	0	0	5	31	3.0	2.5	50
ACCESS	Access road from Hwy 914	ACCESS	SITE1/2	5155.6	30	0	0	0	0	0	0	0	5	31	3.0	2.5	52
SITE1	Site road to accommodations area	SITE1	SITE3	951.9	30	0	50	0	0	50	1	1	3	8	2.1	2.0	200
SITE2	Site road to ISR plant	SITE2	SITE3	899.1	30	0	50	0	32	50	1	1	3	20	2.6	2.7	246
SITE3	Site road from ISR plant to airport	SITE3	Airport	4705	30	0	10	0	15	50	1	1	0	18	2.5	2.6	725

Notes:
VKT = vehicle kilometres travelled
[1] Vehicle weight, height, and width are weighted averages calculated based on vehicle information in Table A. 4.
[2] At the time the assessment was completed, 20 pick-up trucks were assumed. However, the expected amount is 4 trucks. As such, the assumption used in the assessment is conservative.

Table A. 4: Vehicle/Equipment Information

Vehicle Type	Make/ Model	EF-Type	Fuel Type	Engine Size (HP)	Vehicle Height (m)	Vehicle Width (m)	Empty Weight (tonnes)	Full Weight (tonnes)	Avg. Weight (tonnes)	Capacity (tonnes)	Fuel Consumption (L/h)
MaxPERF Truck	Kenworth T800	On-Road HDV	Diesel	510	3.0	2.5	24.9	36.3	30.6	11.3	76.7
Crew Van	Ford E-350	On-Road MDV	Gasoline	350	2.1	2.0	4.6	8.4	6.5	3.8	6.2
Loader	JD 410L	Off-Road	Diesel	116	3.9	2.3	8.2	9.5	8.8	1 m^3	13.7
Haul Truck	CAT 772G	Off-Road	Diesel	605	4.3	4.8	35.0	82.0	58.5	47.0	50
Pick-up Trucks	Ford F250	On-Road LDV	Gasoline	430	2.0	2.0	6.4	9.9	8.2	3.5	4.9
Ambulance	-	On-Road MDV	Gasoline	255	2.0	2.0	5.0	5.0	5.0	n/a	9.7
Fire Truck	-	On-Road MDV	Diesel	300	4.0	3.0	20.0	25.0	22.5	n/a	19.6
Delivery/Freight	Kenworth T800	On-Road HDV	Diesel	510	3.0	2.5	24.9	36.3	30.6	11.3	76.7
Cement Truck	SCM Twin Cementer	On-Road HDV	Diesel	750	n/a	n/a	n/a	n/a	n/a	n/a	102.4
Water truck	-	Off-Road	Diesel	425	n/a	n/a	n/a	n/a	n/a	n/a	19.6
Grader	JD 770	Off-Road	Diesel	152	n/a	n/a	n/a	n/a	n/a	n/a	42.0
Dozer	D11	Off-Road	Diesel	913	n/a	n/a	n/a	n/a	n/a	n/a	110.0
Forklift	JLG 943	Off-Road	Diesel	110	n/a	n/a	n/a	n/a	n/a	n/a	13.7
Man lift	JLG 400	Off-Road	Diesel	49	n/a	n/a	n/a	n/a	n/a	n/a	6.0
Skid steer	JD 324G	Off-Road	Diesel	47	n/a	n/a	n/a	n/a	n/a	n/a	12.8
Flat deck truck	M2106 freightliner	Off-Road	Diesel	350	n/a	n/a	n/a	n/a	n/a	n/a	37.5
Vacuum truck	Peterbilt 348	Off-Road	Diesel	380	n/a	n/a	n/a	n/a	n/a	n/a	51.1
Crane	RT765E-2	Off-Road	Diesel	260	n/a	n/a	n/a	n/a	n/a	n/a	42.0
DR drill rig	Foremost DR-12	Off-Road	Diesel	525	n/a	n/a	n/a	n/a	n/a	n/a	88.0
Mud rotary drill rig	Ingersoll Rand TH-100	Off-Road	Diesel	470	n/a	n/a	n/a	n/a	n/a	n/a	76.7

Notes:
n/a – information not required for emissions calculations; HDV = heavy-duty vehicle; MDV = medium-duty vehicle; LDV = light-duty vehicle

Table A. 5: Material Handling Rates for Operations and Decommissioning

Scenario	Description	Material Origin	Material Type	Handling Rate (tonnes/year)
Max Operations	Well cuttings to loader	Injection wells	Mineralized	6,755
	Well cuttings to loader	Recovery wells	Mineralized	2,252
	Well cuttings to loader	Freeze wells	Blend	1,943
	Well cuttings to loader	Monitoring wells	Clean	0
	Well cuttings to special waste pad	Injection/recovery/freeze wells	Mineralized	9,977
	Well cuttings to clean waste pad	Freeze/monitoring wells	Clean	971
	Borrow materials for landfill cover (summer only)	Borrow pit	Aggregate	13,531
	Domestic landfill cover (summer only)	Borrow pit	Aggregate	4,510
	Construction waste laydown area cover (summer only)	Borrow pit	Aggregate	4,510
	Industrial landfill cover (summer only)	Borrow pit	Aggregate	4,510
Average Operations	Well cuttings to loader	Injection wells	Mineralized	6,755
	Well cuttings to loader	Recovery wells	Mineralized	2,252
	Well cuttings to loader	Freeze wells	Blend	1,943
	Well cuttings to loader	Monitoring wells	Clean	0
	Well cuttings to special waste pad	Injection/recovery/freeze wells	Mineralized	9,977
	Well cuttings to clean waste pad	Freeze/monitoring wells	Clean	971
	Borrow materials for landfill cover (summer only)	Borrow pit	Aggregate	13,531
	Domestic landfill cover (summer only)	Borrow pit	Aggregate	4,510
	Construction waste laydown area cover (summer only)	Borrow pit	Aggregate	4,510
	Industrial landfill cover (summer only)	Borrow pit	Aggregate	4,510
Max. Decommissioning	Special waste to industrial landfill (summer only)	Special waste pad	Mineralized	317
	Borrow materials for landfill cover (summer only)	Borrow pit	Aggregate	13,531
	Domestic landfill cover (summer only)	Borrow pit	Aggregate	6,766
	Construction waste laydown area cover (summer only)	Borrow pit	Aggregate	6,766
Average Decommissioning	Special waste to industrial landfill (summer only)	Special waste pad	Mineralized	317
	Borrow materials for landfill cover (summer only)	Borrow pit	Aggregate	13,531

Scenario	Description	Material Origin	Material Type	Handling Rate (tonnes/year)
	Domestic landfill cover (summer only)	Borrow pit	Aggregate	6,766
	Construction waste laydown area cover (summer only)	Borrow pit	Aggregate	6,766

Notes:
Material handling emissions for construction activities captured under general construction calculations (Section A.1)

Table A. 6: Storage Area Information

Name	Description	Max. Footprint (m^2)	Max. Storage Capacity	Max. Height (m)	Final Disposal Plan/Location [2]
Clean waste pad	Clean drill waste storage area	2,500	17,024 tonnes	4	Clean waste can be used for road maintenance or used during reclamation for soil cover. Remaining will be contoured.
Special waste pad	Mineralized drill cuttings storage area and contaminated ground from spills.	2,500	317 tonnes	0 [1]	Mineralized waste disposed of in industrial landfill.
Domestic landfill		6,000	n/a	0	Cover & revegetate.
Construction waste laydown area		2,500	n/a	0	Cover & revegetate.
Industrial landfill		10,000	n/a	0	Cover & revegetate.
Process precipitate pond	Process plant radioactive waste	5,776	10,000 m^3	0 [1]	Removed from site at the end of operation for processing.
Uranium rich solution holding area	Process solution pond	3,481	5,000 m^3	0	Process solution in the ponds through the mill and remove any sludge. Cover pond with geotextile liner system (encapsulate in place), drainage layer and rocks.
Industrial WWTP precipitate pond	Process plant waste	22,500	50,000 m^3	0	Removed from site at the end of operation for processing.

Notes:
[1] Special waste pad and process precipitates will be sub-grade.
[2] Assumed worst-case options for air quality emissions based on preliminary decommissioning plans.

Table A. 7: Drilling Data

Well Type	Hole Size (diameter x depth)	Total Number	Max Number Per Year			Notes
			Construction	Operations	Decomm.	
Injection	12" x 600 m	300	30	43	n/a	
Recovery	12" x 600 m	100	20	14	n/a	
Freeze	5" x 600 m	500	75	71	n/a	Assume half in mineralized waste
Monitoring	5" x 600 m	50	50	0	n/a	Clean waste
Well Type	**Hole Size (m^3)**	**Total Quantity (tonnes)**	**Material Amounts (tonnes)**			**Notes**
			Construction	Operations	Decomm.	
Injection	43.8	11483	4728	6755	n/a	
Recovery	43.8	5404	3152	2252	n/a	
Freeze	7.6	3995	2052	1943	n/a	Assume half in mineralized waste
Monitoring	7.6	1368	1368	0	n/a	Clean waste

Table A. 8: Propane Consumption

Scenario/Location	Value	Units
Construction Propane Consumption		
Construction heating	386,211	L/year
Operations Propane Consumption		
ISR Plant heating	4,237,539 [1]	L/year
Pumphouse heating	4,985	L/year
Freeze plant heating	82,862	L/year
Operations centre heating	85,433	L/year
Camp heating	288,789	L/year
Storage building heating	19,694	L/year
Substation propane	5,539	L/year
Airport terminal heating	15,435	L/year
Decommissioning Propane Consumption		
ISR Plant heating	1,460,527 [1]	L/year
Pumphouse 1 heating	0	L/year
Pumphouse 2 heating	0	L/year
Pumphouse 3 heating	0	L/year
Freeze plant heating	82,862	L/year
Operations centre heating	85,433	L/year
Camp heating	288,789	L/year
Storage building heating	19,694	L/year

Scenario/Location	Value	Units
Substation propane	5,539	L/year
Airport terminal heating	15,435	L/year

Notes:
[1] Excludes calciner burner consumption – this is accounted for in the calciner exhaust emission rates (see Section A.13).

Table A. 9: Geochemistry Data

Material	As	Cd	Co	Cu	Pb	Mo	Ni	Se	U	Vn	Zn	Cr	Ra-226	
	%												Bq/g or Bq/L	
Clean waste [1]	0	0	0	0	0	0	0	0	0	0	0		0	
Mineralized waste	0.0327	0.0039	0.0192	0.9596	0.9968	0.0388	0.0516	0.0090	24.20	0.1015	0.3291	0.050	2061	Bq/g
Gypsum [2]	0	0	0	0	0	0	0	0	0	0	0	0	0.6	Bq/g
Borrow material [1]	0	0	0	0	0	0	0	0	0	0	0	0	0	
Yellowcake	0.0001	0.0039	0.0192	0.9596	0.9968	0.0001	0.0516	0.0090	60.10	0.1	0.3291	0.050	nd	

Notes:
nd = no data
[1] Clean waste and borrow quarry materials assumed to have negligible quantities of uranium, metals, and radionuclides.
[2] Material assumed wet, therefore, no emissions of uranium or metals in dust are not expected.

Table A. 10: Radon Calculation Variables for Wellfield Drilling

Variable	Description	Value	Notes
[Ra]	Concentration of Ra-226 in ore (pCi/g)	55,700	Pre-feasibility Study, Table 13-8 [36]. 2,061 Bq/g.
E	Emanating power (dimensionless)	0.2	Typical value used in other uranium mine projects in Saskatchewan.
L	Decay constant of Rn-222 (1/d)	0.181	Constant.
T	Storage time in mud pit (d)	1	Storage time in mud tanks instead of a pit.
M	Average mass of ore material in the pit (g)	3.61E+06	Calculated based on ore zone thickness, drill hole diameter, and bult density.
N	Number of mud pits generated per year	100	Use wells instead of pits. 50 wells per year with safety factor of 2.
	Ore zone thickness (m)	6	
	Drill hole diameter (inches)	12	Diameter ranges from 6 to 12 inches. Used maximum.
	Ore bulk density (g/cm^3)	8.24	Extracted from Denison Geological Database.

Table A. 11: Radon Calculations Variables for Wellfield Production

Variable	Description	Value	Notes
V	Volume of water in circulation (L)	6.62E+06	Calculated from mined area (A), ore body thickness (D) and porosity of ore (p). V = A x D x p x 1000 L per m^3.
C_{Rn}	Rn-222 concentration in process water (pCi/L)	3.23E+7	Calculated.
F	Fraction of radon source carried by circulating water (dimensionless)	0.8	Default.
L	Decay constant of Rn-222 (1/d)	0.181	Constant.
V	Rate of radon venting from piping and valves during circulation (1/d)	0.01	Default.
Fp	Purge rate of treated water (L/d)	0	Captured in Fi
Fi	Water discharge rate to recovered solution pond (L/d)	7.20E+05	30 m^3/h
10^6	Unit conversion factor (cm^3/m^3)	1.0E+06	Constant.
E	Emanating power of active ore zone (dimensionless)	0.06	
[Ra]	Ra-226 concentration in ore zone (pCi/g)	55,700	Pre-feasibility Study, Table 13-11 [36]. 2,061 Bq/g.
A	Active area of ore zone (m^2)	6.13E+03	Area of Phase 5 measured from drawings (approx. 9700 m^2), which is mined over 19 months.
D	Average thickness of ore zone (m)	6	
P	Bulk density of ore material (g/cm^3)	3.6	Extracted from Denison Geological Database.
p	Ore porosity (%)	0.18	Maximum from Table 13-5 of Prefeasibility Study [36].

Table A. 12: Radon Calculation Variables for Wellfield Restoration

Variable	Description	Value	Notes
V	Volume of water in circulation (L)	6.62+06	Calculated from mined area (A), ore body thickness (D) and porosity of ore (p). V = A x D x p x 1000 L per m^3.
C_{Rn}	Rn-222 concentration in process water (pCi/L)	3.54E+07	Calculated.
F	Fraction of radon source carried by circulating water (dimensionless)	0.8	Default.
L	Decay constant of Rn-222 (1/d)	0.181	Constant.
V	Rate of radon venting from piping and valves during circulation (1/d)	0.01	Default.
Fp	Purge rate of treated water (L/d)	5.45E+05	Assume a purge rate of 100 gallons per minute.
Fi	Water discharge rate to recovered solution pond (L/d)	0	No recovered solution, therefore, Rn_u is zero.
10^6	Unit conversion factor (cm^3/m^3)	1.0E+06	Constant.
E	Emanating power of active ore zone (dimensionless)	0.06	
[Ra]	Ra-226 concentration in ore zone (pCi/g)	5.57E+04	Pre-feasibility Study, Table 13-8 [36]. 2,061 Bq/g.
A	Active area of ore zone (m^2)	6.13E+03	Same as operations.
D	Average thickness of ore zone (m)	6	
P	Bulk density of ore material (g/cm^3)	3.6	Extracted from Denison Geological Database.
p	Ore porosity (%)	0.18	Maximum from Table 13-5 of Prefeasibility Study [36].

Table A. 13: Radon Calculation Variables for Other Sources

Material	Location	Flux of Rn/Ra concentration ($Bq/m^2/s$ per Bq/g Ra-226)	Activity concentration Ra-226 (Bq/g)	dw/fw Ratio	Surface area (m^2)
Ore (dry) [1]	Core shack	0.08	2061	0.9	0.96
Ore (cuttings) [1]	Special waste pad	0.9	2061	0.7	2,500
Sludge (moist) [1]	Process precipitates storage pad	0.6	240	0.5	22,500
Process precipitate cake [1]	Process precipitates removal area in ISR plant	0.9	240	0.8	2.35
WWTP solids [2]	Gypsum pond	0.6	0.6	0.5	67,500

Notes:
[1] Variables previously selected by Ecometrix.
[2] WWTP solids will be disposed of in the gypsum pond. Flux and dw/fw were assumed to be like the process precipitates storage pad (i.e., moist sludge).

Appendix B:

CALMET/CALPUFF Information

B.1 CALMET

To overcome the limited meteorological observing record in the Project study area, a meteorological data set was generated using a combination of surface observations from Key Lake airport and data from the Weather Research Forecast Non-Hydrostatic Mesoscale Model (WRF-NMM) for the 2016 calendar year. The model year was selected in consultation with Dennis Fudge at the Saskatchewan Ministry of the Environment (SaskMoE) [19] so that the SaskMoE could compare the CALMET model results to their AERMOD-ready regional meteorological data set applicable to the Project Study Areas. The CALMET modelling approach and results were detailed in a technical memo [37]and reviewed by the SaskMoE in April and May 2021 [38] [39] [40].

B.1.1 Meteorology

WRF-NMM was run in hindcast mode and initialised using North American Mesoscale Forecast System (NAM) analyses available from the U.S. National Centre for Environmental Prediction (NCEP). The NAM analyses assimilate meteorological observations (e.g., land surface measurements, radiosonde, etc.) and are available every six hours at a 12 kilometre (km) horizontal grid resolution. WRF-NMM uses the NAM analyses as both the initial conditions and boundary conditions within the model and updates these values every 24 hours and six hours, respectively.

The WRF-NMM model was run using a grid spacing of 4 km to better resolve meteorological features within the Project Study Areas. The outputs from WRF-NMM were used to generate a 3D.DAT file to input to the CALMET model. The CALMET model (version 6.5) was then run in "NOOBS" mode 2, which uses the 3D.DAT file for all surface and upper air data. Two CALMET runs were completed: one for a 60 km by 60 km domain having a horizontal grid spacing of 1 km; and one for a 20 km by 20 km domain having a horizontal grid spacing of 200 metres (m). This approach was necessary to reduce model run times and to generate reasonably sized CALMET output files for input to CALPUFF.

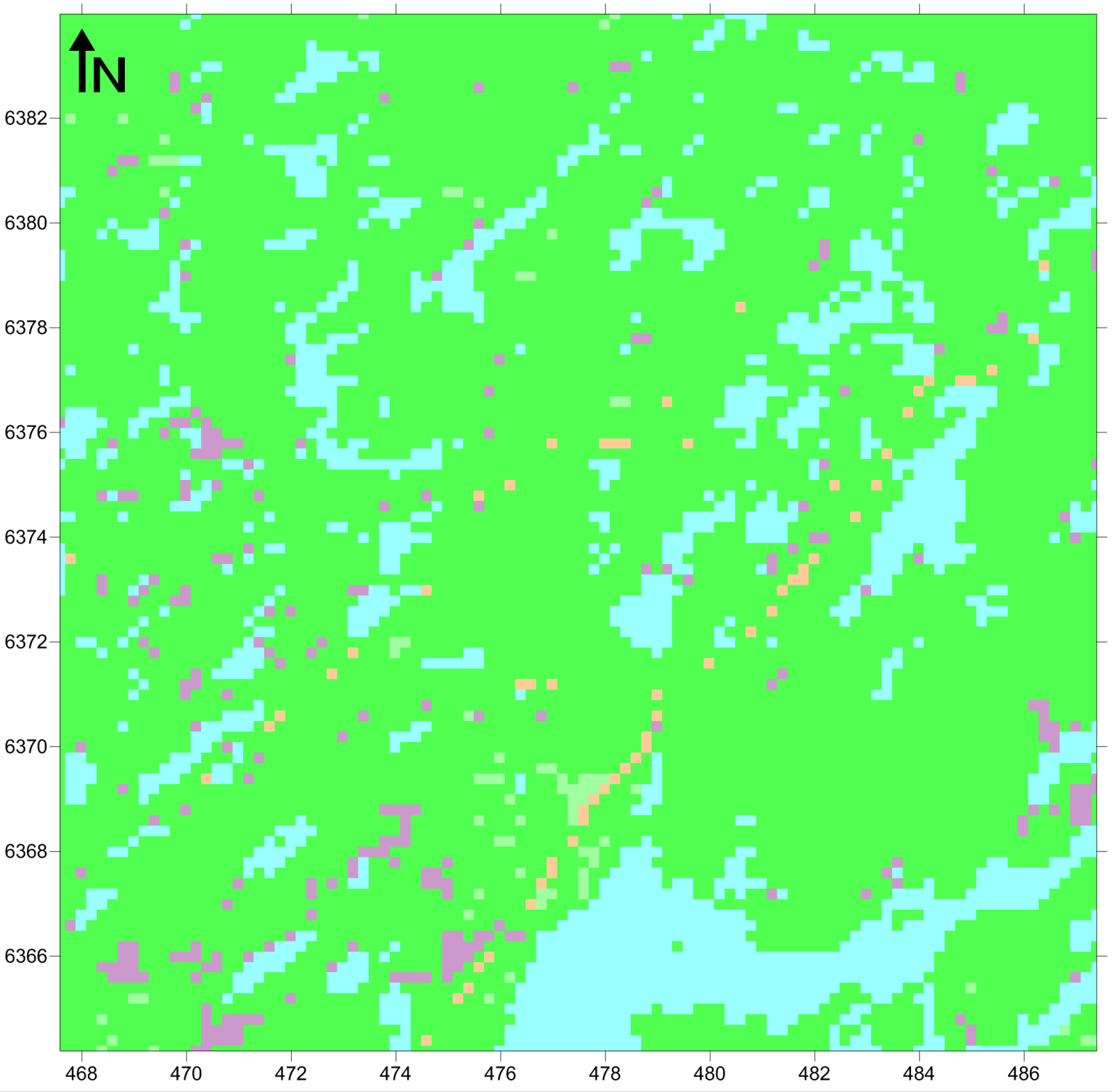
Following an evaluation of the CALMET model run in NOOBS mode 2, problems with the WRF-NMM model results were discovered, which were ultimately attributed to issues in the NAM data files:

- total cloud cover was overestimated,
- total precipitation was overpredicted, and
- extreme minimum temperatures were overestimated in most months, while extreme maximum temperatures were underestimated in the winter and slightly overestimated during the summer.

Due to the problems with the NAM data, temperature and cloud cover data from Key Lake airport were used instead of WRF-NMM data. At an approximate distance of 35 km, Key Lake is the closest observing station to the Project site. To correct precipitation, hourly outputs from WRF-NMM were scaled down using the ratio of total annual precipitation from WRF-NMM (625.7 mm) to total annual precipitation from the 1981-2010 Key Lake climate normals (482.5 mm). The resulting hourly precipitation file was used as input to CALMET. CALMET was then run in "NOOBS" mode 1 using a combination of WRF-NMM outputs and observations from Key Lake to produce surface and precipitation files. The 3D.DAT file generated by WRF-NMM was used for upper air observations.

B.1.2 Terrain and Land Use Data

The terrain data used for CALMET was Shuttle Radar Topography Mission (SRTM) elevation data [41] and used to run the TERREL preprocessor program (version 7). Land use files were generated using the program CTGPROC (version 7) and data from the Canadian Land Cover Geobase Series [42]. Separate land use files were made for 'summer' (May to October) and 'winter' (November to April). To make a winter file, the summer file was modified to change all small water body land use (code 51) to ice/snow (code 90). The MAKEGEO program (version 3.2) was then used to merge terrain and land use data into a geophysical data file for CALMET. The resulting land use and terrain data for the inner CALMET domain are shown in Figure B. 1, Figure B. 2, and Figure B. 3.



Legend

- 100
- 90 (snow/ice)
- 80 (tundra)
- 70 (barren land)
- 60 (wetland)
- 55 (large water body)
- 50 (small water body)
- 40 (forest)
- 30 (rangeland)
- 20 (agricultural)
- 10 (urban)

Notes

Land use produced by MAKEGEO for the 20 km by 20 km CALMET domain

Map Reference

NAD83 UTM (km) Zone 13

Independent Envrionmental Consultants

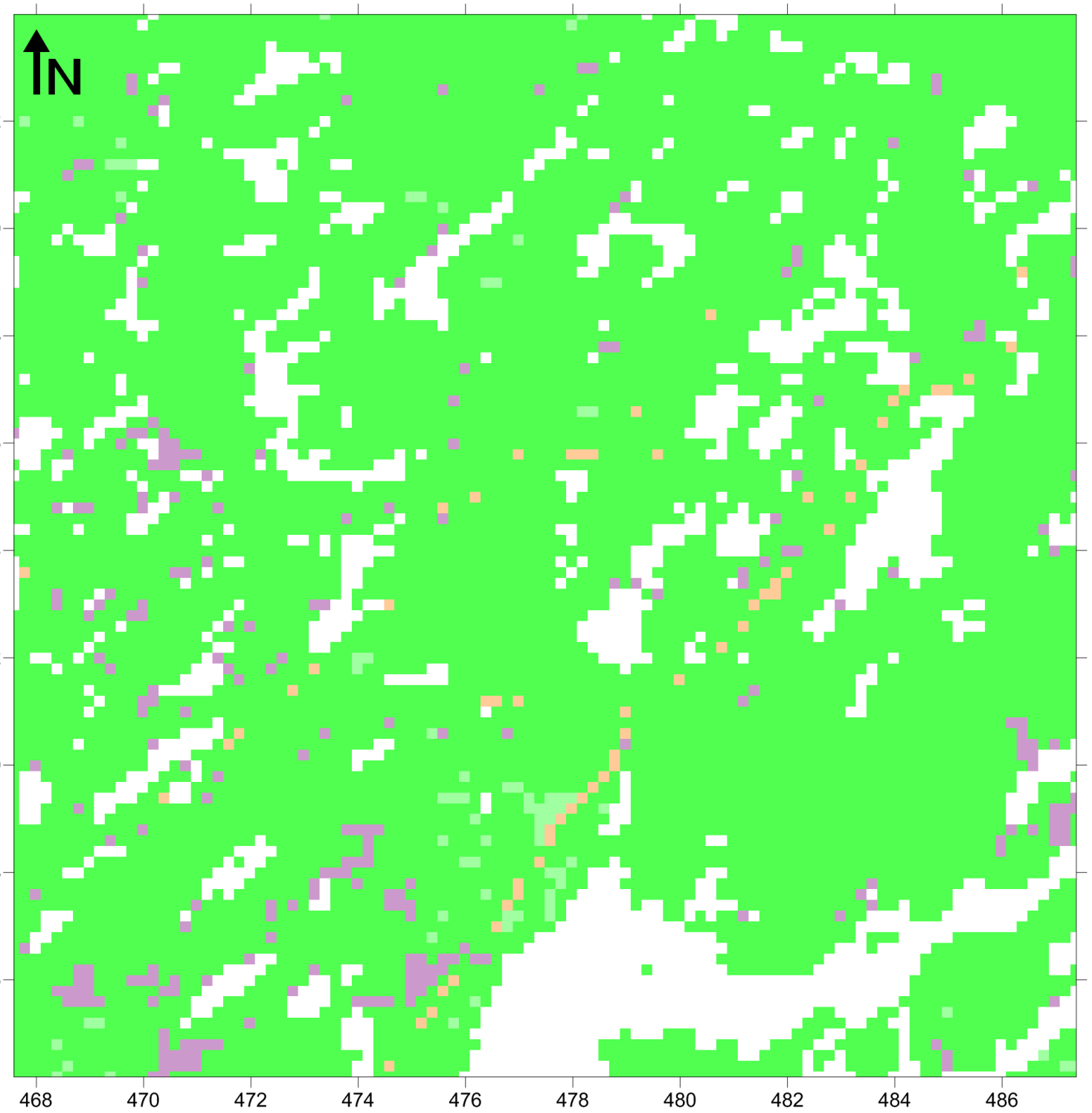
Denison Mines

Wheel River Project EIA

Figure B.1

CALMET Land Use - Summer

Project	Date
SX19-0043	Mar 2022



Legend

- 100
- 90 (snow/ice)
- 80 (tundra)
- 70 (barren land)
- 60 (wetland)
- 55 (large water body)
- 50 (small water body)
- 40 (forest)
- 30 (rangeland)
- 20 (agricultural)
- 10 (urban)

Notes

Land use produced by MAKEGEO
for the 20 km by 20 km CALMET domain

Map Reference

NAD83 UTM (km) Zone 13

Independent Envrionmental Consultants

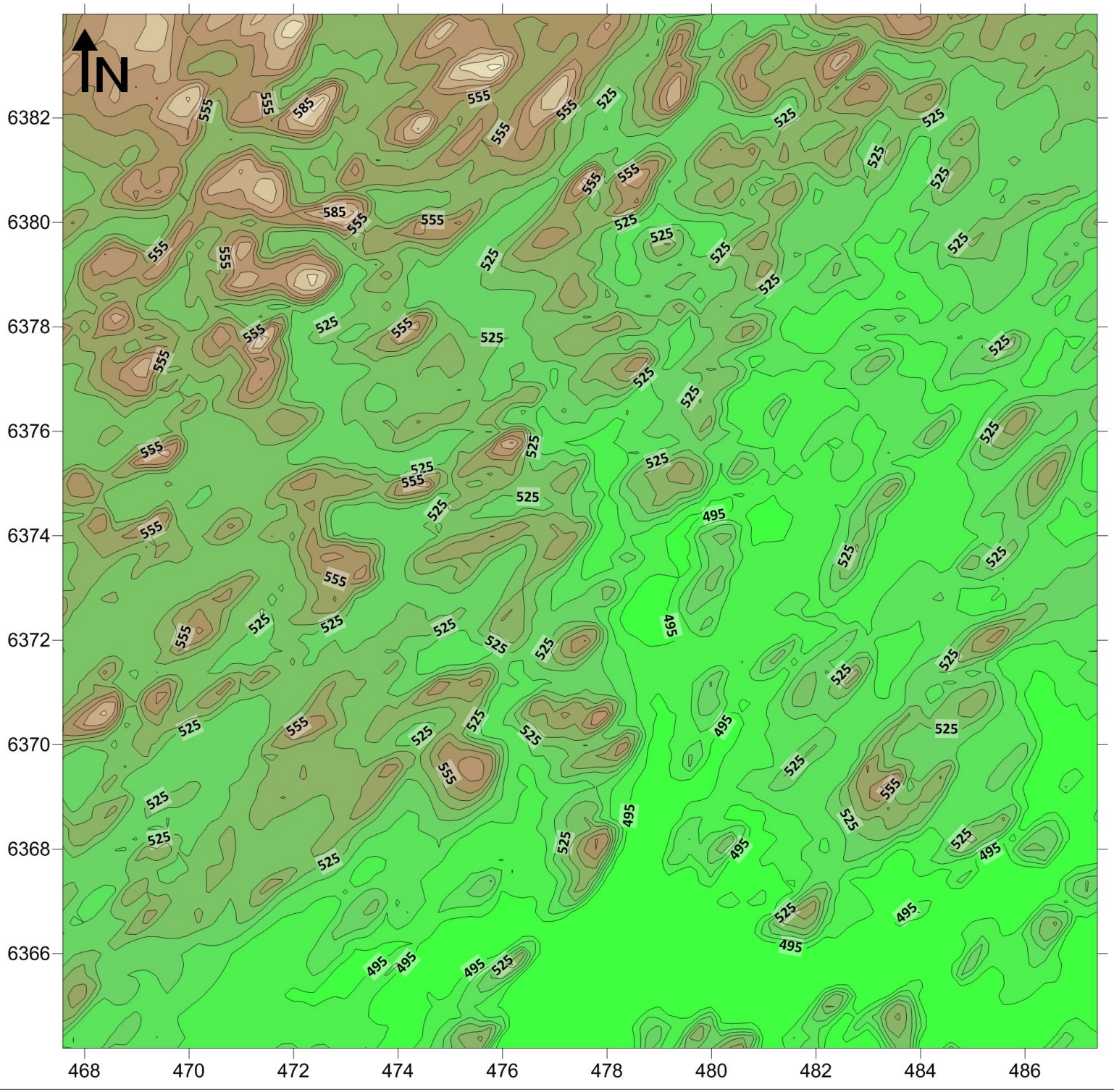
Denison Mines

Wheel River Project EIA

Figure B.2

CALMET Land Use - Winter

Project	Date
SX19-0043	Mar 2022



Legend

Terrain Elevations (m)

605
595
585
575
565
555
545
535
525
515
505
495
485

Notes

Terrain produced by MAKEGEO
for the 20 km by 20 km CALMET domain

Map Reference

NAD83 UTM (km) Zone 13

Independent Envrionmental Consultants

Denison Mines

Wheel River Project EIA

Figure B.3

CALMET Terrain

Project	Date
SX19-0043	Mar 2022

B.1.3 CALMET Options

The following table provides all non-default options used in the CALMET modelling.

CALMET Option	Selected Option	Explanation
No. of Vertical Layers	NZ = 10	10 vertical layers used: 0, 20, 40, 80, 160, 300, 600, 1000, 1500, 2200, 3000 m
No Observation Mode	NOOBS = 1	Use surface and overwater stations (no upper air observations). Use 3D.DAT for upper air data.
Number of surface stations	NSSTA = 1	One surface station
Number of precipitation stations	NPSTA = 1	One precipitation station
Extrapolate surface wind observations to upper layers	IEXTRP = -1	No extrapolation is done. 3D.DAT used for upper air.
Layer-dependent biases modifying the weights of surface and upper air stations	BIAS = 0.0	3D.DAT used for upper air
Use varying radius of influence	LVARY = T	Use varying radius of influence
Maximum radius of influence over land in the surface layer	RMAX1 = 1	Maximum radius of influence of surface stations over land is 1 km
Maximum radius of influence over land in the layer aloft	RMAX2 = 1	Maximum radius of influence of upper air stations over land is 1 km
Maximum radius of influence over water	RMAX3 = 1	Maximum radius of influence of upper air stations over water is 1 km
Radius of influence of terrain features	TERRAD = 1	Terrain effects are considered up to 1 km for each grid point
Relative weighting of the first guess field and observations in the surface layer	R1 = 1	Weighting used for surface layer is 1km
Relative weighting of the first guess field and observations in the layers aloft	R2 = 1	Weighting used for layers aloft is 1 km
Maximum number of stations used in each layer for the interpolation of data to a grid point	NINTR2 = 5	Number of stations for each layer is 5
3D temperature from observations or from prognostic data	ITPROG = 1	Use Surface stations and 3D.DAT for upper air data
Radius of influence for temperature interpolation	TRADKM = 50	Radius of influence is 50 km
Maximum search radius in averaging process	MNMDAV = 10	10 grid cells used to make mixing height more uniform
Maximum overwater mixing height	ZIMAXW = 2500	Maximum overwater mixing height is 2500 m
Maximum number of stations to include in temperature interpolation	NUMTS = 1	Number of surface stations is 1

CALMET Option	Selected Option	Explanation
Land use categories for temperature interpolation over water	JWAT1 = 999 JWAT2 = 999	Temperature interpolation disabled using 999
Precipitation interpolation parameters, radius of influence	SIGMAP = 50	Radius of influence is 50 km

As mentioned above, the CALMET modelling was reviewed by the SaskMoE [38] [39] [40]. During the review process, the selection of terrain data and non-default CALMET options were discussed and the sensitivity of the model to the selection of the following parameters was tested:

- Shuttle Radar Topography (STRM3) terrain data vs. Canadian digital elevation data (CDEM),
- TERRAD = 6 km vs. 1 km, and
- NINTR = 99 vs. 5.

From the testing process, it was determined that the CALMET model results were not sensitive to these parameters and would have a minimal impact on the CALPUFF model results. Consequently, the non-default CALMET options presented in the above table were agreed to with the SaskMoE and applied in the model.

B.1.4 CALMET Results

Wind, temperature, precipitation, and atmospheric stability results from the CALMET model are presented below for a grid point near the centre of the Project site and compared to available observations for the same model year (2016). Comparisons are also made to the 30-year Climate Normals (1981 to 2010) for Key Lake, where available. To ensure that the 2016 CALMET data set is representative of current meteorological conditions, the most recent five years of Key Lake observations available at the time when the analysis was completed (2016 to 2020) are also discussed.

B.1.4.1 Wind Speed and Direction

Wind direction frequencies and the average wind speed (by direction) generated by CALMET are presented as a wind rose in Figure B. 4 for a grid point near the Project site. Figure B. 4 shows that the dominant wind direction at the Project site is northwest (NW) followed by west-northwest (WNW). The average wind speed is 3.4 m/s, and the percentage of calms (wind speeds less than 0.5 m/s) is 1.41%.

Due to a lack of observations near the Project site, a wind rose based on WRF-NMM outputs for a grid point near Key Lake airport was created and compared to observations from the NAV Canada Key Lake weather station (Climate ID 4063757) for both the 2016 calendar year and the 2016 to 2020 period. Figure B. 5 shows that there is good agreement between the observed wind speed and WRF-NMM. The average observed wind speed in 2016 and the 2016 to 2020 period is 3.6 m/s, while the average wind speed predicted by WRF-NMM at Key Lake airport is 3.9 m/s.

Generally, there is good agreement between observed and predicted wind directions, however, the SE and NW directions are slightly overestimated by WRF-NMM, while the E and W directions are underestimated. Comparing 2016 observations to observations for the 2016 to 2020 period, there has been little change in the

distribution of wind direction and wind speed, demonstrating that 2016 wind data is representative of current conditions.

Figure B. 4: Wind Rose from CALMET (2016) for a Grid Point Near the Project Site

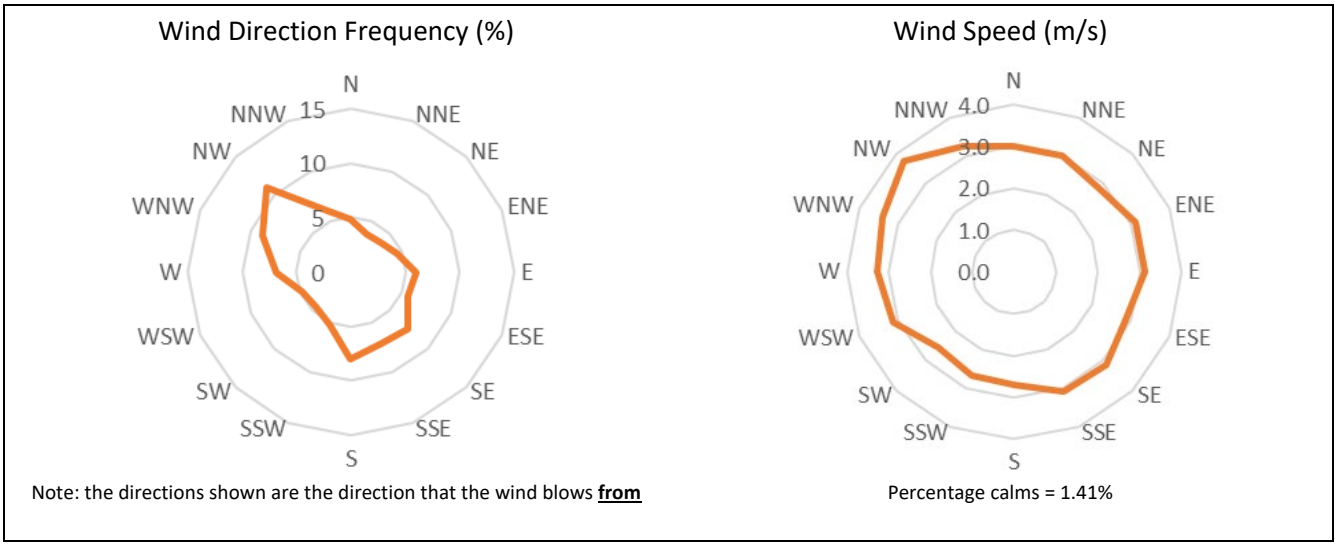
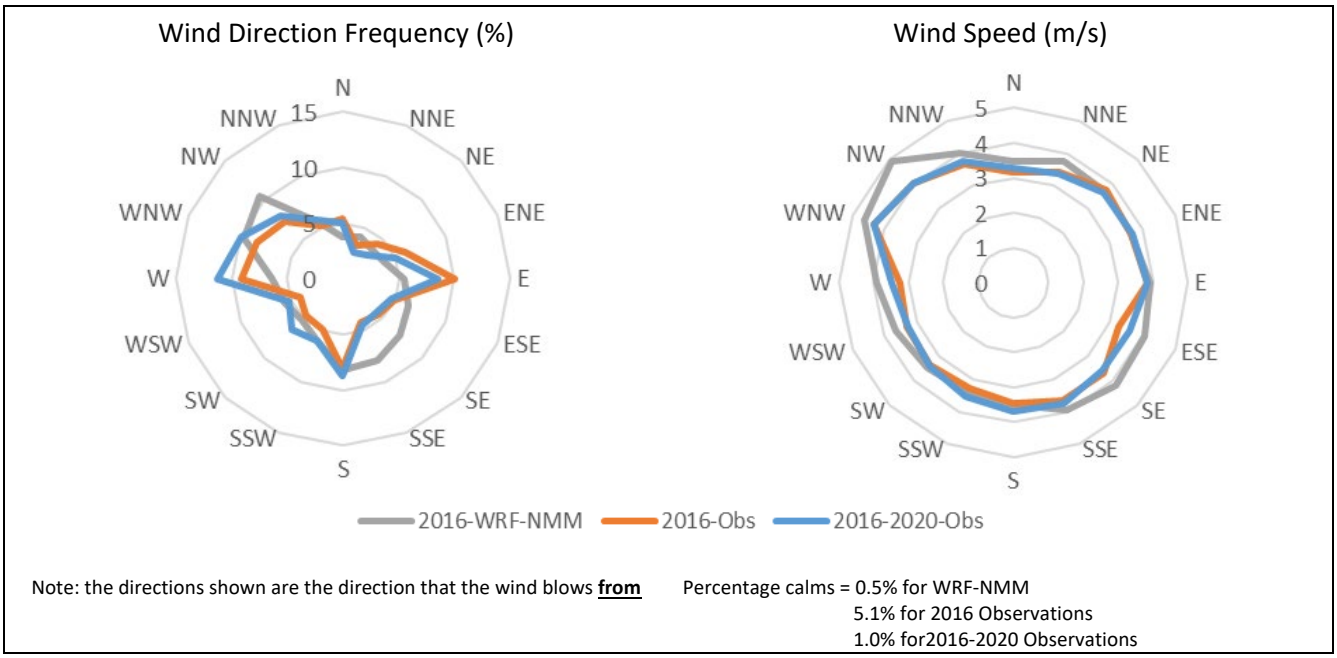


Figure B. 5: Wind Rose from WRF-NMM (2016) compared to Key Lake Airport Observations



B.1.4.2 Temperature

Mean daily, extreme maximum, and extreme minimum temperature data from the CALMET model are provided in Table B. 1 for a grid point near the Project site. The results are compared to surface observations from Key Lake for the 2016 calendar year, and the 2016 to 2020 period. These data were obtained from the Climate Baseline Report, provided under separate cover [43]. Table B. 1 also presents the Key Lake 30-year Climate Normals (1981 to 2010).

Based on the CALMET model, mean daily temperature ranges from -21.1°C to 16.9°C, with an overall annual average of -0.3°C. This compares well with mean daily surface observations in 2016, which range from -21.8°C to 16.0°C, with an overall annual average of -1.1°C. Extreme daily maximum and minimum temperatures also compare well. The extreme daily maximum from CALMET is 29.0°C and 29.5°C from the observations. The extreme daily minimum is -41.9°C from CALMET and -45.2°C from the observations.

Mean daily temperature observations for the 2016 to 2020 period range from -20.9°C to 16.1°C and have an overall annual average of -2.8°C. The extreme daily maximum for this period is 34.0°C, while the extreme daily minimum is -48.0°C. This temperature range is comparable to the 30-year Climate Normals, which have an average annual temperature of -2.3°C, and extremes of -52.5°C and 36°C. Compared to 2016 temperature data, the average annual temperature for the 2016 to 2020 period is slightly colder. This difference is driven by colder temperatures during most of the winter months. The impact of these temperature differences to the dispersion modelling would be minor. As discussed in Section B.2, most modelled sources are non-buoyant ground-based releases (i.e., volume sources and area sources), which are not sensitive to ambient temperature. For point sources, colder ambient temperatures would increase buoyancy and enhance dispersion and so, warmer temperatures in the 2016 data set would be conservative.

In addition to monthly temperature, the average diurnal temperature profile based on CALMET is presented in Figure B. 6. The Figure shows a typical daily temperature profile that increases shortly after sunrise and decreases after sunset, demonstrating that CALMET can reproduce the expected diurnal pattern of temperature.

B.1.4.3 Precipitation

Mean monthly precipitation amounts from the CALMET model are provided in Table B. 2 for a grid point near the Project site. The results are compared to the Key Lake observations for the 2016 calendar year and the 2016 to 2020 period [43]. Key Lake 1981-2010 Climate Normals are also presented for comparison.

Based on the CALMET model, mean monthly precipitation ranges from 10.5 mm to 101.1 mm and has an overall annual total of 485.8 mm, while the 2016 total from Key Lake observations was 550 mm. The annual total for the 2016 to 2020 period is 479.4 mm, which is comparable to the 30-year Climate Normals (482.5 mm). While the annual total from CALMET is less than the observed total in 2016, it compares well with the 2016 to 2020 period, illustrating that precipitation in the model is representative of recent meteorological conditions. It should be noted, however, that the CALPUFF model results are not sensitive to precipitation. Deposition of COPC is driven by dry mechanisms, therefore, precipitation has little impact on modelled deposition rates and concentrations.

Table B. 1: Monthly Temperature Data from CALMET (2016) Compared to Key Lake Airport Observations

Month	Mean Daily Temperature (°C)				Extreme Max. Temperature (°C)				Extreme Min. Temperature (°C)			
	CALMET 2016*	Key Lake Observ. 2016	Key Lake Observ. 2016-2020	Key Lake Climate Normals (1981-2010)	CALMET 2016*	Key Lake Observ. 2016	Key Lake Observ. 2016-2020	Key Lake Climate Normals (1981-2010)	CALMET 2016*	Key Lake Observ. 2016	Key Lake Observ. 2016-2020	Key Lake Climate Normals (1981-2010)
January	-17.1	-20.1	-22.3	1.0	2.0	4.5	10.0	-36.0	-38.7	-48.0	-52.5	-17.1
February	-19.3	-20.9	-18.7	2.0	2.5	8.0	9.0	-40.9	-45.2	-47.7	-48.5	-19.3
March	-10.3	-13.2	-11.7	7.0	7.5	12.3	15.0	-36.9	-40.4	-44.6	-50.5	-10.3
April	-3.2	-5.0	-1.9	21.0	20.8	20.8	28.5	-31.9	-35.6	-40.2	-40.0	-3.2
May	9.6	7.0	6.5	26.6	29.5	31.5	32.5	-2.0	-7.2	-24.6	-21.5	9.6
June	13.8	13.2	13.3	29.0	29.1	34.0	34.5	2.2	-1.2	-6.9	-5.0	13.8
July	16.0	16.1	16.3	29.0	29.0	31.4	33.5	4.2	0.8	-0.7	-1.0	16.0
August	13.9	14.1	14.7	26.0	27.5	32.1	36.0	2.2	-1.1	-1.5	-3.0	13.9
September	9.6	7.5	8.0	20.6	20.5	28.0	28.5	-0.9	-3.5	-8.0	-8.5	9.6
October	-1.3	-1.4	0.0	10.0	10.5	16.9	24.5	-11.9	-13.7	-23.2	-28.0	-1.3
November	-3.6	-11.6	-11.8	9.0	10.0	10.0	12.2	-22.9	-24.1	-36.2	-43.0	-3.6
December	-21.8	-18.8	-19.5	-3.3	-3.5	5.2	5.0	-41.9	-44.5	-46.4	-48.0	-21.8
Annual	**-1.1**	**-2.8**	**-2.3**	**29.0**	**29.5**	**34.0**	**36.0**	**-41.9**	**-45.2**	**-48.0**	**-52.5**	**-1.1**

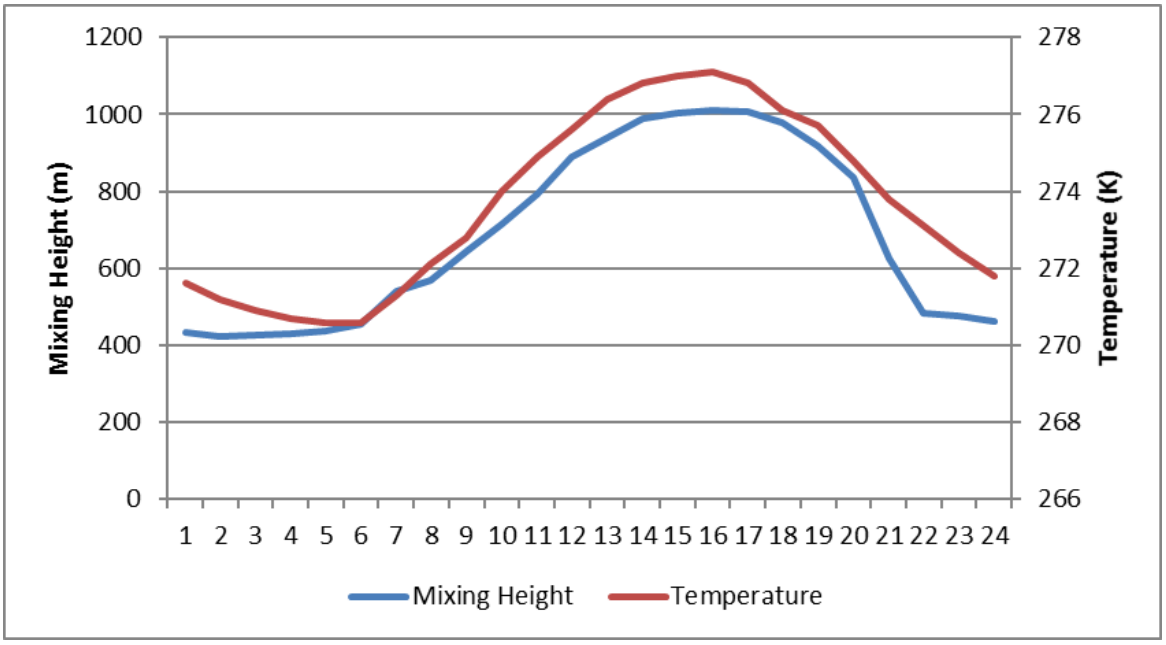
Notes:

*Data extracted from CALMET outputs for a grid point near the centre of the Project site

Key Lake observations from the Climate Baseline Report [43]

Key Lake Climate Normals available from https://climate.weather.gc.ca/climate_normals/index_e.html

Figure B. 6: Diurnal Temperature and Mixing Height Profiles from CALMET (2016)*



Notes:
*Data extracted from CALMET outputs for a grid point near the centre of the Project site

Table B. 2: Precipitation Data from CALMET (2016) Compared to Key Lake Observations and Climate Normals

Month	Mean Total Precipitation (mm)			
	CALMET 2016*	Key Lake Climate Normals (1981-2010)	Key Lake ECCC Station (2016)	Key Lake ECCC Station (2016 to 2020)
January	18.6	22.1	20.1	21.8
February	15.5	17.4	18.9	14.1
March	34.9	21.1	30.5	20.7
April	42.7	23.7	27.6	21.0
May	19.3	36.5	4.1	28.9
June	101.1	63.4	97.9	74.9
July	82.9	88.3	144.4	91.0
August	45.6	66.9	58.9	83.3
September	63.8	58	54.2	45.2
October	37.3	36.4	65.4	41.8
November	10.5	28.6	14.2	20.6
December	13.7	20.2	13.8	16.1
Annual	**485.8**	**482.5**	**550.0**	**479.4**

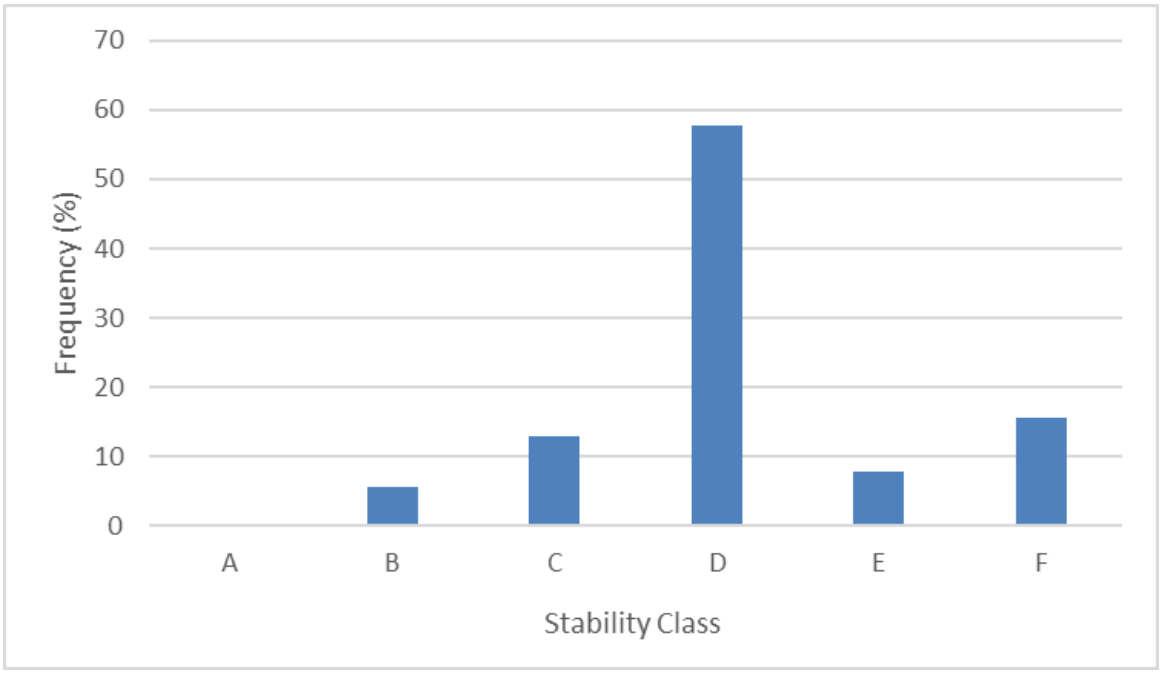
Notes:
*Data extracted from CALMET outputs for a grid point near the centre of the Project site
Key Lake observations from the Climate Baseline Report [43]
Key Lake Climate Normals available from https://climate.weather.gc.ca/climate_normals/index_e.html

B.1.4.4 Atmospheric Stability and Mixing Height

The occurrence of each stability class predicted by CALMET is presented in Figure B.7. The Figure shows that D stability class (neutral) occurs 57.6% of the time. Stability classes E and F, which are indicative of stable atmospheric conditions, are shown to occur 23.5% of the time. Finally, unstable conditions represented by classes B and C occur 18.7% of the time, while very unstable conditions (class A) occur very infrequently (less than 1% of the time). This type of distribution is expected for this region of Saskatchewan.

The diurnal variation of average annual mixing height produced by CALMET was shown in Figure B. 6. The Figure shows that the mixing height grows shortly after sunrise, peaks in the afternoon, and decreases shortly after sunset. Together, the stability class outputs and mixing height profile show that the boundary layer development is accurately represented by the CALMET model, which is important for air dispersion modelling.

Figure B. 7: Stability Class Distribution from CALMET (2016)*



Notes:
*Data extracted from CALMET outputs for a grid point near the centre of the Project site

B.2 CALPUFF

The following sections outline the CALPUFF model setup including a description of the sources, building layout, and receptor grids that were used in the model. The CALPUFF model setup and input file were provided to the SaskMoE for review. The SaskMoE indicated that the source setup and CALPUFF model switches were appropriate [44].

B.2.1 Modelled Sources

Three types of sources were used in the CALPUFF model to represent the various emission sources at the mine, including volume sources, area sources, and point sources. Majority of the emission sources, including general construction activities, the wellfield, waste storage pads/areas, and landfills were represented using area sources. Note that some sources must be represented by multiple area sources. Area sources should not have a length to width ratio greater than 10:1 and ideally should not span across a CALMET grid. Therefore, in some cases multiple area sources must be used to represent a single source. For example, 27 sources were used to represent general construction activities. Point sources were used to represent emissions from stacks where relevant stack information was available (e.g., ISR stacks and generators). Finally, unpaved roads and sources lacking specific point source parameters like general ventilation sources and propane heating, were represented by volumes sources.

Figure B. 8 presents the physical configuration of the proposed model sources for the Construction scenario, while Figure B. 9 and Figure B. 9 present the proposed model sources for the Operations and Decommissioning scenarios. For simplicity, the roads are shown as lines, but as noted above, they will be modelled as a series of volume sources. For detailed source parameters, see Table B. 3 (area sources), Table B. 4 (volume sources), and Table B. 5 (point sources). Note that the locations of the modelled sources are listed in UTM coordinates in metres relative to the NAD83 datum (Zone 13N).

Table B. 3: CALPUFF Area Source Parameters

Model ID	Description	Elevation (m)	Height (m)	Model Area (m^2)	UTM Coordinates - SW Corner	
					X (m)	Y (m)
CONST	General construction area sources (27 areas)	Various	0	991,000	Various	
PH5_1	Phase 5 wellfield area 1	542.67	0	10,924	476747	6373889
PH5_2	Phase 5 wellfield area 2	543.77	0	11,433	476883	6373932
FE_RA	Process precipitates pond	530.57	0	5706	477031	6374489
UBS	Uranium rich solution holding area (pond)	534.75	0	2,425	477227	6374394
LNDFL_1	Domestic landfill area 1	539.28	0	3,219	476161	6372235
LNDFL_2	Domestic landfill area 2	540.44	0	5,644	476175	6372289
LNDFL_C	Construction waste laydown area	540.11	0	2,214	476259	6372353
SWPAD	Special waste pad	527.01	0	2,738	477285	6374518
CWPAD	Clean waste pad	523.36	2	2,724	477441	6374488
BORROW1	Borrow area 1	536.85	0	40,000	477083	6374889
BORROW2	Borrow area 2	530.80	0	15,000	477283	6374889
BORROW3	Borrow area 3	534.66	0	32,000	477323	6375289

Model ID	Description	Elevation (m)	Height (m)	Model Area (m²)	UTM Coordinates - SW Corner	
					X (m)	Y (m)
CONST	General construction area sources (27 areas)	Various	0	991,000	Various	
BORROW4	Borrow area 4	530.65	0	28,000	477483	6375290
BORROW5	Borrow area 5	538.44	0	40,000	477283	6375089
LNDFL_CN	Industrial landfill	528.25	0	8,763	476780	6374985
GYPSUM	Industrial wastewater precipitate pond (Gypsum Pond)	528.67	0	22,444	476978	6374589

Table B. 4: CALPUFF Volume Source Parameters

Model ID	Description	Elevation (m)	Height (m)	Sigma-Y (m)	Sigma-Z (m)	UTM Coordinates	
						X (m)	Y (m)
ISR	ISR plant general ventilation	538.00	22.4	11.63	10.56	477079	6374374
PUMP1	Pumphouse propane heating	542.12	3.0	2.83	1.4	476773	6373971
BATCH	Batch plant	533.59	5.0	2.33	6.98	476971	6374873
FREEZE	Freeze plant propane heating	544.74	10.0	5.81	4.65	476992	6374236
OPS	Operations facility propane heating	544.54	3.0	6.98	1.4	476764	6373555
CAMP	Camp propane heating	542.00	3.0	6.98	1.4	476912	6373544
STORAGE	Storage facility propane heating	545.98	6.0	3.02	2.79	476881	6373696
SUBSTN	Substation propane heating	541.00	2.0	3.49	0.47	476749	6373398
AIRPORT	Airport propane heating	513.91	9.0	6.98	4.19	478858	6376182
CORE	Core shack ventilation	537.34	2.4	0.56	1.12	477134	6374303
HWY914	Highway 914 (121 volumes)	Various	2.13	19.38	0.92	Various	
ACCESS	Access road (162 volumes)	Various	2.13	14.85	0.92	Various	
SITE1	Site road 1 (31 volumes)	Various	2.13	14.51	0.92	Various	
SITE2	Site road 2 (29 volumes)	Various	2.13	14.67	0.92	Various	
SITE3	Site road 3 (148 volumes)	Various	2.13	14.84	0.92	Various	

Table B. 5: CALPUFF Point Source Parameters

Model ID	Description	Elevation (m)	Height (m)	Diam [m]	Velocity [m/s]	Temp. [K]	Orientation	UTM Coordinates	
								X (m)	Y (m)
GEN1	1.1 MW Generator	544.14	4.25	0.380	38	797.15	Vertical	476950	6374239
GEN2	1.1 MW Generator	544.09	4.25	0.380	38	797.15	Vertical	476954	6374242
GEN3	450 kW Generator	542.23	4.25	0.380	15	804.25	Vertical	476724	6373548
GEN4	450 kW Generator	548.71	4.25	0.380	15	804.25	Vertical	476787	6373438
S1	Dryer process gas scrubber	538.00	45.0	0.076	18	365.15	Vertical	477038	6374377
S2	Calciner/process gas scrubber	538.00	45.0	0.067	18	345.15	Vertical	477034	6374382
S3	Dryer/calciner hygiene scrubber	538.00	45.0	1.003	18	316.15	Vertical	477030	6374387
S4	Calciner burner exhaust	538.00	45.0	0.153	18	1173.0	Vertical	477020	6374402
LIME	Lime silo	538.00	23.0	0.300	5	293.15	Vertical	477042	6374413
RN_TANK	Recovered solution surge tank	534.75	10.0	0.254	53.17	273.15	Vertical	477257	6374402

B.2.2 Building Layout

Buildings affect the flow of air in the vicinity of a point source and cause the plume from a point source to be downwashed. To simulate the effect of building downwash in the model, the Plume Rise Model Enhancements version of the Building Profile Input Program (BPIP PRIME) was utilized in the CALPUFF model. The building configuration that was used in the model is shown in Figure B. 11, and detailed building information is provided in Table B. 6. Note that only the generators and the recovered solution surge tank will be subject to building downwash in the Construction scenario, therefore, the generator trailers and the surge tank are the only structures that were modelled during this scenario.

Table B. 6: Modelled Buildings

Building ID	Description	Elevation (m)	Tier Height (m)	Diameter (m)	UTM Coordinates -SW Corner	
					X (m)	Y (m)
OPS	Operations centre	544.51	3.0	n/a	476729.82	6373517
STORAGE	Covered storage	544.83	6.0	n/a	476854.05	6373681
WTP_CAMP	Camp wastewater treatment	547.96	3.0	n/a	476842.27	6373429.31
CAMP_S	Camp south unit	548.35	3.0	n/a	476849.2	6373495.3
CAMP_C	Camp central building	549.68	3.0	n/a	476884.42	6373538.92
CAMP_N	Camp north unit	551.13	3.0	n/a	476960.52	6373541.72
TANK1	Water tank	549.50	3.0	18	477024.39	6373829
TANK2	Fire water tank	549.23	3.0	n/a	477034.02	6373832
PH_PH2	Pumphouse phase 2	538.43	3.0	n/a	477142.58	6374267
PH_PH3	Pumphouse phase 3	541.94	3.0	n/a	477059.83	6374189
PH_PH5	Pumphouse phase 5	542.13	3.0	n/a	476758.14	6373956
FREEZE	freeze plant	544.74	10.0	n/a	476954.67	6374201
ISR_1	ISR plant tier 1	538.00	22.7	n/a	477017.05	6374314
ISR_2	ISR plant tier 2	538.00	14.7	n/a	477087.33	6374363
GEN1	1.1 MW generator trailer	544.56	3.3	n/a	476954.04	6374232
GEN2	1.1 MW generator trailer	544.52	3.3	n/a	476957.88	6374235
GEN3	450 kW generator trailer	542.35	3.3	n/a	476729.15	6373541
GEN4	450 kW generator trailer	548.61	3.3	n/a	476787.1	6373436.33
CORE	Core shack	537.53	2.4	n/a	477130.77	6374299
RN_TANK	Recovered solution surge tank	534.75	3.0	3.6	477254.7	6374400.35

B.2.3 Modelling Domain and Receptors

The Local and Regional Study Areas (LSA/RSA) and the property boundary were discussed in Section 6.1.1.3 of the EIS. A nested receptor grid was used in CALPUFF to cover the Study Areas with the following spacing:

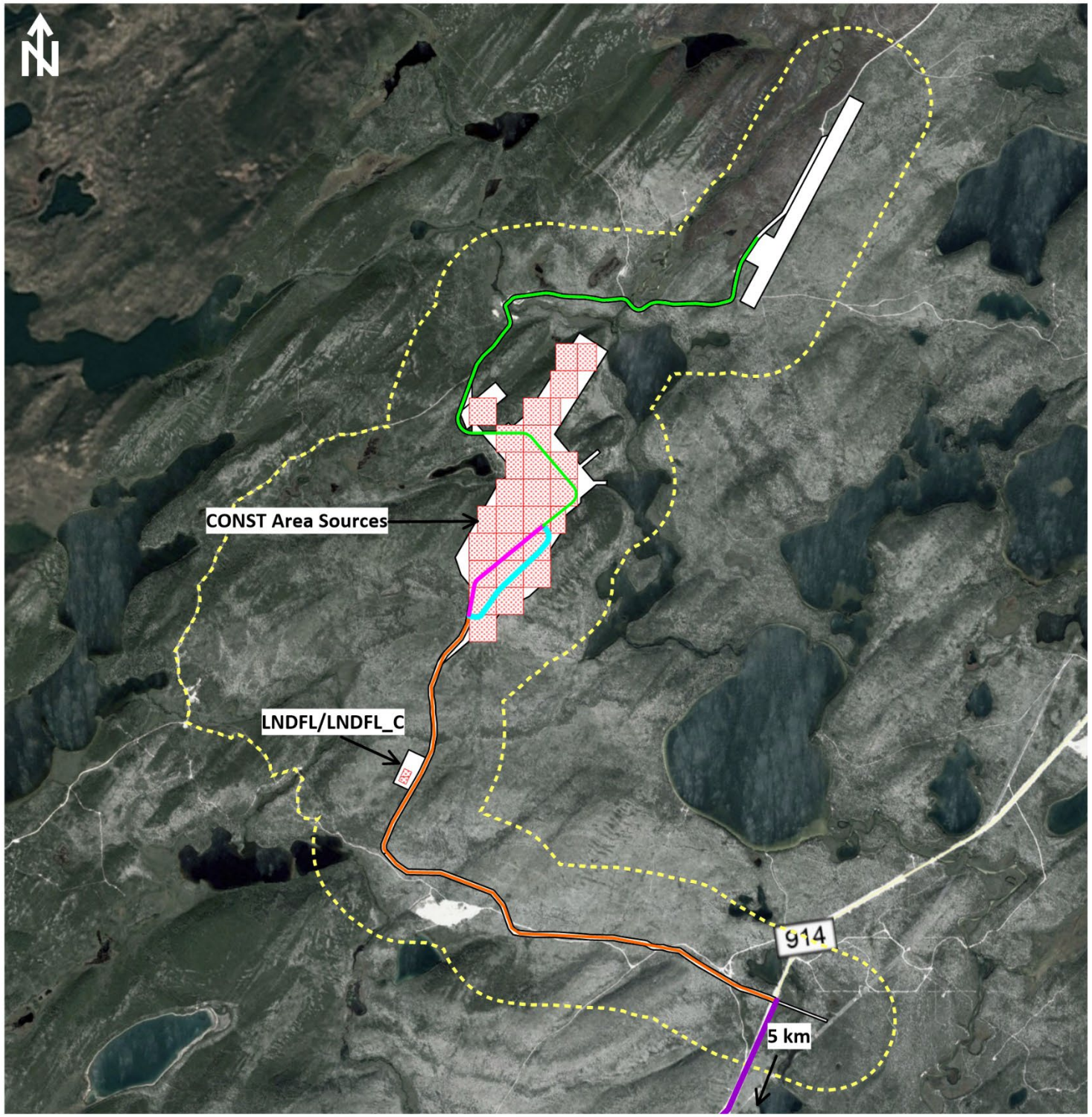
a) 50 m spacing in a 2 km by 2 km box, centred approximately on the mine site,
b) 250 m spacing in a 5 km by 5 km box and outside of the area described in (a),
c) 500 m spacing in a 10 km by 10 km box and outside of the area described in (b),
d) 1,000 m spacing in a 20 km by 20 km area and outside of the area described in (c), and

e) 2,000 m spacing in a 40 km by 40 km area and outside of the area described in (d).

In addition to the nested model grid, receptors were placed every 50 m along the Property Boundary, and road receptors were placed parallel to the roads at distances of 50 m, 150 m, and 250 m from the road edge at a spacing of 200 m. Sixteen discrete receptors were also included in the model to provide model outputs for other disciplines (e.g., risk). The UTM coordinates of these sensitive receptors are provided in Table B. 7 and are listed in metres relative to the NAD83 datum (Zone 13N).

Table B. 7: Discrete Receptors Included in CALPUFF

ID	Type	Description	UTM Coordinates	
			X (m)	X (m)
WE1	Worker exposure	ISR Plant	477122	6374321
WE2	Worker exposure	Special Waste Pad	477342	6374486
WE3	Worker exposure	Industrial landfill	476829	6375006
WE4	Worker exposure	Process precipitates storage pad	477115	6374492
WE5	Worker exposure	Wash Bay/Scanning Facility	477087	6374079
WE6	Worker exposure	Fe disposal wellfield	477486	6374846
WE7	Worker exposure	Wellfield boundary 1	476721	6373937
WE8	Worker exposure	Wellfield boundary 2	476777	6373864
WE9	Worker exposure	Wellfield boundary 3	477043	6374042
WE10	Worker exposure	Wellfield boundary 4	477001	6374109
WE11	Worker exposure	Freeze Plant	477012	6374211
Risk1	Risk	Eco on-site	477708	6374351
Risk2	Risk	Human Location Seasonal Resident at McGowan Lake	479490	6372582
Risk3	Risk	Human Location Camp Worker	476896	6373487
Risk4	Risk	Human Location Seasonal Resident at Russell Lake	478415	6368289
Risk5	Risk	Reference Receptor Location	473146	6375099



LEGEND:

- Modelled Property Boundary
- Modelled Highway 914
- Modelled Access Road
- Modelled Site Road 1
- Modelled Site Road 2
- Modelled Site Road 3
- Modelled Area Source

NOTES:

1. 5 km of Highway 914 south of the mine site is modelled.
2. The point sources modelled during construction (generators, radon surge tank) are illustrated in Figures B.9 and B.10.

SCALE:

0 m — 1000 m — 2000 m

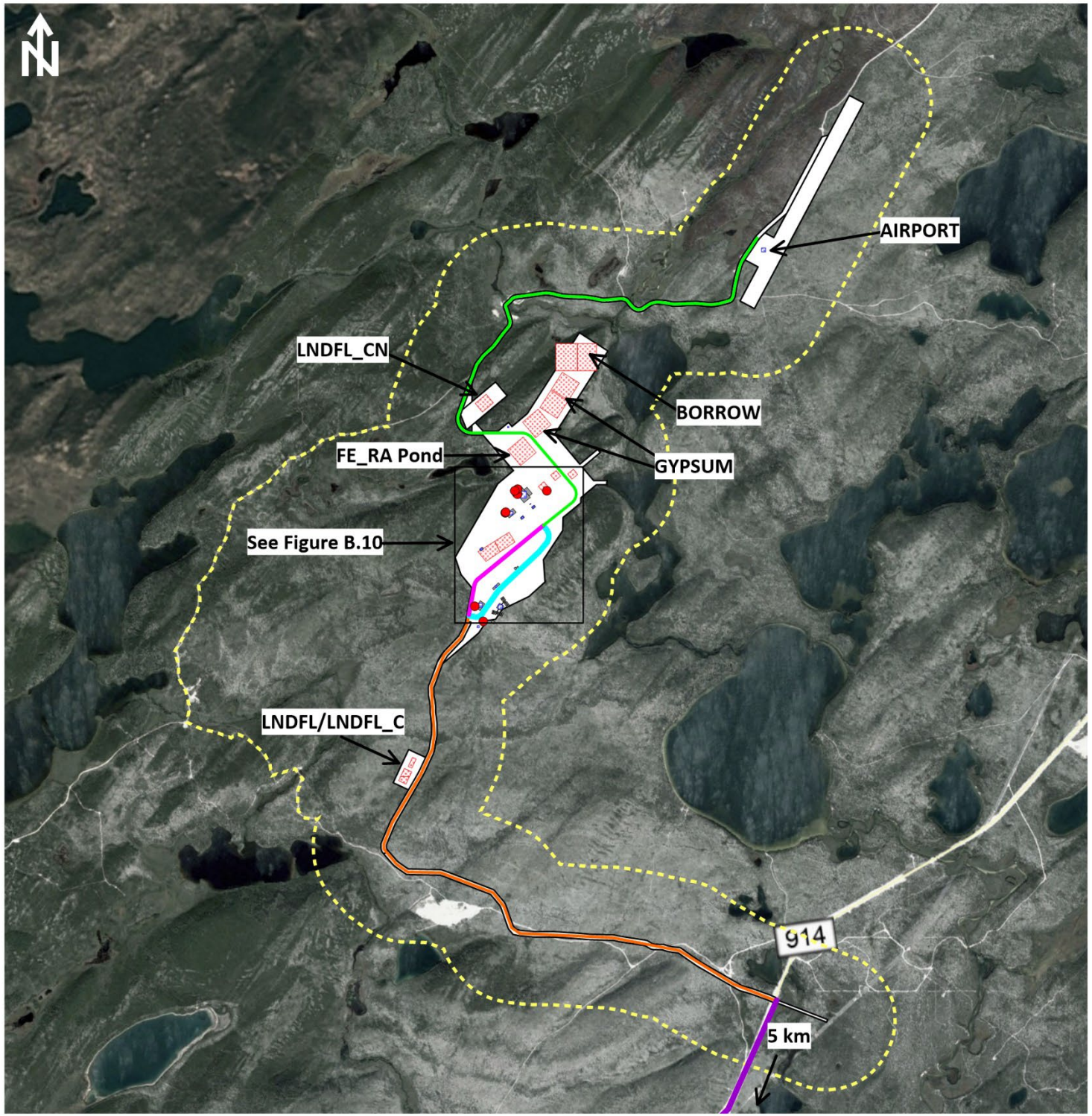
REFERENCE:

UTM Zone 13T, WGS84

Denison Mines
Wheeler River Project, SK

CALPUFF Model Layout - Construction Scenario

Drawn By:	Approved By:	Figure No.:
KT	PLK	B.8
Date:	**Project No.:**	
June 2022	SX19-0043	



LEGEND:

- Modelled Property Boundary
- Modelled Highway 914
- Modelled Access Road
- Modelled Site Road 1
- Modelled Site Road 2
- Modelled Site Road 3
- Modelled Area Source
- Modelled Volume Source
- Modelled Building
- Modelled Point Source

NOTES:

1. 5 km of Hlghway 914 south of the mine site was modelled.

SCALE:

0 m — 1000 m — 2000 m

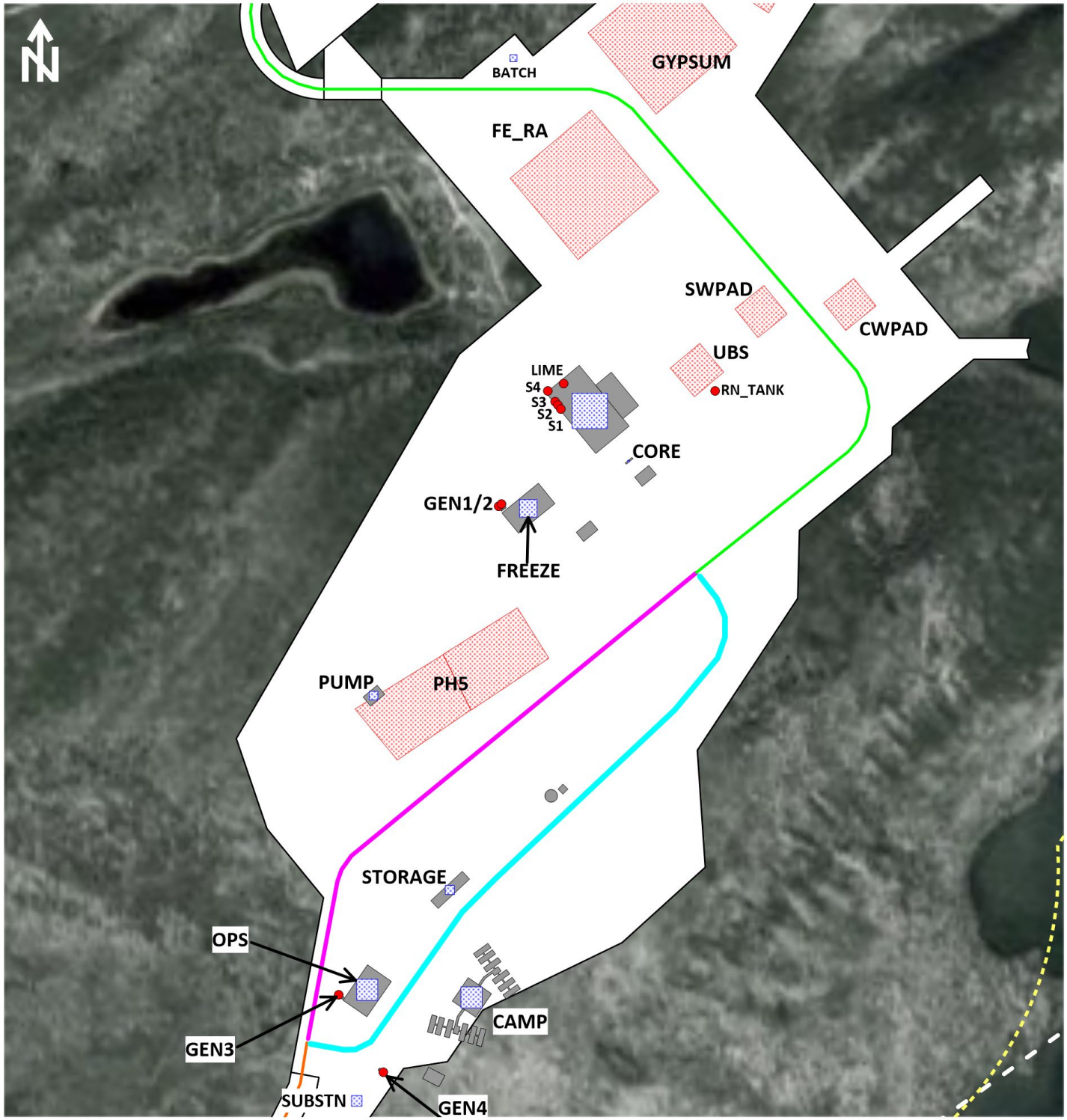
REFERENCE:

UTM Zone 13T, WGS84

Denison Mines
Wheeler River Project, SK

CALPUFF Model Layout - Operations/Decomm. Scenarios

Drawn By:	Approved By:	Figure No.:
KT	PLK	B.9
Date:	Project No.:	
June 2022	SX19-0043	



LEGEND:

- Modelled Property Boundary
- Modelled Highway 914
- Modelled Access Road
- Modelled Site Road 1
- Modelled Site Road 2
- Modelled Site Road 3
- Modelled Area Source
- Modelled Volume Source
- Modelled Building
- Modelled Point Source

NOTES:

SCALE:

0 m — 200 m — 400 m

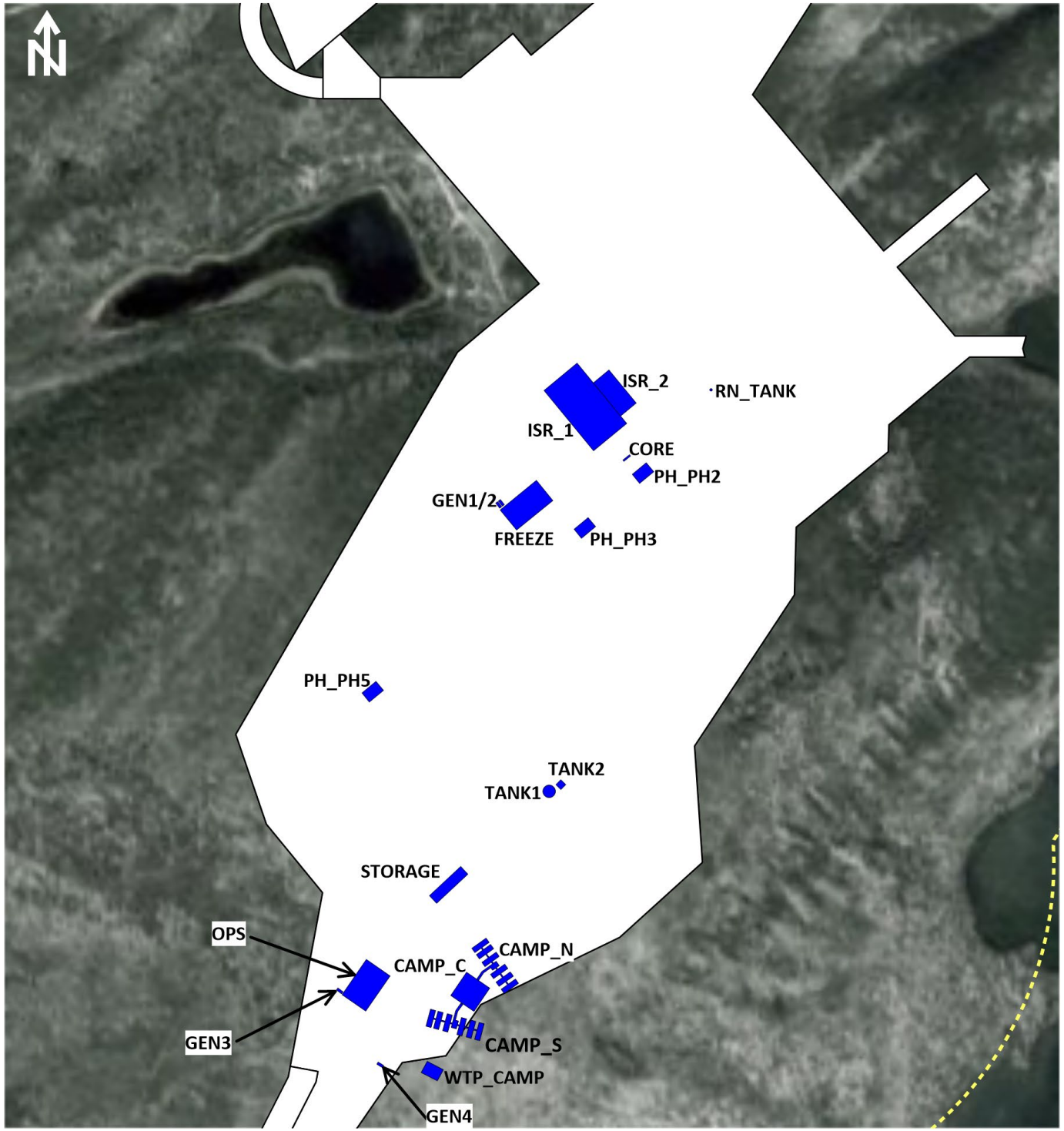
REFERENCE:

UTM Zone 13T, WGS84

Denison Mines
Wheeler River Project, SK

Detailed CALPUFF Model Layout
- Operations/Decomm. Scenarios

Drawn By:	Approved By:	Figure No.:
KT	PLK	B.10
Date:	**Project No.:**	
June 2022	SX19-0043	



LEGEND:

Modelled Property Boundary

Modelled Building

NOTES:

SCALE:

0 m 200 m 400 m

REFERENCE:

UTM Zone 13T, WGS84

Denison Mines
Wheeler River Project, SK

CALPUFF Building Layout

Drawn By:	Approved By:	Figure No.:
KT	PLK	B.11
Date:	Project No.:	
June 2022	SX19-0043	

Appendix C:

HHERA and Worker Exposure Model Results

Table C. 1: Model Predictions of Particulate Matter, CO, SO_2, and NO_2 Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Construction Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP 24-hour	24-h TSP Exceedances (days/year)	TSP Annual	PM_{10} 24-hour	24-h PM_{10} Exceedances (days/year)	$PM_{2.5}$ 24-hour	24-h $PM_{2.5}$ Exceedances (days/year)	$PM_{2.5}$ Annual	CO 1-hour	CO 8-hour	SO_2 1-hour	SO_2 24-hour	SO_2 Annual	NO_2 1-hour	1-h NO_2 Exceedances (hours/year)	NO_2 24-hour	24-h NO_2 Exceedances (days/year)	NO_2 Annual
477.122	6374.321	WE1	341.47	158	73.78	162.22	133	25.87	0	7.51	700.7	648.8	5.72E-01	1.87E-01	4.44E-02	578.63	1489	192.89	0	42.20
477.342	6374.487	WE2	315.81	116	52.49	126.01	77	18.79	0	5.56	630.0	613.6	1.87E-01	8.07E-02	1.95E-02	194.88	338	73.94	0	19.86
476.829	6375.006	WE3	336.56	141	63.99	170.27	123	25.56	0	6.68	651.6	626.5	2.47E-01	1.20E-01	2.86E-02	205.46	646	101.04	0	27.02
477.115	6374.493	WE4	306.79	128	61.61	143.48	107	21.93	0	6.51	646.8	629.7	2.35E-01	1.11E-01	2.94E-02	204.11	858	93.71	0	28.01
477.087	6374.079	WE5	668.85	221	82.38	263.42	177	34.65	1	7.77	708.9	667.2	6.09E-01	1.99E-01	4.76E-02	613.59	1911	194.66	0	46.86
477.486	6374.847	WE6	123.56	6	21.03	66.31	7	12.18	0	3.81	606.7	596.6	9.53E-02	3.55E-02	5.36E-03	84.25	12	36.31	0	8.25
476.721	6373.938	WE7	422.99	168	73.86	209.45	136	30.16	1	7.22	653.9	633.4	2.46E-01	1.14E-01	3.18E-02	203.46	660	94.71	0	29.38
476.777	6373.865	WE8	716.01	244	101.78	293.98	210	38.83	3	8.58	675.2	643.2	3.19E-01	1.50E-01	3.95E-02	248.69	1012	122.23	0	35.26
477.043	6374.042	WE9	731.85	246	102.09	288.44	213	37.16	3	8.77	723.7	668.0	6.66E-01	2.48E-01	4.99E-02	655.73	1834	249.97	3	46.95
477.002	6374.109	WE10	681.31	232	102.03	295.47	214	41.03	6	10.06	770.5	698.6	9.03E-01	3.43E-01	7.49E-02	912.41	2553	349.63	14	70.50
477.012	6374.212	WE11	519.67	231	92.38	239.55	257	58.92	113	18.81	1055.0	943.4	2.26E+00	1.34E+00	3.20E-01	2289.10	4045	1365.58	160	320.18
477.708	6374.352	Risk1	97.13	0	18.67	49.89	0	10.04	0	3.64	602.6	591.9	1.17E-01	3.43E-02	5.07E-03	124.32	47	41.08	0	8.34
478.245	6372.039	Risk2	58.55	0	13.52	31.04	0	7.65	0	3.21	583.3	580.1	3.35E-02	1.14E-02	9.28E-04	42.97	0	20.11	0	4.65
476.896	6373.487	Risk3	285.6	108	48.0	136.0	78	20.5	0	5.4	645.7	614.2	2.16E-01	8.14E-02	1.65E-02	181.0	296	70.6	0	17.1
478.415	6368.290	Risk4	57.2	0	13.0	29.1	0	7.3	0	3.1	578.2	577.2	1.24E-02	3.55E-03	1.96E-04	22.9	0	12.6	0	4.0
473.146	6375.100	Risk5	57.3	0	12.9	32.4	0	7.8	0	3.2	582.8	580.1	3.03E-02	6.75E-03	4.88E-04	40.2	0	15.8	0	4.2
Air Quality Criteria			100	100	60	50	50	27	27	10	15,000	6,000	450	125	20	79	79	200	200	45
Background			46.2	46.2	12.4	23.1	23.1	6.5	6.5	3.1	575	575	0	0	0	11.3	11.3	9.4	9.4	3.8

Table C. 2: Model Predictions of Uranium and Metals Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Construction Scenario

UTM Easting (km)	UTM Northing (km)	ID	As 24-hour	As Annual	Cd 24-hour	Cd Annual	Co 24-hour	Co Annual	Cr 24-hour	Cr Annual	Cu 24-hour	Cu Annual	Mo 24-hour	Mo Annual	Ni 24-hour	Ni Annual	Pb 24-hour	Pb Annual	Se 24-hour	Se Annual	U 24-hour	24-h U Exceedances (days/year)	U Annual	Vn 24-hour	Vn Annual	Zn 24-hour	Zn Annual
477.122	6374.321	WE1	3.05E-03	7.09E-04	2.84E-04	7.55E-05	2.67E-03	7.12E-04	6.04E-04	1.57E-04	3.31E-01	6.33E-02	2.74E-03	7.30E-04	2.09E-03	4.15E-04	1.78E-02	3.39E-03	8.18E-04	1.57E-04	4.31E-02	0	7.58E-03	5.48E-03	1.46E-03	1.13E+00	2.16E-01
477.342	6374.487	WE2	3.04E-03	7.05E-04	2.81E-04	7.50E-05	2.65E-03	7.10E-04	5.87E-04	1.54E-04	3.30E-01	6.32E-02	2.72E-03	7.26E-04	2.06E-03	4.09E-04	1.73E-02	3.26E-03	8.13E-04	1.55E-04	2.92E-02	0	4.60E-03	5.42E-03	1.44E-03	1.13E+00	2.16E-01
476.829	6375.006	WE3	3.05E-03	7.09E-04	2.84E-04	7.54E-05	2.66E-03	7.12E-04	6.04E-04	1.57E-04	3.31E-01	6.33E-02	2.74E-03	7.29E-04	2.08E-03	4.14E-04	1.78E-02	3.36E-03	8.18E-04	1.56E-04	4.26E-02	0	6.94E-03	5.48E-03	1.45E-03	1.13E+00	2.16E-01
477.115	6374.493	WE4	3.05E-03	7.08E-04	2.83E-04	7.54E-05	2.66E-03	7.12E-04	6.00E-04	1.56E-04	3.30E-01	6.32E-02	2.74E-03	7.29E-04	2.08E-03	4.13E-04	1.77E-02	3.35E-03	8.16E-04	1.56E-04	3.94E-02	0	6.61E-03	5.47E-03	1.45E-03	1.13E+00	2.16E-01
477.087	6374.079	WE5	3.05E-03	7.06E-04	2.83E-04	7.52E-05	2.66E-03	7.10E-04	5.96E-04	1.55E-04	3.30E-01	6.32E-02	2.73E-03	7.27E-04	2.07E-03	4.10E-04	1.76E-02	3.29E-03	8.15E-04	1.56E-04	3.66E-02	0	5.25E-03	5.45E-03	1.45E-03	1.13E+00	2.16E-01
477.486	6374.847	WE6	3.02E-03	7.01E-04	2.79E-04	7.46E-05	2.64E-03	7.08E-04	5.70E-04	1.50E-04	3.29E-01	6.30E-02	2.70E-03	7.21E-04	2.03E-03	4.02E-04	1.67E-02	3.15E-03	8.08E-04	1.54E-04	1.54E-02	0	1.70E-03	5.36E-03	1.43E-03	1.13E+00	2.16E-01
476.721	6373.938	WE7	3.05E-03	7.09E-04	2.83E-04	7.55E-05	2.66E-03	7.12E-04	6.00E-04	1.57E-04	3.30E-01	6.33E-02	2.74E-03	7.30E-04	2.08E-03	4.15E-04	1.77E-02	3.39E-03	8.17E-04	1.57E-04	3.96E-02	0	7.58E-03	5.47E-03	1.46E-03	1.13E+00	2.16E-01
476.777	6373.865	WE8	3.07E-03	7.12E-04	2.85E-04	7.58E-05	2.67E-03	7.14E-04	6.14E-04	1.60E-04	3.31E-01	6.33E-02	2.76E-03	7.33E-04	2.10E-03	4.19E-04	1.82E-02	3.46E-03	8.21E-04	1.57E-04	5.14E-02	0	9.30E-03	5.52E-03	1.46E-03	1.13E+00	2.16E-01
477.043	6374.042	WE9	3.07E-03	7.10E-04	2.85E-04	7.55E-05	2.67E-03	7.12E-04	6.15E-04	1.58E-04	3.31E-01	6.33E-02	2.76E-03	7.31E-04	2.10E-03	4.15E-04	1.82E-02	3.39E-03	8.21E-04	1.57E-04	5.17E-02	0	7.66E-03	5.52E-03	1.46E-03	1.13E+00	2.16E-01
477.002	6374.109	WE10	3.07E-03	7.13E-04	2.86E-04	7.60E-05	2.67E-03	7.14E-04	6.18E-04	1.61E-04	3.31E-01	6.34E-02	2.76E-03	7.35E-04	2.11E-03	4.21E-04	1.83E-02	3.50E-03	8.22E-04	1.58E-04	5.46E-02	0	1.03E-02	5.53E-03	1.47E-03	1.13E+00	2.16E-01
477.012	6374.212	WE11	3.07E-03	7.11E-04	2.86E-04	7.57E-05	2.68E-03	7.13E-04	6.21E-04	1.59E-04	3.31E-01	6.33E-02	2.77E-03	7.32E-04	2.11E-03	4.17E-04	1.84E-02	3.43E-03	8.23E-04	1.57E-04	5.65E-02	0	8.73E-03	5.54E-03	1.46E-03	1.13E+00	2.16E-01
477.708	6374.352	Risk1	3.01E-03	7.01E-04	2.78E-04	7.45E-05	2.64E-03	7.07E-04	5.62E-04	1.50E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.01E-03	4.01E-04	1.64E-02	3.13E-03	8.05E-04	1.54E-04	9.24E-03	0	1.26E-03	5.34E-03	1.43E-03	1.13E+00	2.16E-01
478.245	6372.039	Risk2	3.00E-03	7.00E-04	2.78E-04	7.44E-05	2.64E-03	7.07E-04	5.57E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.63E-02	3.10E-03	8.04E-04	1.54E-04	5.15E-03	0	6.90E-04	5.32E-03	1.43E-03	1.13E+00	2.16E-01
476.896	6373.487	Risk3	3.03E-03	7.05E-04	2.81E-04	7.50E-05	2.65E-03	7.10E-04	5.82E-04	1.53E-04	3.30E-01	6.31E-02	2.71E-03	7.25E-04	2.05E-03	4.08E-04	1.71E-02	3.24E-03	8.11E-04	1.55E-04	2.49E-02	0	4.12E-03	5.40E-03	1.44E-03	1.13E+00	2.16E-01
478.415	6368.290	Risk4	3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.55E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.57E-03	0	6.19E-04	5.32E-03	1.43E-03	1.13E+00	2.16E-01
473.146	6375.100	Risk5	3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.56E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	4.21E-03	0	6.59E-04	5.32E-03	1.43E-03	1.13E+00	2.16E-01
Air Quality Criteria			0.3	n/a	0.025	0.005	0.1	n/a	0.5	n/a	50	n/a	120	n/a	0.2	0.04	0.5	n/a	10	n/a	0.15	0.15	0.03	2	n/a	120	n/a
Background			3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.54E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.00E-03	3.00E-03	6.00E-04	5.31E-03	1.43E-03	1.13E+00	2.16E-01

Table C. 3: Model Predictions of Radon Concentrations (Bq/m³) for HHERA and Worker Exposure Receptors: Construction Scenario [1]

UTM Easting (km)	UTM Northing (km)	ID	Rn-222 Annual
477.122	6374.321	WE1	9.89E+00
477.342	6374.487	WE2	1.02E+01
476.829	6375.006	WE3	1.84E+00
477.115	6374.493	WE4	9.35E+00
477.087	6374.079	WE5	1.24E+01
477.486	6374.847	WE6	1.74E+00
476.721	6373.938	WE7	1.59E+01
476.777	6373.865	WE8	1.63E+01
477.043	6374.042	WE9	2.23E+01
477.002	6374.109	WE10	2.32E+01
477.012	6374.212	WE11	1.10E+01
477.708	6374.352	Risk1	1.98E+00
478.245	6372.039	Risk2	2.60E-01
476.896	6373.487	Risk3	2.15E+00
478.415	6368.290	Risk4	5.64E-02
473.146	6375.100	Risk5	1.97E-01

Notes:
[1] Model predictions are incremental (i.e., with no background added).

Table C. 4: Model Predictions of Annual Deposition Rates for HHERA and Worker Exposure Receptors: Construction Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NO_2	As	Cd	Co	Cr	Cu	Mo	Ni	Pb	Se	U	Vn	Zn	Rn-222
			mg/cm²/year																		Bq/cm²/year
477.122	6374.321	WE1	7.85E+00	7.58E-01	2.86E-03	4.77E-02	5.77E-04	4.68E-01	1.11E-05	4.40E-06	4.18E-05	8.88E-06	1.03E-04	4.26E-05	4.19E-05	1.28E-05	8.42E-05	8.22E-05	8.45E-05	3.09E-04	1.08E+02
477.342	6374.487	WE2	5.32E+00	4.58E-01	1.64E-03	2.19E-02	2.33E-04	1.81E-01	1.10E-05	4.40E-06	4.18E-05	8.84E-06	1.01E-04	4.25E-05	4.18E-05	1.13E-05	8.42E-05	4.58E-05	8.44E-05	3.08E-04	1.43E+02
476.829	6375.006	WE3	6.97E+00	7.11E-01	1.85E-03	3.30E-02	3.36E-04	2.59E-01	1.11E-05	4.40E-06	4.18E-05	8.88E-06	1.02E-04	4.26E-05	4.19E-05	1.26E-05	8.42E-05	7.71E-05	8.45E-05	3.08E-04	1.76E+01
477.115	6374.493	WE4	2.90E+00	2.36E-01	1.40E-03	1.74E-02	1.96E-04	1.62E-01	1.10E-05	4.40E-06	4.17E-05	8.81E-06	1.00E-04	4.25E-05	4.18E-05	1.05E-05	8.42E-05	2.60E-05	8.43E-05	3.08E-04	4.33E+01
477.087	6374.079	WE5	7.98E+00	6.62E-01	2.93E-03	4.75E-02	5.77E-04	5.03E-01	1.10E-05	4.40E-06	4.18E-05	8.84E-06	1.01E-04	4.25E-05	4.18E-05	1.13E-05	8.42E-05	4.72E-05	8.44E-05	3.08E-04	1.20E+02
477.486	6374.847	WE6	1.32E+00	6.30E-02	6.27E-04	5.86E-03	5.84E-05	4.64E-02	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.98E-05	4.25E-05	4.17E-05	9.82E-06	8.42E-05	1.02E-05	8.42E-05	3.08E-04	1.89E+01
476.721	6373.938	WE7	7.80E+00	7.86E-01	2.36E-03	3.75E-02	3.85E-04	2.93E-01	1.11E-05	4.41E-06	4.18E-05	8.89E-06	1.03E-04	4.26E-05	4.19E-05	1.29E-05	8.42E-05	8.58E-05	8.45E-05	3.09E-04	1.51E+02
476.777	6373.865	WE8	1.13E+01	1.13E+00	2.85E-03	4.69E-02	4.70E-04	3.56E-01	1.11E-05	4.41E-06	4.18E-05	8.91E-06	1.04E-04	4.26E-05	4.19E-05	1.39E-05	8.42E-05	1.09E-04	8.46E-05	3.09E-04	1.56E+02
477.043	6374.042	WE9	1.08E+01	9.74E-01	3.18E-03	5.32E-02	6.00E-04	4.98E-01	1.11E-05	4.40E-06	4.18E-05	8.88E-06	1.03E-04	4.26E-05	4.19E-05	1.27E-05	8.42E-05	8.00E-05	8.45E-05	3.08E-04	2.28E+02
477.002	6374.109	WE10	1.09E+01	1.11E+00	3.87E-03	7.76E-02	9.41E-04	7.95E-01	1.11E-05	4.41E-06	4.18E-05	8.92E-06	1.04E-04	4.26E-05	4.20E-05	1.41E-05	8.42E-05	1.15E-04	8.47E-05	3.09E-04	2.29E+02
477.012	6374.212	WE11	8.47E+00	8.63E-01	3.15E-03	4.18E-02	4.30E-04	3.23E-01	1.11E-05	4.41E-06	4.18E-05	8.90E-06	1.03E-04	4.26E-05	4.19E-05	1.32E-05	8.42E-05	9.30E-05	8.46E-05	3.09E-04	1.03E+02
477.708	6374.352	Risk1	1.24E+00	5.80E-02	7.18E-04	4.34E-03	5.35E-05	4.27E-02	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.98E-05	4.25E-05	4.17E-05	9.74E-06	8.42E-05	8.28E-06	8.42E-05	3.08E-04	2.17E+01
478.245	6372.039	Risk2	7.91E-01	6.77E-03	1.14E-04	6.12E-04	7.74E-06	6.05E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.54E-06	8.42E-05	3.40E-06	8.42E-05	3.07E-04	1.83E+00
476.896	6373.487	Risk3	4.65E+00	4.37E-01	1.31E-03	1.92E-02	1.88E-04	1.45E-01	1.10E-05	4.40E-06	4.18E-05	8.83E-06	1.01E-04	4.25E-05	4.18E-05	1.12E-05	8.42E-05	4.34E-05	8.43E-05	3.08E-04	1.93E+01
478.415	6368.290	Risk4	7.75E-01	4.46E-03	4.76E-05	1.39E-04	1.54E-06	1.29E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	3.01E-06	8.42E-05	3.07E-04	3.94E-01
473.146	6375.100	Risk5	7.52E-01	3.44E-03	1.58E-04	3.81E-04	4.45E-06	3.47E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.53E-06	8.42E-05	3.21E-06	8.42E-05	3.07E-04	1.35E+00
		Air Quality Standard	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Background	0.73	n/a	n/a	n/a	n/a	n/a	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	2.93E-06	8.42E-05	3.07E-04	n/a

Table C. 5: Model Predictions of Particulate Matter, CO, SO_2, and NO_2 Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Operations Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP 24-hour	24-h TSP Exceedances (days/year)	TSP Annual	PM_{10} 24-hour	24-h PM_{10} Exceedances (days/year)	$PM_{2.5}$ 24-hour	24-h $PM_{2.5}$ Exceedances (days/year)	$PM_{2.5}$ Annual	CO 1-hour	CO 8-hour	SO_2 1-hour	SO_2 24-hour	SO_2 Annual	NO_2 1-hour	1-h NO_2 Exceedances (hours/year)	NO_2 24-hour	24-h NO_2 Exceedances (days/year)	NO_2 Annual
477.122	6374.321	WE1	102.02	1	19.46	49.70	0	13.00	0	4.05	686.7	638.5	5.27E-01	1.65E-01	1.25E-02	543.15	796	175.04	0	9.42
477.342	6374.487	WE2	113.19	1	23.16	52.50	1	10.65	0	3.73	613.3	596.2	1.72E-01	5.49E-02	2.54E-03	174.50	77	58.75	0	5.04
476.829	6375.006	WE3	85.18	0	18.17	44.44	0	10.03	0	3.48	603.6	595.1	1.26E-01	5.15E-02	1.67E-03	132.40	103	54.19	0	4.71
477.115	6374.493	WE4	87.26	0	16.87	44.56	0	10.72	0	3.53	620.6	604.8	2.21E-01	7.94E-02	5.96E-03	190.16	260	67.81	0	6.49
477.087	6374.079	WE5	254.37	60	35.35	95.89	33	15.06	0	4.35	692.8	656.4	5.55E-01	1.83E-01	1.02E-02	571.02	1693	179.17	0	11.19
477.486	6374.847	WE6	66.88	0	14.86	34.48	0	8.28	0	3.28	588.5	583.3	6.16E-02	1.83E-02	1.09E-03	63.27	0	23.75	0	4.34
476.721	6373.938	WE7	143.01	7	20.34	69.31	4	13.65	0	3.92	672.8	637.8	3.58E-01	1.48E-01	1.13E-02	280.46	466	116.77	0	12.41
476.777	6373.865	WE8	215.32	30	27.63	93.10	13	17.16	0	4.17	681.2	648.9	3.99E-01	1.86E-01	1.25E-02	308.18	519	148.62	0	13.14
477.043	6374.042	WE9	263.45	64	35.93	99.77	35	17.81	0	4.63	705.4	664.9	5.99E-01	2.12E-01	1.60E-02	602.58	1409	219.48	2	15.91
477.002	6374.109	WE10	155.40	19	24.31	67.48	8	20.46	0	4.35	756.5	688.2	8.65E-01	3.34E-01	1.68E-02	876.29	1945	336.50	10	16.86
477.012	6374.212	WE11	120.49	6	20.65	76.11	71	58.25	86	4.28	1043.5	940.2	2.22E+00	1.33E+00	1.92E-02	2260.54	3415	1358.37	153	20.77
477.708	6374.352	Risk1	62.88	0	14.59	32.15	0	8.30	0	3.28	599.0	588.6	1.12E-01	2.97E-02	1.17E-03	116.30	36	35.22	0	4.41
478.245	6372.039	Risk2	54.19	0	12.86	28.45	0	7.22	0	3.14	582.5	579.9	3.17E-02	1.14E-02	2.81E-04	40.18	0	19.57	0	3.97
476.896	6373.487	Risk3	124.0	8	20.6	56.6	4	11.0	0	3.7	690.6	639.1	3.71E-01	1.23E-01	1.11E-02	274.8	402	100.31	0	11.3
478.415	6368.290	Risk4	54.5	0	12.7	27.7	0	7.1	0	3.1	578.2	576.9	1.49E-02	4.28E-03	5.73E-05	24.0	0	12.97	0	3.8
473.146	6375.100	Risk5	51.1	0	12.6	26.9	0	7.0	0	3.1	582.7	580.0	3.45E-02	7.21E-03	1.66E-04	43.2	0	15.75	0	3.9
Air Quality Criteria			100	100	60	50	50	27	27	10	15,000	6,000	450	125	20	79	79	200	200	45
Background			46.2	46.2	12.4	23.1	23.1	6.5	6.5	3.1	575	575	0	0	0	11.3	11.3	9.4	9.4	3.8

Table C. 6: Model Predictions of Uranium and Metals Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Operations Scenario

UTM Easting (km)	UTM Northing (km)	ID	As 24-hour	As Annual	Cd 24-hour	Cd Annual	Co 24-hour	Co Annual	Cr 24-hour	Cr Annual	Cu 24-hour	Cu Annual	Mo 24-hour	Mo Annual	Ni 24-hour	Ni Annual	Pb 24-hour	Pb Annual	Se 24-hour	Se Annual	U 24-hour	24-h U Exceedances (days/year)	U Annual	Vn 24-hour	Vn Annual	Zn 24-hour	Zn Annual
477.122	6374.321	WE1	3.26E-03	7.23E-04	3.64E-04	9.39E-05	3.06E-03	8.02E-04	1.92E-03	4.71E-04	3.50E-01	6.78E-02	2.99E-03	7.46E-04	3.14E-03	6.57E-04	3.83E-02	8.05E-03	1.00E-03	1.99E-04	1.33E+00	164	2.75E-01	7.55E-03	1.93E-03	1.14E+00	2.18E-01
477.342	6374.487	WE2	6.31E-03	1.39E-03	6.74E-04	1.59E-04	4.58E-03	1.12E-03	5.61E-03	1.24E-03	4.26E-01	8.38E-02	6.61E-03	1.53E-03	7.22E-03	1.52E-03	1.17E-01	2.47E-02	1.71E-03	3.49E-04	2.46E+00	300	5.50E-01	1.56E-02	3.63E-03	1.16E+00	2.23E-01
476.829	6375.006	WE3	3.11E-03	7.08E-04	2.97E-04	7.72E-05	2.73E-03	7.20E-04	8.76E-04	1.89E-04	3.34E-01	6.37E-02	2.81E-03	7.29E-04	2.27E-03	4.36E-04	2.14E-02	3.80E-03	8.49E-04	1.60E-04	3.08E-01	22	3.43E-02	5.84E-03	1.50E-03	1.13E+00	2.16E-01
477.115	6374.493	WE4	3.36E-03	7.21E-04	3.23E-04	8.11E-05	2.86E-03	7.40E-04	1.18E-03	2.49E-04	3.40E-01	6.46E-02	3.10E-03	7.44E-04	2.60E-03	4.88E-04	2.78E-02	4.80E-03	9.07E-04	1.69E-04	5.59E-01	71	8.02E-02	6.50E-03	1.60E-03	1.13E+00	2.17E-01
477.087	6374.079	WE5	3.18E-03	7.18E-04	3.27E-04	8.03E-05	2.88E-03	7.36E-04	1.33E-03	2.31E-04	3.41E-01	6.44E-02	2.89E-03	7.40E-04	2.66E-03	4.78E-04	2.90E-02	4.60E-03	9.17E-04	1.68E-04	7.71E-01	59	7.19E-02	6.60E-03	1.58E-03	1.13E+00	2.16E-01
477.486	6374.847	WE6	3.18E-03	7.16E-04	3.09E-04	7.73E-05	2.79E-03	7.21E-04	9.97E-04	1.90E-04	3.37E-01	6.37E-02	2.89E-03	7.38E-04	2.42E-03	4.39E-04	2.43E-02	3.85E-03	8.76E-04	1.61E-04	3.09E-01	12	2.85E-02	6.14E-03	1.50E-03	1.13E+00	2.16E-01
476.721	6373.938	WE7	3.29E-03	7.18E-04	3.17E-04	7.79E-05	2.83E-03	7.24E-04	9.97E-04	1.90E-04	3.39E-01	6.39E-02	3.02E-03	7.40E-04	2.52E-03	4.46E-04	2.62E-02	3.99E-03	8.93E-04	1.62E-04	3.34E-01	29	3.52E-02	6.35E-03	1.52E-03	1.13E+00	2.16E-01
476.777	6373.865	WE8	3.41E-03	7.18E-04	3.32E-04	7.79E-05	2.90E-03	7.24E-04	1.08E-03	1.90E-04	3.42E-01	6.39E-02	3.17E-03	7.40E-04	2.72E-03	4.47E-04	3.00E-02	4.00E-03	9.27E-04	1.62E-04	4.31E-01	30	3.54E-02	6.73E-03	1.52E-03	1.13E+00	2.16E-01
477.043	6374.042	WE9	3.24E-03	7.25E-04	3.33E-04	8.07E-05	2.91E-03	7.38E-04	1.42E-03	2.28E-04	3.43E-01	6.45E-02	2.96E-03	7.49E-04	2.74E-03	4.83E-04	3.05E-02	4.70E-03	9.31E-04	1.68E-04	8.61E-01	60	6.94E-02	6.76E-03	1.59E-03	1.13E+00	2.17E-01
477.002	6374.109	WE10	3.26E-03	7.27E-04	3.24E-04	8.13E-05	2.87E-03	7.41E-04	1.29E-03	2.37E-04	3.41E-01	6.47E-02	2.99E-03	7.51E-04	2.62E-03	4.90E-04	2.82E-02	4.85E-03	9.11E-04	1.70E-04	7.08E-01	71	7.65E-02	6.53E-03	1.61E-03	1.13E+00	2.17E-01
477.012	6374.212	WE11	3.15E-03	7.18E-04	3.34E-04	8.16E-05	2.91E-03	7.42E-04	1.48E-03	2.55E-04	3.43E-01	6.48E-02	2.86E-03	7.40E-04	2.75E-03	4.95E-04	3.08E-02	4.93E-03	9.34E-04	1.70E-04	8.65E-01	75	9.17E-02	6.79E-03	1.61E-03	1.13E+00	2.17E-01
477.708	6374.352	Risk1	3.13E-03	7.12E-04	3.01E-04	7.75E-05	2.75E-03	7.22E-04	8.96E-04	1.93E-04	3.35E-01	6.38E-02	2.83E-03	7.34E-04	2.32E-03	4.41E-04	2.23E-02	3.89E-03	8.58E-04	1.61E-04	2.60E-01	17	3.45E-02	5.93E-03	1.51E-03	1.13E+00	2.16E-01
478.245	6372.039	Risk2	3.01E-03	7.01E-04	2.81E-04	7.47E-05	2.65E-03	7.08E-04	6.12E-04	1.54E-04	3.30E-01	6.31E-02	2.69E-03	7.20E-04	2.05E-03	4.04E-04	1.72E-02	3.19E-03	8.12E-04	1.55E-04	6.10E-02	0	5.05E-03	5.41E-03	1.43E-03	1.13E+00	2.16E-01
476.896	6373.487	Risk3	3.05E-03	7.04E-04	2.95E-04	7.58E-05	2.72E-03	7.14E-04	7.91E-04	1.68E-04	3.33E-01	6.33E-02	2.74E-03	7.24E-04	2.23E-03	4.18E-04	2.06E-02	3.45E-03	8.43E-04	1.57E-04	2.08E-01	8	1.77E-02	5.76E-03	1.46E-03	1.13E+00	2.16E-01
478.415	6368.290	Risk4	3.00E-03	7.00E-04	2.79E-04	7.45E-05	2.64E-03	7.07E-04	5.80E-04	1.50E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.02E-03	4.01E-04	1.66E-02	3.12E-03	8.07E-04	1.54E-04	2.83E-02	0	1.79E-03	5.36E-03	1.43E-03	1.13E+00	2.16E-01
473.146	6375.100	Risk5	3.01E-03	7.01E-04	2.81E-04	7.46E-05	2.65E-03	7.08E-04	6.07E-04	1.52E-04	3.30E-01	6.31E-02	2.70E-03	7.20E-04	2.05E-03	4.03E-04	1.71E-02	3.16E-03	8.11E-04	1.55E-04	5.19E-02	0	3.50E-03	5.40E-03	1.43E-03	1.13E+00	2.16E-01
Air Quality Criteria			0.3	n/a	0.025	0.005	0.1	n/a	0.5	n/a	50	n/a	120	n/a	0.2	0.04	0.5	n/a	10	n/a	0.15	0.15	0.03	2	n/a	120	n/a
Background			3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.54E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.00E-03	3.00E-03	6.00E-04	5.31E-03	1.43E-03	1.13E+00	2.16E-01

Table C. 7: Model Predictions of Radon Concentrations (Bq/m³) for HHERA and Worker Exposure Receptors: Operations Scenario [1]

UTM Easting (km)	UTM Northing (km)	ID	Rn-222 Annual
477.122	6374.321	WE1	1.17E+02
477.342	6374.487	WE2	8.82E+02
476.829	6375.006	WE3	2.97E+01
477.115	6374.493	WE4	9.03E+01
477.087	6374.079	WE5	5.34E+01
477.486	6374.847	WE6	3.85E+01
476.721	6373.938	WE7	3.70E+01
476.777	6373.865	WE8	3.74E+01
477.043	6374.042	WE9	6.18E+01
477.002	6374.109	WE10	6.75E+01
477.012	6374.212	WE11	6.26E+01
477.708	6374.352	Risk1	3.61E+01
478.245	6372.039	Risk2	2.50E+00
476.896	6373.487	Risk3	1.24E+01
478.415	6368.290	Risk4	5.92E-01
473.146	6375.100	Risk5	2.07E+00

Notes:
[1] Model predictions are incremental (i.e., with no background added)

Table C. 8: Model Predictions of Annual Deposition Rates for HHERA and Worker Exposure Receptors: Operations Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NO_2	As	Cd	Co	Cr	Cu	Mo	Ni	Pb	Se	U	Vn	Zn	Rn-222
			mg/cm²/year																		Bq/cm²/year
477.122	6374.321	WE1	1.22E+00	3.71E-02	5.37E-04	1.31E-02	4.87E-05	6.34E-02	1.12E-05	4.43E-06	4.19E-05	9.30E-06	1.09E-04	4.27E-05	4.22E-05	1.92E-05	8.43E-05	3.85E-04	8.52E-05	3.11E-04	1.29E+03
477.342	6374.487	WE2	1.88E+00	1.18E-01	5.78E-04	2.82E-03	3.02E-05	1.34E-02	2.29E-05	5.90E-06	4.91E-05	2.82E-05	4.69E-04	5.65E-05	6.16E-05	3.93E-04	8.76E-05	1.00E-02	1.23E-04	4.34E-04	1.09E+04
476.829	6375.006	WE3	1.23E+00	4.94E-02	3.21E-04	1.80E-03	1.71E-05	8.65E-03	1.10E-05	4.44E-06	4.19E-05	9.45E-06	1.11E-04	4.25E-05	4.23E-05	2.11E-05	8.43E-05	6.40E-04	8.54E-05	3.11E-04	2.80E+02
477.115	6374.493	WE4	1.08E+00	3.27E-02	5.33E-04	3.76E-03	4.49E-05	1.98E-02	1.11E-05	4.51E-06	4.23E-05	1.06E-05	1.29E-04	4.27E-05	4.33E-05	4.03E-05	8.45E-05	1.68E-03	8.73E-05	3.18E-04	9.25E+02
477.087	6374.079	WE5	3.12E+00	1.68E-01	7.95E-04	1.10E-02	1.06E-04	7.36E-02	1.11E-05	4.49E-06	4.22E-05	1.02E-05	1.24E-04	4.26E-05	4.30E-05	3.46E-05	8.44E-05	1.39E-03	8.67E-05	3.16E-04	5.01E+02
477.486	6374.847	WE6	9.16E-01	1.55E-02	1.95E-04	1.09E-03	1.15E-05	5.33E-03	1.11E-05	4.42E-06	4.19E-05	9.18E-06	1.06E-04	4.26E-05	4.21E-05	1.67E-05	8.42E-05	3.44E-04	8.49E-05	3.10E-04	3.91E+02
476.721	6373.938	WE7	1.37E+00	4.85E-02	6.10E-04	1.16E-02	1.10E-04	8.06E-02	1.11E-05	4.44E-06	4.19E-05	9.37E-06	1.11E-04	4.26E-05	4.23E-05	2.11E-05	8.43E-05	5.61E-04	8.54E-05	3.11E-04	3.42E+02
476.777	6373.865	WE8	2.16E+00	1.03E-01	6.49E-04	1.30E-02	1.22E-04	8.82E-02	1.11E-05	4.43E-06	4.19E-05	9.32E-06	1.10E-04	4.26E-05	4.23E-05	2.02E-05	8.43E-05	5.10E-04	8.53E-05	3.11E-04	3.47E+02
477.043	6374.042	WE9	3.16E+00	1.71E-01	9.01E-04	1.68E-02	1.68E-04	1.22E-01	1.12E-05	4.48E-06	4.22E-05	9.97E-06	1.21E-04	4.27E-05	4.29E-05	3.22E-05	8.44E-05	1.14E-03	8.65E-05	3.15E-04	5.98E+02
477.002	6374.109	WE10	1.68E+00	6.85E-02	7.34E-04	1.72E-02	1.74E-04	1.29E-01	1.12E-05	4.49E-06	4.22E-05	1.01E-05	1.23E-04	4.27E-05	4.30E-05	3.35E-05	8.44E-05	1.26E-03	8.66E-05	3.15E-04	6.40E+02
477.012	6374.212	WE11	1.32E+00	4.35E-02	5.79E-04	9.68E-03	8.05E-05	5.44E-02	1.11E-05	4.51E-06	4.23E-05	1.05E-05	1.29E-04	4.26E-05	4.33E-05	3.96E-05	8.45E-05	1.70E-03	8.73E-05	3.17E-04	5.97E+02
477.708	6374.352	Risk1	9.26E-01	1.89E-02	3.14E-04	1.06E-03	1.21E-05	5.64E-03	1.11E-05	4.45E-06	4.20E-05	9.56E-06	1.13E-04	4.26E-05	4.24E-05	2.33E-05	8.43E-05	6.96E-04	8.56E-05	3.12E-04	3.63E+02
478.245	6372.039	Risk2	7.59E-01	2.63E-03	4.44E-05	2.01E-04	2.27E-06	1.17E-03	1.10E-05	4.40E-06	4.17E-05	8.83E-06	1.00E-04	4.25E-05	4.18E-05	1.04E-05	8.42E-05	5.01E-05	8.43E-05	3.08E-04	1.66E+01
476.896	6373.487	Risk3	1.58E+00	7.42E-02	3.46E-04	1.35E-02	1.14E-04	7.43E-02	1.10E-05	4.41E-06	4.18E-05	9.03E-06	1.04E-04	4.25E-05	4.19E-05	1.38E-05	8.42E-05	2.38E-04	8.46E-05	3.09E-04	1.08E+02
478.415	6368.290	Risk4	7.52E-01	2.04E-03	2.10E-05	4.33E-05	4.32E-07	2.26E-04	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.97E-05	4.25E-05	4.17E-05	9.69E-06	8.42E-05	1.27E-05	8.42E-05	3.07E-04	4.14E+00
473.146	6375.100	Risk5	7.40E-01	1.22E-03	6.35E-05	1.53E-04	1.35E-06	7.21E-04	1.10E-05	4.39E-06	4.17E-05	8.83E-06	1.00E-04	4.25E-05	4.18E-05	1.03E-05	8.42E-05	4.44E-05	8.43E-05	3.08E-04	1.40E+01
		Air Quality Standard	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Background	0.73	n/a	n/a	n/a	n/a	n/a	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	2.93E-06	8.42E-05	3.07E-04	n/a

Table C. 9: Model Predictions of Particulate Matter, CO, SO_2, and NO_2 Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Decommissioning Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP 24-hour	24-h TSP Exceedances (days/year)	TSP Annual	PM_{10} 24-hour	24-h PM_{10} Exceedances (days/year)	$PM_{2.5}$ 24-hour	24-h $PM_{2.5}$ Exceedances (days/year)	$PM_{2.5}$ Annual	CO 1-hour	CO 8-hour	SO_2 1-hour	SO_2 24-hour	SO_2 Annual	NO_2 1-hour	1-h NO_2 Exceedances (hours/year)	NO_2 24-hour	24-h NO_2 Exceedances (days/year)	NO_2 Annual
477.122	6374.321	WE1	143.22	6	22.32	66.03	4	16.22	0	4.61	687.1	639.8	5.26E-01	1.65E-01	2.11E-02	543.87	895	176.41	0	25.17
477.342	6374.487	WE2	225.06	30	26.99	77.03	15	19.89	0	3.95	623.7	600.7	2.05E-01	5.18E-02	5.20E-03	173.78	114	62.08	0	8.74
476.829	6375.006	WE3	111.44	3	21.38	56.08	2	11.92	0	3.75	606.6	597.4	1.24E-01	4.61E-02	4.32E-03	135.21	105	54.82	0	8.01
477.115	6374.493	WE4	106.30	1	18.48	54.27	1	12.84	0	3.84	625.1	606.7	1.76E-01	5.61E-02	8.00E-03	189.88	292	66.45	0	11.83
477.087	6374.079	WE5	356.62	124	45.98	133.75	61	27.17	1	6.57	764.4	681.3	5.52E-01	1.78E-01	3.95E-02	570.96	1826	187.93	0	43.41
477.486	6374.847	WE6	88.27	0	16.21	43.75	0	10.69	0	3.41	594.5	585.3	6.28E-02	1.69E-02	1.97E-03	67.47	0	25.14	0	5.69
476.721	6373.938	WE7	212.17	38	26.73	90.53	28	35.00	3	5.60	776.0	705.4	4.59E-01	1.76E-01	1.90E-02	470.09	724	188.75	0	23.36
476.777	6373.865	WE8	303.81	76	36.55	113.91	51	50.82	2	5.96	789.4	723.7	4.96E-01	2.34E-01	2.10E-02	508.48	756	242.09	1	24.72
477.043	6374.042	WE9	366.14	149	49.47	137.88	87	34.52	7	7.55	837.3	723.2	6.20E-01	2.30E-01	4.12E-02	631.82	1713	239.83	4	45.93
477.002	6374.109	WE10	222.18	63	34.79	103.68	50	41.79	11	7.78	829.7	759.6	8.54E-01	3.22E-01	5.62E-02	876.01	2215	335.61	18	61.70
477.012	6374.212	WE11	161.57	31	35.49	88.84	95	58.25	96	15.79	1043.5	940.2	2.22E+00	1.33E+00	2.96E-01	2260.54	3508	1358.37	153	303.77
477.708	6374.352	Risk1	78.97	0	15.76	38.24	0	9.72	0	3.43	601.3	588.2	1.09E-01	2.64E-02	3.34E-03	120.86	39	35.77	0	7.08
478.245	6372.039	Risk2	52.25	0	12.90	26.54	0	7.40	0	3.17	583.3	580.3	3.10E-02	1.06E-02	8.20E-04	41.64	0	19.79	0	4.60
476.896	6373.487	Risk3	135.0	6	22.1	61.1	6	14.5	0	4.0	740.8	661.1	4.71E-01	1.54E-01	1.74E-02	355.1	494	119.9	0	16.4
478.415	6368.290	Risk4	49.7	0	12.6	25.1	0	6.8	0	3.1	578.2	576.9	1.16E-02	3.02E-03	1.71E-04	22.7	0	12.4	0	4.0
473.146	6375.100	Risk5	52.1	0	12.7	28.0	0	7.4	0	3.1	582.7	580.0	2.76E-02	6.31E-03	4.27E-04	39.0	0	15.6	0	4.2
Air Quality Criteria			100	100	60	50	50	27	27	10	15,000	6,000	450	125	20	79	79	200	200	45
Background			46.2	46.2	12.4	23.1	23.1	6.5	6.5	3.1	575	575	0	0	0	11.3	11.3	9.4	9.4	3.8

Table C. 10: Model Predictions of Uranium and Metals Concentrations (µg/m³) for HHERA and Worker Exposure Receptors: Decommissioning Scenario

UTM Easting (km)	UTM Northing (km)	ID	As 24-hour	As Annual	Cd 24-hour	Cd Annual	Co 24-hour	Co Annual	Cr 24-hour	Cr Annual	Cu 24-hour	Cu Annual	Mo 24-hour	Mo Annual	Ni 24-hour	Ni Annual	Pb 24-hour	Pb Annual	Se 24-hour	Se Annual	U 24-hour	Exceedances days/year	U Annual	Vn 24-hour	Vn Annual	Zn 24-hour	Zn Annual
477.122	6374.321	WE1	3.03E-03	7.02E-04	2.80E-04	7.46E-05	2.65E-03	7.08E-04	5.95E-04	1.52E-04	3.30E-01	6.31E-02	2.71E-03	7.21E-04	2.04E-03	4.03E-04	1.70E-02	3.16E-03	8.10E-04	1.55E-04	2.27E-02	0	2.02E-03	5.40E-03	1.43E-03	1.13E+00	2.16E-01
477.342	6374.487	WE2	3.33E-03	7.68E-04	3.17E-04	8.26E-05	2.83E-03	7.47E-04	1.06E-03	2.53E-04	3.39E-01	6.50E-02	3.08E-03	8.00E-04	2.53E-03	5.08E-04	2.64E-02	5.19E-03	8.94E-04	1.73E-04	2.50E-01	20	5.12E-02	6.35E-03	1.64E-03	1.13E+00	2.17E-01
476.829	6375.006	WE3	3.02E-03	7.01E-04	2.79E-04	7.45E-05	2.64E-03	7.07E-04	5.78E-04	1.50E-04	3.30E-01	6.30E-02	2.70E-03	7.20E-04	2.03E-03	4.01E-04	1.68E-02	3.12E-03	8.08E-04	1.54E-04	1.71E-02	0	1.11E-03	5.37E-03	1.43E-03	1.13E+00	2.16E-01
477.115	6374.493	WE4	3.06E-03	7.04E-04	2.84E-04	7.49E-05	2.67E-03	7.09E-04	6.42E-04	1.55E-04	3.31E-01	6.31E-02	2.75E-03	7.24E-04	2.09E-03	4.06E-04	1.79E-02	3.16E-03	8.13E-04	1.55E-04	2.96E-02	0	2.04E-03	5.42E-03	1.43E-03	1.13E+00	2.16E-01
477.087	6374.079	WE5	3.01E-03	7.01E-04	2.79E-04	7.45E-05	2.64E-03	7.07E-04	5.71E-04	1.50E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.02E-03	4.01E-04	1.65E-02	3.12E-03	8.06E-04	1.54E-04	1.11E-02	0	1.18E-03	5.35E-03	1.43E-03	1.13E+00	2.16E-01
477.486	6374.847	WE6	3.02E-03	7.02E-04	2.79E-04	7.46E-05	2.64E-03	7.08E-04	5.81E-04	1.51E-04	3.30E-01	6.30E-02	2.70E-03	7.21E-04	2.03E-03	4.02E-04	1.67E-02	3.15E-03	8.08E-04	1.54E-04	1.58E-02	0	1.72E-03	5.37E-03	1.43E-03	1.13E+00	2.16E-01
476.721	6373.938	WE7	3.01E-03	7.00E-04	2.78E-04	7.44E-05	2.64E-03	7.07E-04	5.63E-04	1.49E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.01E-03	4.01E-04	1.63E-02	3.11E-03	8.05E-04	1.54E-04	7.19E-03	0	8.59E-04	5.33E-03	1.43E-03	1.13E+00	2.16E-01
476.777	6373.865	WE8	3.00E-03	7.00E-04	2.78E-04	7.44E-05	2.64E-03	7.07E-04	5.61E-04	1.49E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.01E-03	4.01E-04	1.63E-02	3.11E-03	8.04E-04	1.54E-04	6.40E-03	0	8.52E-04	5.33E-03	1.43E-03	1.13E+00	2.16E-01
477.043	6374.042	WE9	3.01E-03	7.01E-04	2.78E-04	7.45E-05	2.64E-03	7.07E-04	5.68E-04	1.50E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.01E-03	4.01E-04	1.64E-02	3.12E-03	8.05E-04	1.54E-04	9.69E-03	0	1.09E-03	5.34E-03	1.43E-03	1.13E+00	2.16E-01
477.002	6374.109	WE10	3.01E-03	7.01E-04	2.78E-04	7.45E-05	2.64E-03	7.07E-04	5.68E-04	1.50E-04	3.29E-01	6.30E-02	2.69E-03	7.20E-04	2.01E-03	4.01E-04	1.64E-02	3.12E-03	8.05E-04	1.54E-04	9.53E-03	0	1.13E-03	5.34E-03	1.43E-03	1.13E+00	2.16E-01
477.012	6374.212	WE11	3.01E-03	7.01E-04	2.79E-04	7.45E-05	2.64E-03	7.07E-04	5.76E-04	1.50E-04	3.29E-01	6.30E-02	2.70E-03	7.20E-04	2.02E-03	4.02E-04	1.66E-02	3.13E-03	8.07E-04	1.54E-04	1.35E-02	0	1.31E-03	5.36E-03	1.43E-03	1.13E+00	2.16E-01
477.708	6374.352	Risk1	3.01E-03	7.01E-04	2.79E-04	7.45E-05	2.64E-03	7.07E-04	5.74E-04	1.51E-04	3.29E-01	6.30E-02	2.70E-03	7.21E-04	2.02E-03	4.02E-04	1.66E-02	3.14E-03	8.07E-04	1.54E-04	1.26E-02	0	1.47E-03	5.35E-03	1.43E-03	1.13E+00	2.16E-01
478.245	6372.039	Risk2	3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.56E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.68E-03	0	6.39E-04	5.32E-03	1.43E-03	1.13E+00	2.16E-01
476.896	6373.487	Risk3	3.00E-03	7.00E-04	2.78E-04	7.44E-05	2.64E-03	7.07E-04	5.61E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.01E-03	4.00E-04	1.63E-02	3.11E-03	8.04E-04	1.54E-04	6.23E-03	0	7.70E-04	5.33E-03	1.43E-03	1.13E+00	2.16E-01
478.415	6368.290	Risk4	3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.55E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.14E-03	0	6.08E-04	5.31E-03	1.43E-03	1.13E+00	2.16E-01
473.146	6375.100	Risk5	3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.56E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.81E-03	0	6.32E-04	5.32E-03	1.43E-03	1.13E+00	2.16E-01
Air Quality Criteria			0.3	n/a	0.025	0.005	0.1	n/a	0.5	n/a	50	n/a	120	n/a	0.2	0.04	0.5	n/a	10	n/a	0.15	0.15	0.03	2	n/a	120	n/a
Background			3.00E-03	7.00E-04	2.77E-04	7.44E-05	2.63E-03	7.07E-04	5.54E-04	1.49E-04	3.29E-01	6.30E-02	2.68E-03	7.19E-04	2.00E-03	4.00E-04	1.62E-02	3.10E-03	8.03E-04	1.54E-04	3.00E-03	3.00E-03	6.00E-04	5.31E-03	1.43E-03	1.13E+00	2.16E-01

Table C. 11: Model Predictions of Radon Concentrations (Bq/m³) for HHERA and Worker Exposure Receptors: Decommissioning Scenario [1]

UTM Easting (km)	UTM Northing (km)	ID	Rn-222 Annual
477.122	6374.321	WE1	7.76E+01
477.342	6374.487	WE2	8.21E+01
476.829	6375.006	WE3	1.57E+01
477.115	6374.493	WE4	4.63E+01
477.087	6374.079	WE5	4.00E+01
477.486	6374.847	WE6	1.53E+01
476.721	6373.938	WE7	3.23E+01
476.777	6373.865	WE8	3.29E+01
477.043	6374.042	WE9	5.19E+01
477.002	6374.109	WE10	5.59E+01
477.012	6374.212	WE11	4.44E+01
477.708	6374.352	Risk1	1.71E+01
478.245	6372.039	Risk2	1.51E+00
476.896	6373.487	Risk3	8.57E+00
478.415	6368.290	Risk4	3.71E-01
473.146	6375.100	Risk5	1.37E+00

Notes:
[1] Model predictions are incremental (i.e., with no background added).

Table C. 12: Model Predictions of Annual Deposition Rates for HHERA and Worker Exposure Receptors: Decommissioning Scenario

UTM Easting (km)	UTM Northing (km)	ID	TSP	PM_{10}	$PM_{2.5}$	CO	SO_2	NO+	As	Cd	Co	Cr	Cu	Mo	Ni	Pb	Se	U	Vn	Zn	Rn-222
			mg/cm²/year																		Bq/cm²/year
477.122	6374.321	WE1	1.43E+00	5.25E-02	1.43E-03	2.48E-02	3.01E-04	2.77E-01	1.10E-05	4.39E-06	4.17E-05	8.81E-06	1.00E-04	4.25E-05	4.18E-05	1.00E-05	8.42E-05	1.56E-05	8.42E-05	3.08E-04	9.00E+02
477.342	6374.487	WE2	2.27E+00	1.20E-01	7.04E-04	6.25E-03	7.04E-05	6.12E-02	1.22E-05	4.53E-06	4.24E-05	1.06E-05	1.34E-04	4.39E-05	4.36E-05	4.58E-05	8.45E-05	8.81E-04	8.79E-05	3.19E-04	1.22E+03
476.829	6375.006	WE3	1.50E+00	6.96E-02	4.89E-04	4.72E-03	4.90E-05	4.55E-02	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.97E-05	4.25E-05	4.17E-05	9.67E-06	8.42E-05	6.72E-06	8.42E-05	3.07E-04	1.55E+02
477.115	6374.493	WE4	1.21E+00	4.07E-02	6.79E-04	9.30E-03	1.09E-04	1.01E-01	1.10E-05	4.39E-06	4.17E-05	8.81E-06	1.00E-04	4.25E-05	4.17E-05	9.99E-06	8.42E-05	1.44E-05	8.42E-05	3.08E-04	5.03E+02
477.087	6374.079	WE5	4.04E+00	2.31E-01	2.24E-03	4.26E-02	4.85E-04	4.60E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.97E-05	4.25E-05	4.17E-05	9.69E-06	8.42E-05	7.18E-06	8.42E-05	3.07E-04	3.84E+02
477.486	6374.847	WE6	1.03E+00	2.36E-02	3.11E-04	2.42E-03	2.53E-05	2.22E-02	1.10E-05	4.39E-06	4.17E-05	8.80E-06	9.98E-05	4.25E-05	4.17E-05	9.76E-06	8.42E-05	8.78E-06	8.42E-05	3.08E-04	1.73E+02
476.721	6373.938	WE7	1.81E+00	7.52E-02	1.73E-03	2.71E-02	1.94E-04	1.92E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.96E-05	4.25E-05	4.17E-05	9.59E-06	8.42E-05	4.81E-06	8.42E-05	3.07E-04	3.04E+02
476.777	6373.865	WE8	2.87E+00	1.47E-01	1.58E-03	2.97E-02	2.13E-04	2.05E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.96E-05	4.25E-05	4.17E-05	9.59E-06	8.42E-05	4.74E-06	8.42E-05	3.07E-04	3.11E+02
477.043	6374.042	WE9	4.35E+00	2.48E-01	2.57E-03	5.13E-02	4.86E-04	4.70E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.97E-05	4.25E-05	4.17E-05	9.66E-06	8.42E-05	6.47E-06	8.42E-05	3.07E-04	5.15E+02
477.002	6374.109	WE10	2.32E+00	1.04E-01	2.63E-03	6.33E-02	6.80E-04	6.61E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.97E-05	4.25E-05	4.17E-05	9.69E-06	8.42E-05	7.04E-06	8.42E-05	3.07E-04	5.42E+02
477.012	6374.212	WE11	1.58E+00	6.15E-02	1.65E-03	1.80E-02	1.39E-04	1.29E-01	1.10E-05	4.39E-06	4.17E-05	8.80E-06	9.98E-05	4.25E-05	4.17E-05	9.76E-06	8.42E-05	8.78E-06	8.42E-05	3.08E-04	4.32E+02
477.708	6374.352	Risk1	1.04E+00	2.80E-02	4.81E-04	3.00E-03	3.79E-05	3.23E-02	1.10E-05	4.39E-06	4.17E-05	8.80E-06	9.99E-05	4.25E-05	4.17E-05	9.90E-06	8.42E-05	1.21E-05	8.42E-05	3.08E-04	1.96E+02
478.245	6372.039	Risk2	7.59E-01	2.75E-03	7.42E-05	5.83E-04	7.07E-06	5.83E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	3.11E-06	8.42E-05	3.07E-04	1.03E+01
476.896	6373.487	Risk3	1.70E+00	8.40E-02	5.53E-04	2.02E-02	1.81E-04	1.27E-01	1.10E-05	4.39E-06	4.17E-05	8.79E-06	9.96E-05	4.25E-05	4.17E-05	9.56E-06	8.42E-05	3.98E-06	8.42E-05	3.07E-04	7.63E+01
478.415	6368.290	Risk4	7.45E-01	1.35E-03	2.24E-05	1.25E-04	1.36E-06	1.20E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	2.97E-06	8.42E-05	3.07E-04	2.61E+00
473.146	6375.100	Risk5	7.43E-01	1.61E-03	1.10E-04	3.70E-04	3.97E-06	3.30E-03	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	3.14E-06	8.42E-05	3.07E-04	9.28E+00
		Air Quality Standard	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Background	0.73	n/a	n/a	n/a	n/a	n/a	1.10E-05	4.39E-06	4.17E-05	8.78E-06	9.96E-05	4.25E-05	4.17E-05	9.52E-06	8.42E-05	2.93E-06	8.42E-05	3.07E-04	n/a

Appendix D:

Quantitative Screening Level Analysis of Acrolein (IR-35)

The air quality assessment in the EIS considered combustion emissions (i.e., NOx, SO_2, CO, and fine particulate matter) from diesel-powered equipment/vehicles and the standby diesel generators. While acrolein is a component of diesel exhaust, it was not identified as a contaminant of potential concern (COPC) given that the use of diesel equipment/vehicles and generators at the Wheeler River Project will be limited. To demonstrate this, a quantitative screening level assessment of acrolein emissions from diesel combustion was carried out. Because there is no acrolein criterion or standard in Saskatchewan, 1- and 24-hour Ambient Air Quality Criteria (AAQC) from Ontario were used [45]. These short-term criteria have also been adopted in Alberta. Annual concentrations were evaluated using the tolerable concentration from Environment and Climate Change Canada (ECCC) and Health Canada's (HC) Priority Substance List Assessment Report [46] and the chronic reference concentration from the U.S. EPA [47]. The screening level assessment is described in the following paragraphs.

Using the nitrogen oxide (NOx) results from the air quality modelling assessment, 1-hour, 24-hour, and annual dispersion factors (i.e., µg/m³ per g/s emitted) were calculated for each assessment scenario. A dispersion factor was calculated for both the worker camp receptor, and the off-property receptor with the highest predicted NOx concentration. These dispersion factors were then applied to estimates of acrolein emissions to predict 1-hour, 24-hour, and annual concentrations of acrolein at both locations. The acrolein emission rate from the standby diesel generators were estimated using fuel flow rates from manufacturer's specifications and emission factors from Chapters 3.3 and 3.4 of the U.S. EPA AP-42 Compilation of Emission Factors, depending on the generator size. For mobile equipment and vehicles, a ratio of acrolein to non-methane hydrocarbons (NMHC) was applied to the total HC emission factors (see Section A.9 and A.10), conservatively assuming total HC equals NMHC. The ratio of acrolein to NMHC was obtained from the U.S. EPA document "*Speciation Profiles and Toxic Emission Factors for Non-road Engines in MOVES3*" (2022) and assumed Tier II engines. The short-term (i.e., 1- and 24-hour) site-wide emission rates for acrolein were estimated to be 1.89E-03 g/s for Construction, 1.04E-03 g/s for Operation, and 1.53E-03 g/s for Decommissioning, while the annual emission rates for the same scenarios were 1.55E-03 g/s, 7.58E-04 g/s, and 1.20E-03 g/s. In all scenarios, the generators were assumed to operate 24-hours per day and increased equipment usage during Construction and Decommissioning resulted in higher acrolein emissions compared to the Operation scenario.

The results of the screening level assessment are outlined in Table D.1 below. Calculated acrolein concentrations are compared against Ontario AAQC for the 1- and 24-hour averaging periods and ECCC/HC and U.S. EPA guidelines for the annual averaging period. As can be seen in the table, acrolein concentrations are expected to be below the applicable criteria and guidelines for all scenarios. The highest estimated short-term concentrations occur for the Decommissioning scenario and are 6.7% of the 24-hour AAQC, and 1.8% of the 1-hour AAQC at the worker camp. At the maximum off- property receptor, the estimated acrolein concentrations for Decommissioning are predicted to be 0.9% and 2.0% of the 1-hour and 24-hour AAQC, respectively. The annual concentration is highest for the Operation scenario and is 1.5% of the ECCC/HC guideline at the worker camp and 0.1% of the guideline at the maximum off-property receptor. Compared to the U.S. EPA chronic reference concentration, the highest annual concentration is 30.1% of the reference level at the worker camp and 2.4% at the maximum off-property receptor.

Based on the results of the screening level assessment, acrolein is not considered a COPC.

Table D.1: Calculated Dispersion Factors and Resulting Acrolein Concentrations

Scenario	Averaging Period	Criteria or Guideline (µg/m³)	Emission Rate (g/s)	Dispersion Factor [1] (µg/m³ per g/s)		Concentration [2] (µg/m³)		% of Criteria or Guideline	
				Camp Receptor	Max Off-Property Receptor	Camp Receptor	Max Off-Property Receptor	Camp Receptor	Max Off-Property Receptor
Construction	1-hour	4.5	1.89E-03	25.5	24.9	4.84E-02	4.71E-02	1.1%	1.0%
	24-hour	0.4		9.2	5.0	1.75E-02	9.56E-03	4.4%	2.4%
	Annual	0.4	1.55E-03	2.1	0.5	3.19E-03	7.29E-04	0.8%	0.2%
		0.02						16.0%	3.6%
Operations	1-hour	4.5	1.04E-03	37.5	23.6	3.91E-02	2.47E-02	0.9%	0.5%
	24-hour	0.4		12.9	5.3	1.35E-02	5.55E-03	3.4%	1.4%
	Annual	0.4	7.58E-04	7.9	0.6	6.02E-03	4.84E-04	1.5%	0.1%
		0.02						30.1%	2.4%
Decomm.	1-hour	4.5	1.53E-03	54.1	26.2	8.29E-02	4.01E-02	1.8%	0.9%
	24-hour	0.4		17.4	5.2	2.66E-02	8.02E-03	6.7%	2.0%
	Annual	0.4	1.20E-03	2.0	0.5	2.44E-03	5.48E-04	0.6%	0.1%
		0.02						12.2%	2.7%

Notes:

[1] Based on the incremental NOx predictions at the worker camp receptor and the off-property receptor where maximum NOx concentrations were predicted.

[2] Concentrations are incremental and do not include the addition of a background. Background is expected to be negligible.