YUKON ENERGY CORPORATION

WHITEHORSE THERMAL GENERATING STATION PROJECT RENEWAL

MAY 30, 2024

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1 INTRODUCTION

1.1 PROPONENT INFORMATION

Yukon Energy Corporation (YEC) is the Project proponent. It was established in 1987 and is a public electric utility wholly owned by the Yukon Development Corporation (a Crown corporation). YEC is the main generator and transmitter of electrical energy in the Yukon to provide Yukoners with a sufficient supply of safe, reliable electricity and related energy services. Its headquarters are located near the Whitehorse Rapids hydro plant in Whitehorse, with community offices in Mayo, Faro, and Dawson City.

YEC is regulated principally under the Yukon Business Corporations Act, Public Utilities Act, and Waters Act, and the federal Fisheries Act. In particular, under the Public Utilities Act, YEC has an obligation to supply electricity service to its customers, and its rates and operations are subject to regulation by the Yukon Utilities Board. YEC's diesel generation facilities are also subject to regulation under the Yukon Environment Act and Air Emissions Regulations, as well as YESAA.

1.2 PROJECT PURPOSE & SCOPE

The backbone of Yukon Energy's generation resources is three hydro-electric and five thermal generation resources (diesel- and natural gas-fired) that, when connected with our transmission, form the electric grid of the Yukon Integrated System (YIS). Historically, Yukon Energy has met over 90% of the Yukon's electricity needs with generation from our renewable hydro-electric facilities. In the winter, the Yukon's peak electricity demand is over twice as high as in the summer and we supplement the hydro-electric generation with thermal generation to meet winter demand. As the Yukon's electricity grid is not connected to neighbouring systems, we cannot rely on electricity imports during peak load periods. On the coldest winter days, when electricity demand peaks, Yukon Energy must be self-sufficient to meet the electricity needs of the territory. The Yukon has a cold climate and electricity is critical to the safety and wellbeing of our customers: as more and more Yukoners depend on electricity to heat their homes in winter, power outages in wintertime are a risk to public safety.

Yukon Energy requires diesel generation facilities to meet customer demand when our other generation resources are unavailable, such as planned maintenance, emergency repair, and peaking demand during cold winter temperatures. The current need for diesel generation is related to several factors including:

- The need to meet demand for electricity during those times when hydro-electric and LNG facilities are taken offline for routine maintenance.
- The need to meet demand for electricity during those times when hydro-electric and LNG facilities are offline as a result of an emergency condition.
- The need to meet demand for electricity during those times when there is a grid separation (i.e., transmission outage) and electricity from some of our generation resources may not be available.
- The need to exercise a particular diesel unit as a part of routine maintenance.
- The need to meet demand for electricity during those times when hydro-electric and LNG facilities are otherwise unable to meet current demand for energy.

YEC's thermal generating stations are installed and operated to ensure continuity of the overall Yukon Integrated System, and so all customers on the system can receive reliable power consistent with YEC's and regulatory obligations. As described above, given the current generation mix (hydro, wind, solar, thermal) and system design, YEC's ability to operate the installed thermal plants, particularly during conditions where demand for electricity cannot be adequately met by hydro (e.g., planned maintenance, emergency repair, demand during cold winter temperatures), is essential to avoid scenarios where there would be a requirement to impose blackout conditions to various customers. This is particularly relevant during times where the lack of such ability would at best be very inconvenient, and at worst dangerous to infrastructure and human health and safety, such as would be the case during cold winter temperatures.

YEC has operated the Whitehorse Rapids Thermal Generating Station (WRGS) in Whitehorse, Yukon (the Project) since 1968. The Station provides reliable energy supply to supplement renewable energy sources. The operation of the Project requires periodic authorization renewals (every 10 years) under the Environment Act for air emissions and fuel storage. An applicable decision document, issued pursuant to an assessment completed under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA), is required. The Project has been assessed under YESAA three times in the past (2008, 2010, and 2013), with the last assessment being completed as part of the addition of natural gas generation to the station. YEC is applying for two principal authorization renewals as shown in Table 1-1 below.

Table 1-1: Required Project Authorizations

Agency	Agency (Department)	Authorization
Yukon Government	Environment	Environment Act, Air Emissions Regulation • Air Emissions Permit
Yukon Government	Community Services Fire Marshal's Office	Environment Act, Storage Tank Regulation • Tanks Regulation, Storage Tanks System Permit

The Project is effectively a renewal of existing thermal electricity generating activities. As such, its key phase is Operations and Maintenance, thus does not include decommissioning. Periodic swapping of capacity may occur at the site (e.g., when a unit reaches end of life or becomes irreparable), which would involve removing a unit and replacing it with a similar or more efficient unit of a similar generating capacity. Depending on the nature of the swap, such activities may be approved by the air emissions regulator under provisions of the current air emissions permit for the facility without further assessment.

The natural gas portion of the WRGS is subject to the requirement for renewal of the air emission permit like the diesel component, but the other aspects of the natural gas facility are regulated under the Yukon Oil and Gas Act and the authorization under that legislation (Facility Licence No. 1140) does not expire until July 2054. As such, only the air emissions from the natural gas facility are expected to be subject to assessment for this Project at this time.

The Project will include modifications or replacement of the existing permanent fuel storage system to bring it up to applicable and recent code changes. Those changes are in the design phase at this time and will be subject to non-discretionary legislation that will be used to verify compliance at the permitting stage. The remaining mobile fuel storage activities at the Project Site will remain unchanged. As the Project is not new, the activities associated with the Project include those associated with operations and maintenance/repair only.

2 PROJECT DESCRIPTION

2.1 PROJECT COMPONENTS

The Whitehorse Rapids Thermal Generating Station is located on YEC land at the site of the Whitehorse Rapids Hydroelectric Generating Station on the Yukon River (Figure 1). The Project Site is heavily developed and now surrounded by residential, commercial, and other industrial development, including significant ground and air transportation infrastructure.

The Project will include the operation and maintenance of the following infrastructure (Figure 2):

- 3 x 4.4 MW natural gas generators
- 1 x 3.5 MW diesel generator (Pre-Tier)
- 1 x 2.7 MW diesel generator (Pre-Tier)
- 2 x 2.5 MW diesel generators (Pre-Tier)
- 2 x 2.5 MW diesel generators (EPA Tier 4)
- 7 x 1.8 MW rental diesel emergency backup generators (EPA Tier 2)
- 160,000 liter permanent diesel fuel storage tank (to be modified or replaced to address new connection requirements and recent code changes)
- 3 x 75,000 liter portable diesel fuel storage tanks (for mobile/rental diesels)

The WRGS is not expected to run continuously and is designed to provide electricity quickly during the loss of hydro generation, peak hours of consumption (e.g., cold winter days), periods of low water, periods of planned and unplanned transmission outages, and emergencies. In summary, the current and planned production capacity is:

- The total production capacity at the Project Site in winter is approximately 42.2 MW (13.2 MW gas and 29 MW diesel, including 12 MW of emergency diesel)
- The existing air emission permit currently authorizes a production capacity of 29.4 MW (13.2 MW natural gas, 16.2 MW diesel).
- The production capacity that will be requested for the renewed air emissions permit will be 42.2 MW (13.2 MW natural gas, 29 MW diesel, including 12 MW of emergency only diesel). This would restore the previous authorization for 12 MW of diesel under emergency conditions, which expired in 2022.

The above equipment is expected to run during normal operation and emergency conditions. Based on YEC projections, the frequency with which the units are used under the typical operations are:

- Permanent natural gas units: all three units will be used in the winter from December through April; in the shoulder months (May and November) typically, only one or two units would be used.
- New Tier 4 permanent diesel generators: these two units will typically only run in the winter (December through April) and will not run continuously. During those months, the units would run for approximately 24 hours (nonconsecutively) within any given two-week period.
- Permanent diesel generators or temporary mobile diesel generators: these units will typically only run during the winter (December through April) and will not run continuously. During those months, the units would run for approximately six hours (nonconsecutively) within any given two-week period.

In addition to the expected typical operations and emergency (N-1) events, all thermal units are operated for short periods (1-2 hours) on a monthly basis throughout the year for maintenance/operational readiness purposes.

2.2 AIR EMISSIONS AND MITIGATION

The WRGS consists of a variety of generators with vintages ranging from the 1970s to present. To minimize the environmental impacts from the generators, YEC has ranked operation priority to run their equipment based on the following orders:

- Three permanent natural gas units
- Two new Tier 4 diesel generators
- Renal diesel generators
- The old pre-tier permanent units

The primary air emissions associated with the Project are from diesel fuel and natural gas combustion associated with the generators. The criteria air contaminants (CAC) are: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), total suspended particulates (TSP) and diesel particulate matter (DPM). For older units reaching their end of life, YEC will seek to replace them with units that have the best available control technology (BACT). In 2024, YEC plans to install two new diesel generators (CAT C175-16[1]) Whitehorse Diesel Number 8 and 9 (WD8+WD9) for approximately 5.2 MW of permanent diesel generation capacity to replace a diesel generator (WD3 at 5.2 MW), which was retired several years ago. These CAT C175-16 generators meet US EPA Tier 4 final emission standards. They contain clean emission modules, which include diesel oxidation catalyst for PM and hydrocarbon control as well as selective catalytic reduction (SCR) for NOx control.

Emissions from WD3 and WD8 + WD9 were compared to see the emission differences due to the generator replacement. The WD3 emissions were taken from Table 2-2 of the SENES report[2] and the WD8+ WD9 emission were taken from air quality assessment report (AQA)[3] prepared by WSP Canada Inc. (Appendix A). Significant emission reductions for all CACs except SO_2 were noticed as shown in Table 2-1 of the report. Although SO_2 emissions increased, their total contribution to the atmosphere is relatively small. The predicted SO_2 concentrations were well below the ambient air quality standards (See section 4.1). The overall CAC emission reduction indicates that BACT from the two Tier 4 diesel generators are effective in controlling air emissions.

Table 2-1 Emission Reductions from the Replacement of WD3 with WD8 and WD9 Generators

Status	Diesel Engines ID	Power Generation Output (MW)	Emissions					Unit
			CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	
Retired	WD3	5.2	1.15	6.02	0.01	1.02	0.08	g/s
New -Tier 4	WD8 + WD9	5.2	0.97	0.97	0.024	0.039	0.039	g/s
Emission Changes			16%	84%	-129%	96%	54%	%

[1] CAT C175-16 Diesel Generator Sets Electric Power, 2023
[2] Air Emissions Permit (No. 4201-60-010) Renewal Application Support Document, Report on Updated Air Quality Assessment for Yukon Energy Diesel Generator Operations, Prepared by SENES Consultants Ltd., Appendix B, October 20, 2011
[3] Air Quality Assessment Whitehorse Rapids Generating Station, prepared by WSP, August 07, 2023

3 EXISTING ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

3.1 GENERAL CONDITIONS

The project is a brownfield industrial site in Whitehorse, Yukon. Site access is via an existing public paved access road – Miles Canyon Road – located off Robert Service Way. Robert Service Way is connected to the Alaska Highway, a paved, transport-grade, multi-lane highway. The project sees numerous passenger and large vehicle visits per day (>100) and includes frequent fuel tanker visits, particularly in winter (approximately 1 to 2 per day) when active thermal generation is occurring[4].

The Station is located in Whitehorse in the Yukon Southern Lakes area, where its landscape is characterized by broad valleys and large lakes. The vegetation of this area is mainly open coniferous and mixed woodland typical of the boreal forest. In open areas and at lower elevations grasslands are common[5].

The population of Whitehorse in 2021 was recorded at 30,081 residents according to Yukon Bureau of Statistics[6]. this number represents approximately 70% of Yukon's population. Whitehorse has grown consistently over the past several decades and has added approximately 500 residents and 215 homes per year between 2011 – 2020. According to the Yukon Bureau of Statistic's Population Projections report, the preferred projection for Whitehorse is expected to reach 40,600 in 2040 which would represent 73.1% of the estimated Yukon population.

With various governments operating within Whitehorse (federal, territorial, municipal, and First Nations), the largest economic sector for Whitehorse employment is public administration. Tourism is also a significant driver of Yukon's economy, with the retail and accommodation sectors both strong and growing. The health care and construction sectors are also major employers. The top three contributors to Yukon GDP by industry in 2020 were: public administration; real estate and rental leasing; as well as mining and quarrying.

Emerging economic sectors and opportunities for Whitehorse include innovation, technology, professional, and business services. In addition, the health and education sectors are also projecting new growth. Resource-based enterprises, mainly Yukon's mining industry, continue to dominate the light and heavy industry sector with Whitehorse shop-based industrial mechanical businesses providing primary service support. Sports and outdoor recreation are a cornerstone of the Whitehorse lifestyle. Whitehorse has become an eco-adventure destination renowned for its access to the wilderness. As a hub for Yukon activity and tourism, Whitehorse welcomes hundreds of thousands of visitors each year. In 2018, the Canadian Tourism Research Institute estimated that approximately 323,000 persons visited the Yukon for an overnight stay, many of whom would have visited Whitehorse.

3.2 BACKGROUND AIR QUALITY

Local ambient air quality condition is monitored and operated by Yukon's Department of Environment as part of Canada's National Air Pollution Surveillance (NAPS) program (NAPS ID: 119004). The collected data reflecting baseline ambient air quality conditions from both natural and anthropogenic sources. This station continuously

[4] YEC, YESAA Project Description, Whitehorse Rapid Generating Station Relicensing Project, November 2023
[5] Whitehorse 2040 Official Community Plan
[6] Yukon Bureau of Statistics, Population Report: Q2 2021

monitors NO_2, ozone (O_3) and $PM_{2.5}$. The PM_{10} and TSP baseline concentrations were calculated based on data from urban sites across Canada provided in the literature. The measured concentrations were compared with the Yukon Ambient Air Quality Standards (YAAQS). The baseline ambient concentrations were in the range of 28% to 70% current YAAQS as shown in Table 3-1.

Table 3-1 Baseline Air Quality Conditions

Whitehorse Monitoring Station (2018-2020)				
Air Contaminant	**Averaging Period**	**Concentration (µg/m^3)**	**Current YAAQS ((µg/m^3)**	**% of Current YAAQS**
NO_2	1-hour	73.3	113	65%
	Annual	11.2	32	35%
$PM_{2.5}$	24-hour	17.5	27	65%
	Annual	4.4	8.8	50%
PM_{10}	24-hour	35.0	50	70%
	24-hour	67.3	120	56%
TSP	Annual	17.0	60	28%

Based on the YEC's supporting document in 2011[7], majority of air emissions from Whitehorse are from home heating, local vehicle traffic, and other sources. Emissions from the project account for less than 1% of total NOx, and PM, indicating insignificant contributions from the project.

3.3 BACKGROUND NOISE LEVELS

The Ambient Sound Levels (ASL) is representative of the natural and non-industrial noise sources in the vicinity of the Station. Baseline noise monitoring was carried out by Hemmera in 2020 at the Station's fenceline and at the nearby substation[8]. Baseline noise levels measured at the substation, the nearest location to the nearest receptor to the Project, were 54 dBA during the daytime and 49 dBA during the nighttime.

There are no significant existing and approved third-party facilities in the vicinity of the Station, therefore, there was no noise contribution from industrial sources towards the baseline noise levels.

The Erik Nielsen Whitehorse International Airport is located approximately 2 km from the Station, with the nearest point on the runway located approximately 600 m from the Station. Arriving and departing flights are infrequent (i.e., less than 10 arrivals and 10 departures per day) and therefore, noise from the airport was not considered in the noise impact assessment (NIA).

[7] Yukon Energy, Air Emissions Permit (No. 4201-60-010) Renewal Application Supporting Document, Oct 25, 2011
[8] Hemmera 2020, Yukon Energy, Whitehorse Rapids Generating Station - Noise Monitoring Assessment

4 ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS ASSESSMENT

4.1 AIR QUALITY ASSESSMENT

4.1.1 AQA ASSESSMENT SCENARIOS

An air quality assessment (AQA) was completed for the proposed project and applied an air dispersion modelling approach to evaluate combustion sources from the WRGS. The AQA evaluated two emission scenarios:

1. Expected Scenario [21.312 MW]: 3 existing permanent natural gas units [13.125 MW] + 2 new Tier 4 diesel generators [5.2 MW] + 2 existing diesel units [3 MW] or 2 mobile diesel units [3 MW]
2. Emergency (N-1) Scenario [41.725 MW]: 3 existing permanent natural gas units [13.125 MW] + 4 existing permanent diesel units [10.8 MW] + 2 new Tier 4 diesel generators [5.2 MW] + 7 of 10 mobile diesel units [12.6 MW]

These scenarios are conservative and assume that the generators are operating constantly year-round at the maximum nameplate capacity, except for the mobile generators, which were only modelled from December to April. The actual WRGS emissions are expected to be much lower. In typical operations, only required units are run in winter months to meet energy demands. Based on YEC's decades of operational experience, the Emergency (N-1) Scenario is predicted to occur once in 20 years for a cumulative total of 1 to 5 days during a 2-week period.

4.1.2 AQA RECEPTOR GRID

Pollutant concentrations were estimated every 20 m in the general area of maximum impact and the property boundary, 50 m within 0.5 km of the property boundary, 250 m from 0.5 to 2 km of the boundary, and 500 m from 2 km of the boundary to the edge of the domain. The following sensitive receptors were included in the modelling:

- Nearest residence to the power plant, 0.34 km away from the property.
- Christ the King Elementary School, 0.93 km away from the property.
- Grey Mountain Primary School, 1.33 km away from the property.
- F.H. Collins Secondary School, 1.55 km away from the property.
- Selkirk Elementary School, 1.26 km away from the property.
- Whitehorse General Hospital, 2.41 km away from the property.

4.1.3 AQA APPROACH

The impacts on ambient air quality associated with air emissions from the Station were evaluated through the use of a regulatory approved CALPUFF air dispersion model. CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) to provides a scientific means of relating air emissions to ambient concentrations via simulation of air contaminant transport and dispersion under a variety of meteorological conditions. Detailed three-dimensional meteorological fields were produced by the diagnostic computer model CALMET based on digital land use data and terrain data, as well as observed upper air and the most recent five years (2016-2020) of meteorological data. CALPOST is used to post-process and summarize the modelling output from CALPUFF.

Air dispersion modelling was conducted following the methods recommended in the BC AQDMG (British Columbia Ministry of Environment and Climate Change Strategy). The previous version of the BC AQDMG is referenced by the Yukon Environmental and Socio-economic Assessment Board Proponent's Guide: Model Documentation Report (Government of Yukon, 2016) as an exemplary guideline for air dispersion modelling.

4.1.4 AQA MODELLING RESULTS

Two air quality assessment scenarios were conducted. The Expected Scenario applies the best available technology for the most frequently used units, which include 3 permanent natural gas units and the 2 new TIER 4 permanent diesel gensets. All permanent units were modelled as operating every hour of the year instead of the much shorter operational frequency on as needed basis. For the Emergency (N-1) Scenario, emissions were conservatively modelled every hour of the year for permanent units and every hour from December 1 to April 30 for the mobile diesel units instead of the estimated cumulative total of 1 to 5 days during a 2-week period that may occur once in approximately 20 years. The typical Station emissions are expected to be lower as compared to the emission scenarios considered in this assessment.

Maximum model predicted concentrations of the contaminants of concern, along with the baseline air quality concentrations, were compared to the Yukon Ambient Air Quality Standards (YAAQS) (Government of Yukon, 2019) where applicable. The CO concentrations were compared to the BC Pollution Control Objectives, since this pollutant is not considered in the YAAQS. Modelling results indicate that:

- For all scenarios, the maximum predicted concentrations for SO_2 and CO were well below the YAAQS and BC Pollution Control Objectives at all receptors.
- For TSP, $PM_{2.5}$ or PM_{10}, the maximum predicted concentrations exceeded the YAAQS in some scenarios and averaging periods, however, the predicted exceedances are in the immediate vicinity of the WRGS boundary (less than 220 m) and decrease quickly to below the YAAQS moving away from the WRGS boundary. There are no predicted exceedances at the sensitive receptors for TSP, $PM_{2.5}$ or PM_{10}.
- For NO_2, the baseline ambient concentrations (the existing background concentrations without the Generating Station) considered in the assessment are elevated, with the 1-hour baseline at 65% of the current YAAQS and 93% of the 2025 YAAQS. When the baseline is added to the maximum predicted 1-hour and annual NO_2 concentrations from the WRGS for all scenarios the predicted results are above the YAAQS. There are predicted 1-hour exceedances over most of the domain for both scenarios; however, there are no predicted annual exceedances at the sensitive receptors. The maximum points of impingement (worst-case receptors) for all contaminants were all found near the Station.
- DPM results are not included in this assessment as there are no air quality standards for DPM.
- For the Emergency (N-1) Scenario, the cumulative predicted air contaminant concentrations were higher than those of the Expected Scenario due to increased power generation. However, the Emergency (N-1) Scenario is expected to occur rarely, only when the ambient temperature is colder than -30 °C for a cumulative total of 1 to 5 days during a 2-week period and when YEC loses its single largest source of electricity supply and/or transmission at the time. N-1 conditions have occurred, but based on historic data, these conditions only occur once in approximately 20 years.
- For both the Expected Scenario and the Emergency (N-1) Scenario, maximum emissions from all operating sources are only expected to occur for a small number of hours each year.

It is important to note that the modelling results represent the worst-case potential air quality impacts based upon the WRGS maximum operating conditions occurring concurrently with worst-case meteorological conditions. As such, the model predicted air contaminant concentrations are considered conservative. The typical Station emissions are expected to be lower as compared to the emission scenarios considered in this assessment.

4.2 HEALTH IMPACT ASSESSMENT

A Human Health Risk Assessment (HHRA) was conducted by WSP to evaluate the potential risks to human health associated with air pollutant emissions from the operation of the WRGS in Whitehorse, Yukon. The HHRA report is included in Appendix B, which provides detailed evaluation approach, uncertainty analysis, as well as summary and conclusion.

4.2.1 HHRA RECEPTORS AND SCENARIOS

The HHRA study area is a 10-km by 10-km area centered on the WRGS. The following human health receptors were identified for HHRA, including four schools, one hospital and the nearest residence. These receptors are consistent with those presented in Section 4.1.2 of the report for AQA.

- Schools or Childcare Facilities – Students (children and teenagers) who are attending classes on a full-time basis and toddlers and young children who attend a daycare facility on a full-time basis).
- Hospitals or Health Facilities – adult patients who are receiving care at hospitals whose health is already compromised, and elderly adults who reside in long-term care facilities.
- Residences – individuals of all ages who live in the residential communities near the Station.

The two assessment scenarios for HHRA are the same as the AQA presented in Section 4.1.1 of the document.

4.2.2 HHRA ASSESSMENT APPROACHES

The HHRA relies on air dispersion modelling results from AQA (Appendix A) to evaluate the potential risks to human health associated with seven different pollutant or criteria air contaminant (CAC) emissions from the station during typical operations (Expected emission scenario) and emergency (N-1) operations (emergency emissions scenario). The predicted air emissions conservatively assumed that all stationary generators were continuously and simultaneously operating under maximum rated capacities year around. Mobile units were assumed to be operation continuously from December through April.

The potential acute (short-term) and chronic (long-term) risks to human health were evaluated using a risk assessment framework in accordance with Health Canada's Guidance for Evaluating Human Health Impacts in Environmental Assessment: Human Health Rish Assessment. The guidance included four key components of the risk assessment framework, including problem formulation, exposure assessment ((acute and chronic exposure), toxicity assessment and risk assessment (acute inhalation assessment and chronic inhalation assessment).

Constituents of potential concern (COPC) were first screened based on exceedance of air quality thresholds (acute and long-term) at receptor points. NO_2, $PM_{2.5}$, and PM_{10} are non-threshold constituents, and were retained for further evaluation even if they did not exceed any thresholds. NO_2 (1-hour average), $PM_{2.5}$, PM_{10} (24-hour averages) and DPM (1-hour average) were retained for the acute exposure assessment. The acute inhalation assessment also considered that people may spend a short amount of time at the maximum point of impingement (MPOI, locations with highest predicted concentrations outside of the property boundary). The MPOI locations for the chronic inhalation COPCs do not overlap with any of the receptor locations evaluated and people are not expected to spend extended amounts of time at these locations. Therefore, the MPOI was not considered relevant for long-term exposure and was not evaluated in the chronic assessment.

NO_2, $PM_{2.5}$, and DPM (annual averages) were retained for the chronic inhalation assessment. For the toxicity assessment, the concentration of the contaminant in the air that people can be exposed to without generating adverse health effects was determined. The risk characterization stage integrated exposure and toxicity assessments to evaluate whether the exposure to the selected contaminants has the potential for adverse health effects to occur, by calculating a Hazard Quotient (HQ).

4.2.3 HHRA RESULTS AND DISCUSSION

The HHRA evaluated the potential acute and chronic risks to human health associated with CAC emissions from the operation of the WRGS for two scenarios. The findings of the HHRA are summarized below:

- **Acute Health Risks**: non-negligible risks were identified for all acute COPCs (e.g., NO_2, DPM, $PM_{2.5}$, PM^{10}) for current and future standards, where applicable, at all locations evaluated in both scenarios. In both scenarios and for all acute COPCs, risks were highest at the MPOI, followed by the nearest residence.
- **Chronic Health Risks**:
  - NO_2 (annual, non-carcinogenic): non-negligible risks were identified for the residents at the nearest residence and the Whitehorse General Hospital for both current and 2025 standards. There were negligible risks for the hospital/teacher/student receptor at all human health receptor locations assessed for both current and 2025 standards.
  - $PM_{2.5}$ (annual, non-carcinogenic): non-negligible risks were identified for the residents at the nearest residence and the Whitehorse General Hospital, with similar magnitude of risks.
  - DPM (annual, carcinogenic): non-negligible risks were identified for the residents (composite and adult) at all receptor locations assessed. For the hospital worker/teacher receptor, risks were acceptable at all receptor locations assessed.

It should be mentioned that these risk estimates are likely conservative and might overestimate potential health risks, since the emissions estimations assumed that all stationary generators are emitting simultaneously and continuously at the name-plate capacity year-round, except for the mobile units, where were assumed to be operating continuously from December through April. In reality, the generators are typically operated during winter months to meet energy demands. In summary, the HHRA supports the renewal of YEC's emissions permit as outlined in this project proposal.

4.3 NOISE IMPACT ASSESSMENT

Thermal operations are intermittent and mostly occur in the winter. During operations temporary increases in localized site noise occur. This noise can affect other land users, particularly residents in the adjacent Riverdale residential subdivision, which was developed after the generating station was established. The noise impact assessment (NIA) was conducted by WSP to evaluate the potential effects of the Station's future noise emissions on the existing acoustic environment surrounding the Station. A detailed NIA report is included in Appendix C.

4.3.1 NIA ASSESSMENT SCENARIOS

The NIA assessed two variants of an Expected Case (i.e., typical operations) and an Emergency (N-1) Case, as follows:

- The Expected Case consists of the cumulative noise level associated with the baseline in combination with the Project's expected operating scenario:

  1) Expected Scenario 1 (21.312 MW): 3 existing permanent natural gas units (13.125 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 2 existing pre-tier diesel units (3 MW)

  2) Expected Scenario 2 (21.312 MW): 3 existing permanent natural gas units (13.125 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 2 mobile diesel units (3 MW).

- The Emergency (N-1) Case consists of the cumulative noise level associated with the baseline in combination with the Project's emergency scenario.

  1) Emergency (N-1) Scenario (41.725 MW): 3 existing permanent natural gas units (13.125 MW) + 4 existing permanent diesel units (10.8 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 7 of 10 mobile diesel units (12.6 MW).

Noise emissions for Station sources were established using manufacturers' data and previous site measurements. Based on YEC projections, the frequency with which the units are used under the expected typical operations are:

- Permanent natural gas units (WG1-3): All three units will be used in the winter from December through April; in the shoulder months (May and November) typically, only one or two units would be used.
- New Tier 4 permanent diesel generators (WD8 and WD9): these two units will typically only run in the winter (December through April) and will not run continuously. During those months, the units would run for approximately 24 hours (nonconsecutively) within any given two-week period.
- Permanent diesel generators or temporary mobile diesel generators: Typically two of these units will run concurrently, only during the winter (December through April) and will not run continuously. During those months, the units would run for approximately six hours (nonconsecutively) within any given two-week period.

In addition to the expected typical operations and emergency (N-1) events, all thermal units are operated for short periods (1 to 2 hours) on a monthly basis throughout the year for maintenance/operational readiness purposes.

4.3.2 NIA RECEPTOR GRID

The noise levels were assessed at three dwellings identified within 1.5 km of the station as listed below:

- Receptor R01 is located 200 m east of the station in an area with dwelling unit density of greater than the 160 dwellings per quarter section (dwellings within a 451 m radius) and is more than 100 m and less than 500 m from a heavily travelled road. R01 is the nearest receptor to the Station and is considered to be representative of its neighbourhood. The Daytime Permissible Sound level (PSL) for this location is 61 dBA.
- Receptor R02 is located 1.3 km north of the Station, also in an area with a population density greater than 160 dwellings per quarter section. It is located less than 100 m from a heavily travelled road, and therefore, the daytime PSL is 66 dBA. R02 is the nearest receptor in the northern direction from the Station.
- Receptor R03 is a RV Park (Hi Country RV Park), located 1.4 km southwest of the Station, within 100 m of the Alaska Highway and with a population density of 9 to 160 dwellings per quarter section. Therefore, the daytime PSL for this location is 63 dBA. R03 is the nearest receptor in the southern and western directions from the Station.

These above receptors were selected as the most impacted locations representative of various directions from the Project.

4.3.3 NIA APPROACH

The NIA was conducted following the BC Oil and Gas Commission's (OGC) *British Columbia Noise Control Best Practice Guideline* (OGC Guideline)[9] and Health Canada's *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise* (Health Canada Guidance)[10]. The OGC Guideline considers broadband compliance and assessment of potential low frequency noise (LFN) issues. Broadband compliance is typically assessed by comparing cumulative noise level predictions at each receptor to PSL values specified by the OGC Guideline. The PSLs and % HA criteria are applicable to expected scenarios, not applicable for emergency situations. The Health Canada Guidance considers the change in the percentage of highly annoyed (HA) people due to changes in noise levels. If the %HA increases by more than 6.5% as a result of the Project, then the Health Canada Guidance recommends mitigation be considered.

Project noise levels at each identified representative receptor were estimated using the Computer Aided Noise Attenuation (CadnaA) prediction model (version 2023 MR2). CadnaA has the capability to simulate a series of point, line and area emission sources. For this NIA, all sources were modelled as point sources and assumed to operate continuously during the daytime and nighttime period. Each source type can be characterized by entering noise emissions in terms of frequency components of the emission. Other parameters, such as building dimensions and equipment enclosure noise attenuation ratings, are also used to define the nature of noise emissions. The CadnaA model also accounts for noise attenuation related to meteorological conditions (such as temperature and humidity), ground cover and physical barriers, either natural (terrain based) or man-made.

4.3.4 NIA RESULTS

Assessment noise levels were calculated by summing the baseline noise levels and the contribution from the noise prediction modelling of the Project assessment cases. For the Expected Case, the results indicate that noise levels at all receptors are below the PSL during both the daytime and nighttime periods except for R01 for Scenario 1. Noise levels at R01 for the Expected Case Scenario 1 is above the PSL and results in a change in %HA greater than 6.5% during the nighttime period. The Expected Case Scenario 1 cumulative daytime noise levels at R01 (61 dBA) were very similar to the findings of the 2021 noise assessment conducted by Hemmera in 2021[11]. Expected Case Scenario 1 could result in noise levels above guidance documents during the nighttime period. Therefore, if Expected Case Scenario 1 is to operate during the nighttime period, mitigation measures, such as an 8 m tall noise barrier and other acoustically equivalent noise controls, such as large silencers or acoustic louvers were recommended for this scenario.

The NIA indicates that the operation of Expected Case Scenario 2 , where two mobile generators are used in place of two permanent diesel generators, results in predicted noise levels that meet applicable guidance documents with no further mitigation. Noise levels due to the Emergency Case will increase, but are expected to be short-term and occur very infrequently.

It should be mentioned that conservative assumptions regarding the Project have been made to account for the level of uncertainty inherent in the noise level predictions. All receptors are assumed to be downwind from all sources 100% of the time; because downwind conditions tend to enhance noise propagation, this assumption will tend to overestimate the noise effect of the Project.

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[9] OGC (BC Oil and Gas Commission). 2023. British Columbia Noise Control Best Practices Guideline. Version 2.3. December 2023. Available at: https://www.bc-er.ca/files/operations-documentation/Oil-and-Gas-Operations-Manual/Supporting-Documents/BC-Noise-Control-Best-Practices-Guideline.pdf, accessed in April 2024

[10] Health Canada. 2017. Guidance for Evaluating Human Heath Impacts in Environmental Assessment: Noise. January 2017

[11] Hemmera, Noise Monitoring at the Whitehorse Rapids Generating Station, 2021

4.4 EROSION AND SEDIMENT

The Project Site is mostly paved and no significant sources erosion or sediment transport direct to surface water are present.

4.5 WASTE MANAGEMENT

Wastes from the Project include operating materials such as waste wood, metal, material packaging, and oily wastes such as used sorbents. Special and Hazardous Wastes, such as oil and coolants, and site worker generated domestic wastes are all handled pursuant to non-discretionary legislation (e.g., Environment Act and application regulations) and industry best practices (e.g., segregated, reused, recycled where possible). Special wastes (e.g., used/waste oil) are stored and disposed of pursuant to Yukon Energy's Special Waste Permit.

Domestic wastewater produced on site is collected in holding tanks and collected by a local education truck service provider. No significant risks associated with waste management are expected from the project.

4.6 STORAGE AND SPILL MANAGEMENT

There are several diesel storage tanks at WRGS as a fuel supply for stationary and mobile generators. The operation and maintenance of storage tanks follows National and Provincial guidance and standards, such as:

- Storage Tank System for Petroleum Products and Allied Petroleum Products Regulations[12]
- Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products[13]
- Yukon Environment Act – Storage Tank Regulations[14]
- Permit and Authorization Guide for Yukon Activities[15]

YEC employs good environmental practices for fuel storage and handling. All diesel fuels are delivered to site by a licensed carrier. The tanks are/will be registered according to storage tank regulations. Fuel and other chemicals are stored in such a manner to prevent spillage into a body or water or onto the surrounding land. Secondary containment (double-walled tanks) and in some cases, tertiary containment, is in place to minimize environmental damage resulting from a failure of the primary tank storage system itself. Regular visual inspections are conducted to inspect the tanks. A Spill Contingency Plan is in place and a copy of it posted on-site. Fuel spill kits and materials are readily available onsite. Personnel are trained in safe handling and emergency spill procedures. Waste fuel products and chemicals are stored in sealed and labelled containers in a designated area. In the event of fuel spills, the spills will be immediately contained, clean up and reported to an inspector.

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[12] Government of Canada, Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations, https://laws-lois.justice.gc.ca/PDF/SOR-2008-197.pdf, accessed in April 2024
[13] Canadian Council of Minister of the Environment (CCME), Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products. https://www.canada.ca/content/dam/eccc/documents/pdf/cepa/ccme-pn-1326-eng.pdf, accessed in April 2024
[14] Yukon Environment Act, Storage Tank Regulations, https://laws.yukon.ca/cms/images/LEGISLATION/regs/oic1996_194.pdf, accessed in April 2024
[15] Yukon Corporate Policy and Planning Branch, Energy, Mines and Resources, Permit and Authorization Guide for Yukon Activities, https://www.yukonwaterboard.ca/forms/permit_authorization_guide_yukon_activities_april2013.pdf, April 2013, accessed in April 2024

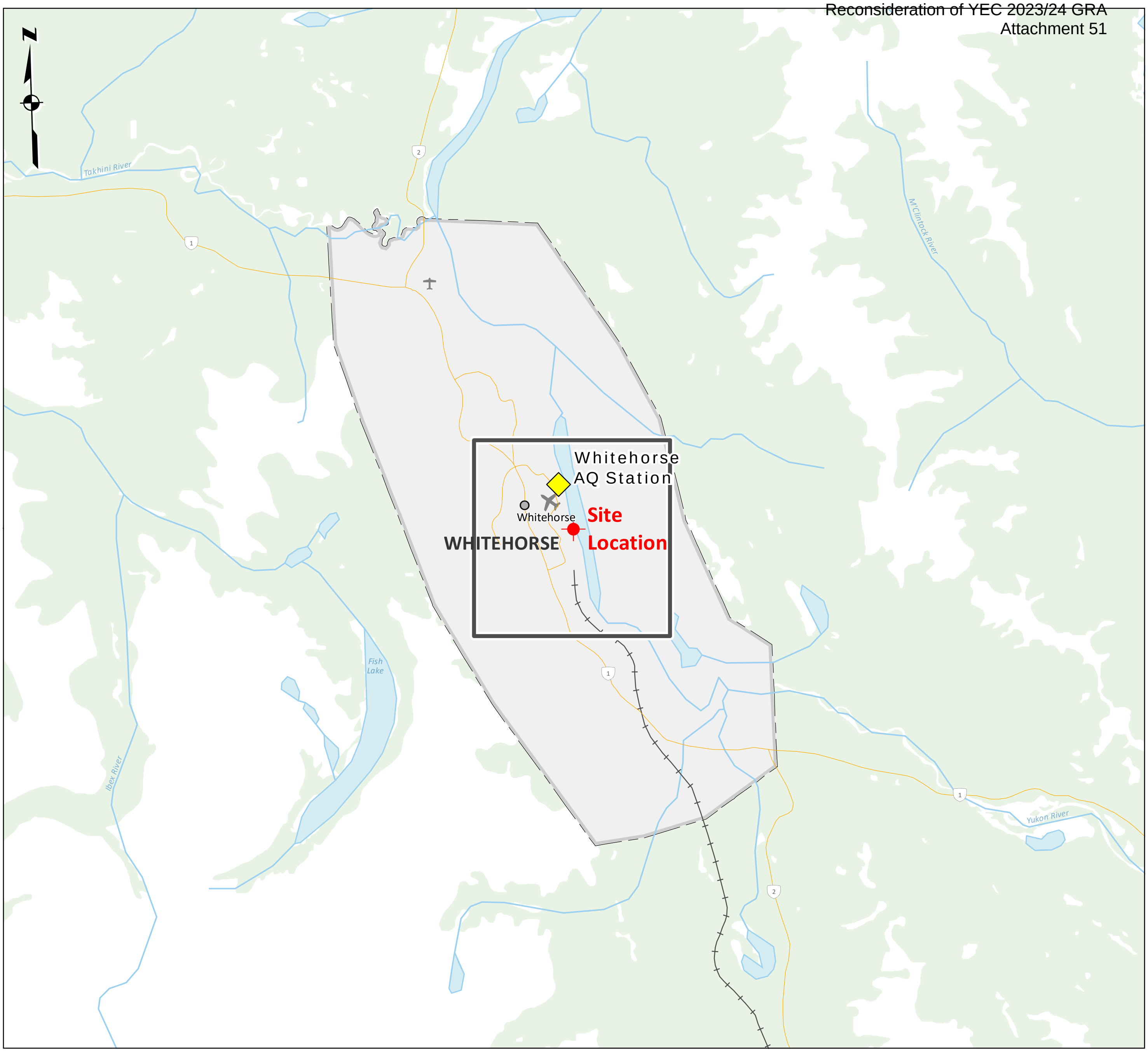
5 SUMMARY

YEC's thermal generating station has an obvious beneficial effect on human health and safety, given YEC's reliance on the facility for back-up power generation capacity. The thermal generating station is essential to the Corporation's ability to provide a reliable supply of electricity to customers on those occasions when YEC is unable to satisfy total customer demand through hydro generation alone; i.e., in emergency situations, as well as during periods of planned maintenance, or when demand otherwise outstrips hydro supply as a result of peaking demand during cold winter temperatures. If YEC were not able to use and rely on its thermal generation station to provide a reliable supply of back-up power to customers in these circumstances, this would put both infrastructure and human health and safety at very serious risk, particularly during the cold and dark winter months.

The operation of the equipment does generate air emissions and noise to the atmosphere. The potential environmental and health risk impacts associated with the operation of the generators were evaluated for AQA, HHRA, and NIA. Each impact assessment included two operational scenarios: one represents typical operations (expected emission scenario) and one reflects emergency (N-1) operations (emergency emissions scenario).

- The AQA applied CALPUFF air dispersion modelling to simulate air contaminant transport and dispersion under a variety of meteorological conditions. Air dispersion modelling was conducted following the methods recommended in the BC AQDMG. The dispersion modelling predicated some exceedances for TSP, $PM_{2.5}$ or PM_{10}, and NO_2 emissions in some scenarios and averaging periods. All predicted exceedances for particulate are expected to occur in a small, localized area directly adjacent to the Station. The NO_2 exceedances are largely due to high background NO_2 levels in the airshed.
- The HHRA was conducted in accordance with federal guidance and included the four key components of the risk assessment framework, including problem formulation, exposure assessment, toxicity assessment and risk characterization. The HHRA identified some potential acute and chronic risks with the ambient air concentrations of NO_2, $PM_{2.5}$, PM_{10} and DPM during both scenarios. The risks are likely conservative as the air dispersion model assumed year-round operations from all stationary generators at the maximum name-plate capacity with worst-case meteorological conditions. In reality, the Expected Scenario will only run during the winter to meet the demand need. It is anticipated that peak emissions occur for a small number of hours. The emergency scenario is predicted to occur once in 20 years for a cumulative total of 1 to 5 days during a two-week period. Overall, the HHRA supports the renewal of YEC's emissions permit as described in this project proposal.
- The NIA used CadnaA prediction model to simulate a series of point, line and area emission sources. The NIA was conducted following the BC OGC Guideline[9]. The NIA indicated that for the Expected Case, the noise levels at all receptors are below the PSL during both the daytime and nighttime periods except for R01 for Scenario 1. The Expected Scenario 1 (i.e., use of the original permanent pre-tier units located closest to Riverdale) could result in noise levels above guidance documents during the nighttime period, thus mitigation measures are required. For the Expected Case Scenario 2, where two mobile generators are used, the predicted noise levels meet applicable guidance documents with no further mitigation.

As the WRGS consists of a variety of generators with vintages ranging from the 1970s to present. YEC will seek to replace the old units with the BACT when they reach their end of life. The progressive implementation of BACT will significantly reduce the CAC emissions, consequently lower the potential risk to the environment and human health.



Legend

Activity
- Site Location
- Whitehorse AQ Station
- Modelling Domain (10 km x 10 km)

Water Features
- Major Lake/River
- Perennial Creeks/Streams

Municipal
- Major Urban Centre

Transportation
- Paved Roads
- Railways
- Airport
- Airfield

Environmental
- Vegetation

Scale: 1:300,000

0 3 6 9 12 15 Km

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

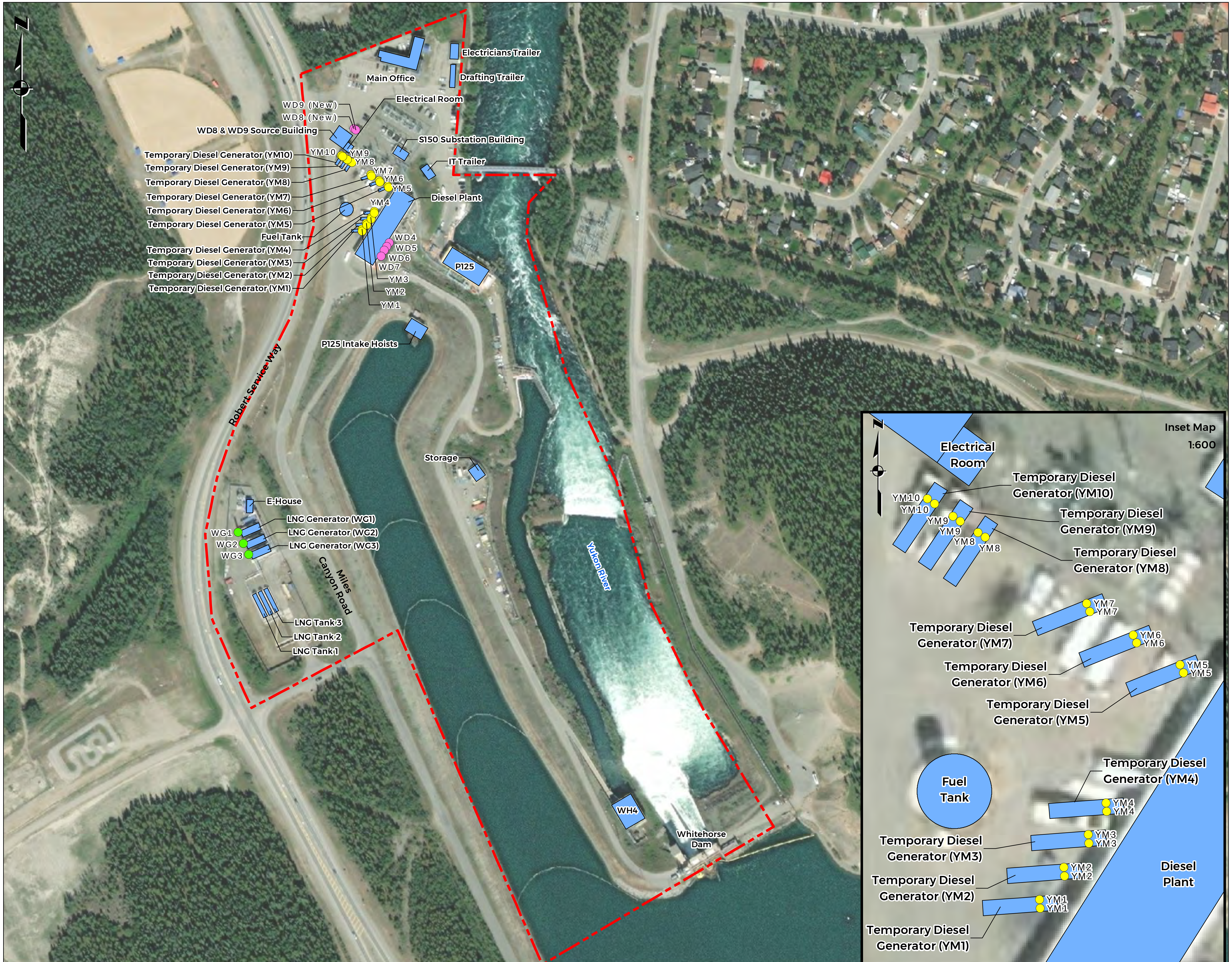
wsp

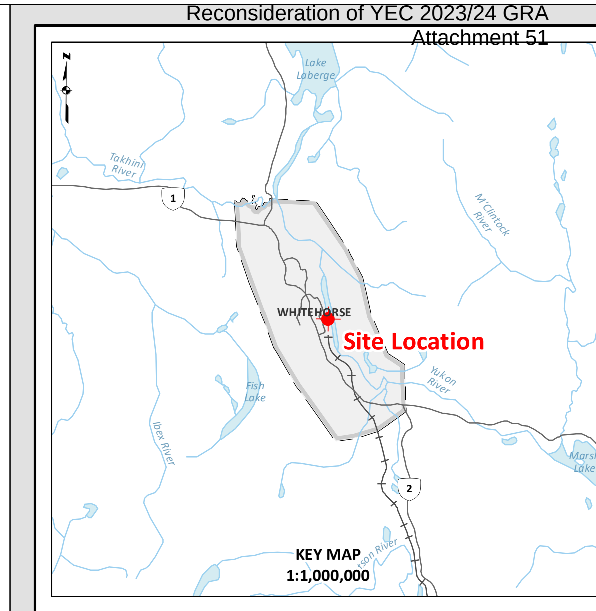
Site Location Map

Whitehorse Rapids Generating Station Yukon

énergie yukon / yukon energy

Figure 1





Legend

- Mobile Diesel Generators
- Permanent Diesel Generators
- Permanent Natural Gas Generators
- Station Boundary
- Buildings

énergie yukon / yukon energy

Air Quality Assessment

Figure 2

Site Diagram

Whitehorse Rapids Generating Station
Yukon

Scale: 1:3,000

0 20 40 80 120 160 200 Metres

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

wsp

Report By: JS
Drawn by: JH
Reviewed By: JS

WSP Job #: 221-07678-00
Date: April 4, 2023
Office: Calgary

Notes:Imagery Source: ESRI Imagery Service [2021]

APPENDIX

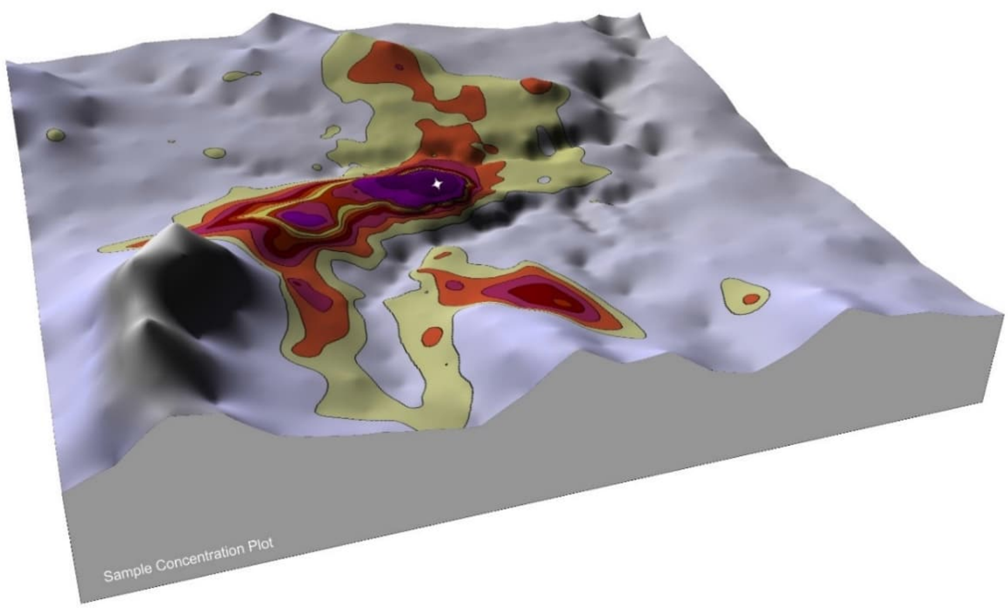
A AIR QUALITY ASSESSMENT

YUKON ENERGY CORP.

AIR QUALITY ASSESSMENT

WHITEHORSE RAPIDS GENERATING STATION

AUGUST 07, 2023 FINAL



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EXECUTIVE SUMMARY

WSP Canada Inc. conducted an air quality dispersion modelling assessment for the Yukon Energy Corporation Whitehorse Rapids Generating Station (the Station) in Whitehorse, Yukon to evaluate the potential air quality impacts of fossil fuel-fired (also referred to as thermal) electrical generating equipment at the Station while keeping the permitted capacity at 42 megawatts (MW).

This report outlines our assumptions, approach, and presents the results for the air quality assessment of the contaminants of concern: **nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), total suspended particulates (TSP) and diesel particulate matter (DPM)**.

Since there is no air dispersion modelling guideline in Yukon, the air dispersion modelling assessment followed recommendations contained in the *British Columbia Air Quality Dispersion Modelling Guideline* (BC AQDMG) (British Columbia Ministry of Environment and Climate Change Strategy, 2022a) and the *British Columbia Guidance on Nitrogen Dioxide Modelling* (BC GNDM) (British Columbia Ministry of Environment and Climate Change Strategy, 2022b). The dispersion modelling was completed following the requirements of a Level 3 Comprehensive Assessment as defined by the BC AQDMG, and was conducted using the refined air dispersion modelling suite CALPUFF. Maximum[1] predicted concentrations of the contaminants of concern, along with the baseline air quality concentrations, were compared to the Yukon Ambient Air Quality Standards (YAAQS) (Government of Yukon, 2019), with CO being the exception as there are no YAAQS established. The Pollution Control Objectives (used for reference purposes) from the nearest jurisdiction, British Columbia (BC Ministry of Environment and Climate Change Strategy, 2021), were therefore considered.

In addition to evaluating the ambient air quality impacts, another objective of the air quality assessment was to evaluate the potential human health risks. The modelling results were provided to the WSP Environmental Risk Assessment Team to prepare a Human Health Risk Assessment (WSP, 2023), the results of which are provided in a companion report (WSP, 2023).

To evaluate the Station's predicted impacts with YAAQS, two (2) modelling scenarios are presented in this report:

1 Expected Maximum Emission Scenario (*Expected Scenario*).

2 Emergency (N-1 event[2]) Maximum Emission Scenario (*Emergency (N-1) Scenario*).

The scenarios were evaluated assuming maximum emissions from the Station generators based upon maximum operating conditions and nameplate capacities. The modelling also conservatively assumed that all generators are emitting simultaneously and continuously at the nameplate capacity year-round, except for the mobile units, which were assumed to be operating continuously from December through April.

The results showed that:

– **SO_2:** the maximum[1] predicted concentrations were well below the YAAQS for all scenarios.

– **CO:** the maximum[1] predicted concentrations were well below the BC Pollution Control Objectives (used for reference purposes) for all scenarios.

– **TSP, $PM_{2.5}$ and PM_{10}:** the maximum[1] predicted concentrations exceeded the YAAQS in some scenarios and averaging periods. The predicted exceedances are in the immediate vicinity of the Station boundary (less

[1] The 'maximum' is based on the statistical form presented in Table 3-1.

[2] N-1 event as described in Section 1.1.

than 220 m) and decrease quickly to below the YAAQS moving away from the Station boundary. There are no predicted exceedances at the sensitive receptors for TSP, $PM_{2.5}$ or PM_{10}. The maximum[1] point of impingement is found near the Station.

– **NO_2:** The baseline ambient concentrations considered in the assessment (measured at the Whitehorse air quality monitoring station) are elevated, with the 1-hour baseline at 65% of the current YAAQS and 93% of the 2025 YAAQS. When the baseline is added to the maximum[1] predicted 1-hour and annual NO_2 concentrations from the Station for all scenarios the predicted results are above the YAAQS. There are maximum[1] predicted 1-hour exceedances over most of the domain for both scenarios; however, there are no predicted annual exceedances at the sensitive receptors. The maximum point of impingement is found near the Station.

– **DPM:** There are no known territorial, provincial or Canadian air quality standards or objectives for DPM. Therefore, DPM results were not presented in this report. Predicted DPM results were provided for the Human Health Risk Assessment (WSP, 2023).

It is important to note that the modelling results represent the worst-case predicted air quality impacts based upon the Station's maximum operating conditions. As such, the model predicted air contaminant concentrations are considered conservative. Additionally, the modelled emissions scenarios considered are very conservative when compared to the expected annual operations at the Station. The *Expected Scenario* was modelled at full capacity for all hours instead of a typical operation where only the required units are run in winter to meet demand. The actual Station emissions are expected to be much lower. Based on Yukon Energy's decades of operational experience, the *Emergency (N-1) Scenario* is predicted to occur once in 20 years for a cumulative total of 1 to 5 days during a 2-week period.

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APPENDICES

1 INTRODUCTION

WSP Canada Inc. conducted an air quality dispersion modelling assessment for the Yukon Energy Corporation (Yukon Energy) Whitehorse Rapids Generating Station (the Station) in Whitehorse, Yukon, to evaluate the potential air quality impacts of fossil fuel-fired (also referred to as thermal) electrical generating equipment at the Station while keeping the permitted capacity at 42 megawatts (MW). The 42 MW is made up of existing natural gas generating capacity of 13.2 MW along with 16.2 MW of diesel generating capacity. The remaining 12 MW of mobile diesel generating capacity is maintained for emergency/back-up purposes.

Since there is no air dispersion modelling guideline in Yukon, the air dispersion modelling assessment followed recommendations contained in the *British Columbia Air Quality Dispersion Modelling Guideline* (BC AQDMG) (British Columbia Ministry of Environment and Climate Change Strategy, 2022a) and the *British Columbia Guidance for Nitrogen Dioxide Modelling* (BC GNDM) (British Columbia Ministry of Environment and Climate Change Strategy, 2022b). The dispersion modelling was completed following the requirements of a Level 3 Comprehensive Assessment as defined by the BC AQDMG and was conducted using the refined dispersion modelling suite CALPUFF.

Maximum predicted concentrations, based on the statistical form presented in Table 3-1, of the contaminants of concern, along with the baseline air quality concentrations, were compared to the Yukon Ambient Air Quality Standards (YAAQS) (Government of Yukon, 2019) where applicable.

1.1 Project Description

The Station provides reliable energy supply to supplement renewable energy sources. The Station is designed to quickly provide electricity during loss of hydro generation, peak hours of consumption, low water periods, extremely low temperatures and emergencies.

The Station currently has 13.125 MW of permanent natural gas generation capacity and 10.8 MW of permanent diesel generation capacity. The additional permitted diesel capacity of approximately 5.4 MW is supplied at this time by three (3) mobile rental diesel engines. The Station is planning on installing two new Tier 4 diesel generators for approximately 5.2 MW of permanent diesel generation capacity to replace a unit, Whitehorse Diesel Number 3 (WD3), which was retired several years ago. During the emergency (N-1) events[3], the Station needs access to an additional 12 MW of capacity from six (6) temporary mobile diesel generators for a total capacity of 42 MW at the Station. One additional mobile rental diesel is installed at the station in winter as redundant back up. The last N-1 event was approximately 17 years ago, so this event is expected to be short-term and very infrequent.

---

[3] N-1 (Single Contingency) Planning Criterion: A reliability planning criterion used to determine the capacity requirements of the system. Yukon Energy's N-1 criterion requires that each part of the Yukon Energy transmission grid should be able to carry the forecast peak winter demand, excluding major industrial demand, under the largest single contingency. The single largest contingency is defined as loss of the largest single element which could be either a transmission line or generating station. This criterion considers the ability to interrupt large industrial customers during an emergency event, which is why only non-industrial peak demand is included.

Capacity Planning Criterion: This criterion ensures that the system has sufficient capacity to meet peak demand (peak capacity) for two consecutive weeks under extreme cold winter conditions. The capacity planning criterion is based on the single contingency (N-1) criterion, which states that each part of the Yukon Energy transmission grid shall supply the forecast non-industrial peak winter demand, excluding major industrial demand, under the largest single contingency. Yukon Energy's current largest single contingency corresponds to the loss of the 37 MW Aishihik Generation Station, either through an outage of the generating station itself or an outage of the L171 transmission line that interconnects the Aishihik Generating Station to the Takhini Substation.

Expected normal operations would include the 13.125 MW permanent natural gas generation, 5.2 MW from the new Tier 4 permanent diesel generators and 3 MW from either the other permanent diesel units or from the temporary mobile diesel generators for a normal peak capacity of 21 MW.

Based on Yukon Energy projections, the frequency with which the units are used under the expected normal operations are:

- Permanent natural gas units: All three units will be used in the winter from December through April; in the shoulder months (May and November) typically, only one unit would be used.
- New Tier 4 permanent diesel generators: these two units will normally only run in the winter (December through April) and will not run continuously. During those months, the units would run for approximately 24 hours (nonconsecutively) within any given two-week period.
- Permanent diesel generators or temporary mobile diesel generators: Only two of these units will run concurrently, only during the winter (December through April) and will not run continuously. During those months, the units would run for approximately six hours (nonconsecutively) within any given two-week period.

In addition to the expected normal operations and emergency (N-1) event, all thermal units are operated for short periods (1-2 hours) on a monthly basis throughout the year for maintenance/operational readiness purposes.

1.2 Project Location

The Station is located in Whitehorse, Yukon (latitude 60.698°, longitude -135.045°) (Figure 1). For this assessment, the study area was defined as a 10 km by 10 km area centred at the Station location (Figure 1). The YAAQS are applicable in areas that are accessible by the public, the Station boundary (Figure 2) was selected as the area that restricts public access.

2 CONTAMINANTS OF CONCERN

The power generation operations at the Station will result in the release of emissions into the atmosphere from the combustion of natural gas and diesel. The contaminants of concern considered in this assessment are:

- Nitrogen Oxides (NO_x)
- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Total Suspended Particulates (TSP)
- Fine Particulate Matter ($PM_{2.5}$)
- Coarse Particulate Matter (PM_{10})
- Diesel Particulate Matter (DPM)

There is no standard for ambient NO_x concentrations; however, ambient nitrogen dioxide (NO_2) standards have been established. Both the Total Conversion Method (TCM) and Ozone Limiting Method (OLM) were applied for the NO_x to NO_2 conversion. The TCM method is the more conservative method as it assumes 100% of NO_x will be converted to NO_2. OLM is described in Section 6.7.

As there are no air quality standards for DPM, DPM results are not presented in this assessment. DPM was modelled to provide predicted concentrations to the Human Health Risk Assessment (WSP, 2023), the results of which are presented in a companion report.

3 AMBIENT AIR QUALITY STANDARDS

The Government of Yukon has established the YAAQS (Government of Yukon, 2019), based on the Canadian Ambient Air Quality Standards, to protect air quality. A summary of the YAAQS considered in the assessment are shown in Table 3-1.

Table 3-1 Yukon Ambient Air Quality Standards

Air Contaminant	Averaging Period	Current Standard ($\mu g/m^3$)	2025 Standard (effective January 1, 2025) ($\mu g/m^3$)	Statistical Form[a]
NO_2	1-hour	113	79	The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations.
	Annual	32	23	The average over a single calendar year of all 1-hour average concentrations.
SO_2	1-hour	183	170	The 3-year average of the annual 99th percentile of the daily maximum 1-hour average concentrations.
	Annual	13	11	The average over a single calendar year of all 1-hour average concentrations.
Co[b]	1-hour	14,300	-	The maximum 1-hour average concentration.
	8-hour	5,500	-	The maximum 8-hour average concentration.
$PM_{2.5}$	24-hour	27	-	The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
	Annual	8.8	-	The 3-year average of the annual average of all the daily 24-hour average concentrations.
PM_{10}	24-hour	50	-	The maximum 24-hour average concentration.

Air Contaminant	Averaging Period	Current Standard (µg/m^3)	2025 Standard (effective January 1, 2025) (µg/m^3)	Statistical Form[a]
TSP	24-hour	120	-	The maximum 24-hour average concentration.
	Annual	60	-	The average over a single calendar year of all 1-hour average concentrations.

Notes: [a] The statistical form is based on the Canadian Ambient Air Quality Standards for NO_2, SO_2 and $PM_{2.5}$.

[b] There are no YAAQS established for CO. The Pollution Control Objectives (used for reference purposes) from the nearest jurisdiction – British Columbia (BC Ministry of Environment and Climate Change Strategy, 2021), were chosen as the air quality criteria for CO in this assessment.

4 BASELINE AIR QUALITY

Baseline air quality concentrations are determined in air dispersion modelling assessments in order to estimate cumulative air quality impacts. In this context, the BC AQDMG states that "baseline" is meant to be the concentrations due to emissions from both natural and anthropogenic sources. In other words, it is intended to be the result of the contribution from all sources except the source(s) being modelled. To evaluate predicted impacts against the YAAQS, selected baseline air quality concentrations for the City of Whitehorse were added to the air dispersion model predictions resulting in estimated cumulative concentrations.

Continuous ambient air quality monitoring data is available from one station in Yukon located in downtown Whitehorse (the Whitehorse AQ Station) (Figure 1) and is operated by Yukon's Department of Environment as part of Canada's National Air Pollution Surveillance (NAPS) program (NAPS ID: 119004). This station continuously monitors NO_2, ozone (O_3) and $PM_{2.5}$. To determine the baseline air quality concentrations, the most recent available three (3) years of NO_2 and $PM_{2.5}$ monitoring data from the Whitehorse AQ Station were gathered and analyzed in accordance with the BC AQDMG and the statistical form identified in Table 3-1. There are no monitoring data for SO_2 and CO in Yukon, as such, the baseline concentrations for SO_2 and CO were not applied in this assessment. The PM_{10} and TSP baseline concentrations were calculated based on data from urban sites across Canada provided in the literature (Air & Waste Management Association, 2011), where the ratio of $PM_{2.5}$ to PM10 at the 50th percentile is 0.5, and the ratio of $PM_{2.5}$ to TSP at the 50th percentile is 0.26. The baseline air quality concentrations are summarized in Table 4-1.

Except for the annual baseline values, contaminants have a baseline that is more than 50% of the current YAAQS. The 1-hour NO_2 baseline is even higher at 65% of the current YAAQS. Compared to the 2025 YAAQS, the 1-hour NO_2 baseline is approximately 93% of the 2025 YAAQS.

Table 4-1 Baseline Air Quality Concentrations

Whitehorse AQ Station (2018-2020)			
Air Contaminant	Averaging Period	Concentration (µg/m^3)	% of Current YAAQS
NO_2	1-hour	73.3	65%
	Annual	11.2	35%
SO_2	1-hour	Not monitored	N/A
	Annual	Not monitored	N/A
CO	1-hour	Not monitored	N/A

Whitehorse AQ Station (2018-2020)			
Air Contaminant	**Averaging Period**	**Concentration ($\mu g/m^3$)**	**% of Current YAAQS**
	8-hour	Not monitored	N/A
$PM_{2.5}$[a]	24-hour	17.5	65%
	Annual	4.4	50%
PM_{10}[b]	24-hour	35.0	70%
TSP[c]	24-hour	67.3	56%
	Annual	17.0	28%

Notes: [a] Average of 2018 and 2020 as 2019 did not meet the 75% completeness requirement.

[b] PM_{10} is based on the 50th percentile ratio of $PM_{2.5}/PM_{10}$ from Canadian urban sites stated in the Journal of the Air & Waste Management Association (Air & Waste Management Association, 2011) of 0.5.

[c] TSP is based on the 50th percentile ratio of $PM_{2.5}$/TSP from Canadian urban sites stated in the Journal of the Air & Waste Management Association (Air and Waste Management Association, 2011) of 0.26.

5 SOURCES AND EMISSIONS

5.1 Modelling Scenarios

To evaluate the potential air quality impacts from the Station, two (2) modelling scenarios were assessed:

1. *Expected Scenario* [21.312 MW]: 3 existing permanent natural gas units [13.125 MW] + 2 new Tier 4 diesel generators [5.2 MW] + 2 existing diesel units [3 MW] or 2 mobile diesel units [3 MW].
2. *Emergency (N-1) Scenario* [41.725 MW]: 3 existing permanent natural gas units [13.125 MW] + 4 existing permanent diesel units [10.8 MW] + 2 new Tier 4 diesel generators [5.2 MW] + 7 of 10 mobile diesel units [12.6 MW].

Both emission scenarios assumed that the generators are operating continuously at the maximum rated capacity. To reflect the worst-case predicted air quality impacts from the Station, the estimated emission rates established for each emission scenario were applied to all hours, except for the mobile generators, which were only modelled from December through April. This conservative approach is common in air dispersion modelling assessments. It allows for emission sources to be assessed at maximum air contaminant emission rates under all meteorological condition combinations to predict the potential worst-case air contaminant concentrations. However, it should be noted that this conservative assessment of potential air quality impacts did not account for load variations whereby the generators often operate well below their nameplate or total Station capacity. The actual Station loads, and associated emissions are expected to be lower than the maximum possible loads / emission rates modelled in this assessment.

For the *Expected Scenario*, the 3 permanent natural gas generators, the 2 new Tier 4 permanent diesel generators and 2 of the permanent diesel generators were conservatively modelled at full capacity (21 MW) for all hours instead of typical operation where only the required units are run in winter to meet demand. A second variation was modelled where the 2 permanent diesel generators are swapped out for 2 mobile diesel generators. The mobile diesel generators were modelled each hour from December 1 to April 30 which is conservative compared to normal operation. The variation with the highest predicted concentrations was presented in Section 7.

For the *Emergency (N-1) Scenario*, the permanent generators were conservatively modelled at full capacity for all hours, and the mobile diesel generators were conservatively modelled each hour from December 1 to April 30 instead of the estimate by Yukon Energy that the N-1 event would occur only when the ambient temperature is colder than -30°C for a cumulative total of 1 to 5 days during a 2-week period, and based on historic data, only occurring once in approximately 20 years.

The 1-2 hours per month operation of the units for maintenance are very short term non-continuous events and were not included as a scenario in the modelling.

5.2 Emission Sources and Characteristics

Emissions associated with the Station include the following emission sources:

– 3 permanent natural gas units [13.125 MW] – WG1 through WG3.

– 4 permanent diesel units [10.8 MW] – WD 4 through WD7.

– 2 new Tier 4 permanent diesel gensets [5.2 MW] – WD8 and WD9.

– 7 of 10 mobile diesel units [12.6 MW] – YM1 through YM7.

Emission source locations are shown on Figure 2. A summary of the total emission from each scenario are presented in Table 5-1. Detailed calculations of the Station emissions are presented in Appendix A.

The 3 permanent natural gas units and the 2 new Tier 4 permanent diesel gensets would be considered the best available technology for these units. The expected case will preferentially select the best available technology units over the other units to reduce the emissions from the higher emission sources.

Table 5-1 Station Total Emission Rates by Scenario & Air Contaminant

Scenario	Emission Rate (g/s)						
	NO_x	SO_2	CO	TSP	$PM_{2.5}$	PM_{10}	DPM
1. Expected Scenario	25.3	0.065	16.4	0.78	0.48	0.59	0.40
2. Emergency (N-1) Scenario	61.8	0.14	18.4	1.6	0.89	1.03	0.82

Table 5-2 lists the emission source parameters used in the modelling for the permanent units and Table 5-3 lists the emission source parameters for the mobile units.

Table 5-2 Station Emission Source Parameters – Permanent

Parameter	Unit/Variable	WG1	WG2	WG3	WD4^	WD5^	WD6^	WD7^	WD8	WD9
Release Direction	vertical/horizontal/angle/capped	vertical								
Modelled Temporal Variation	continuous/ intermittent/upset	continuous								
Source Type	point/line/area/volume	point								
Engine Model	-	General Electric (GE) Jenbacher JMC 624 GS-NL			Electro-Motive Diesel (EMD) 20C			CAT 3612	CAT C175-16 with SCR	
Power Rating	kW	4.375			2.5			3.3	2.6	
Universal Transverse Mercator Location										
Easting	mE	497420	497425	497429	497553	497551	497549	497546	497524	497522
Northing	mN	6728957	6728947	6728937	6729212	6729208	6729205	6729200	6729311	6729312
Elevation	m asl*	661	661	660	640	640	640	640	640	640
Stack Parameters										
Release Height	m	12.2			12.0			12.0	15.0	
Diameter	m	0.71			0.53			0.43	0.71	
Exit Velocity	m/s	31.6			40.1			35.7	23.9	
Temperature	Kelvin	617			632			704	717	
Emission Parameters										
Existing Emission Rates										
NO_x	g/s	2.25	2.25	2.25	9.20	8.34	8.48	6.53	0.48	0.48
NO_2	g/s	0.42	0.42	0.42	0.76	0.69	0.70	0.54	0.04	0.04
NO	g/s	1.19	1.19	1.19	5.50	4.99	5.07	3.91	0.29	0.29
SO_2	g/s	0.004	0.004	0.004	0.015	0.015	0.014	0.004	0.012	0.012
CO	g/s	4.93	4.93	4.93	0.51	0.15	0.08	0.19	0.48	0.48
TSP	g/s	0.049	0.049	0.049	0.30	0.30	0.30	0.39	0.019	0.019
$PM_{2.5}$	g/s	0.024	0.024	0.024	0.14	0.23	0.23	0.049	0.019	0.019
PM_{10}	g/s	0.049	0.049	0.049	0.15	0.26	0.24	0.055	0.019	0.019
DPM	g/s	-	-	-	0.14	0.23	0.23	0.049	0.019	0.019

Note: *metres above sea level.
^ During the expected case only 2 of WD4, WD5, WD6 or WD7 will be running, or 2 mobile diesel units.

Table 5-3 Station Emission Source Parameters – Mobile

Parameter		Unit/Variable	YM1	YM2	YM3	YM4	YM5	YM6	YM7	YM8	YM9	YM10
Release Direction		vertical/horizontal/angle/capped	vertical									
Modelled Temporal Variation		continuous/ intermittent/upset	continuous December through April									
Source Type		point/line/area/volume	point									
Engine Model		-	CAT 3516									
Power Rating		kW	1.825									
Universal Transverse Mercator Location												
Easting		mE	497529	497533	497537	497540	497553	497545	497537	497520	497516	497512
Northing		mN	6729222	6729227	6729232.62	6729238	6729260	6729265	6729270	6729282	6729285	6729288
Elevation		masl*	640	640	640	640	640	640	640	640	640	640
Stack Parameters												
Release Height		m	4.3									
Diameter		m	0.254									
Exit Velocity		m/s	67.10									
Temperature		Kelvin	656									
Emission Parameters												
Existing Emission Rates	NO_x	g/s	3.072	3.072	3.072	3.072	3.072	3.072	3.072	3.072	3.072	3.072
	NO_2	g/s	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
	NO	g/s	1.837	1.837	1.837	1.837	1.837	1.837	1.837	1.837	1.837	1.837
	SO_2	g/s	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
	CO	g/s	0.248	0.248	0.248	0.248	0.248	0.248	0.248	0.248	0.248	0.248
	TSP	g/s	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	$PM_{2.5}$	g/s	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	PM_{10}	g/s	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	DPM	g/s	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020

Note: *metres above sea level.
Only 2 mobile diesel units, or 2 of WD4, WD5, WD6 or WD7 would be running under the expected case.
Only 7 of the 10 mobile diesel units would be running during the emergency N-1 event, 3 units are for back -up.
Each unit has 2 stacks 1.4 m apart, the emissions were split between the two stacks.

6 MODELLING APPROACH

The impacts on ambient air quality associated with air emissions from the Station were evaluated through the use of a regulatory approved air dispersion model. Air dispersion models provide a scientific means of relating air emissions to ambient concentrations via simulation of air contaminant transport and dispersion under a variety of meteorological conditions. The following sections provide an overview of the modelling methodology used for this assessment.

Air dispersion modelling was conducted following the methods recommended in the BC AQDMG (British Columbia Ministry of Environment and Climate Change Strategy, 2022a). The previous version of the BC AQDMG is referenced by the Yukon Environmental and Socio-economic Assessment Board Proponent’s Guide: Model Documentation Report (Government of Yukon, 2016) as an exemplary guideline for air dispersion modelling.

6.1 Description of Model

Various air dispersion models are available for ambient concentration predictions. The appropriate model selection depends on project-specific needs, such as local topography and near-field or long-range study.

The CALPUFF air dispersion modelling suite was used for assessing potential air quality impacts. CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) used in series to determine the potential impact of emissions near a source or group of sources.

Detailed three-dimensional meteorological fields were produced by the diagnostic computer model CALMET (Version 6.5.0), based on digital land use data and terrain data, as well as observed surface and upper air data that are available for the domain. The most recent five years (2016-2020) of meteorological data were modelled in CALMET. CALPUFF used the three-dimensional meteorological fields produced by CALMET (Version 7.2.1), a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on air contaminant transport. Finally, post-processing utilities, including CALPOST, were used to post-process and summarize the modelling output from CALPUFF.

6.2 Geophysical

Digital terrain elevation and land use data covering the CALMET model domain were used to simulate the effects of the topography and surface characteristics on the meteorological fields in the model. In accordance with the BC AQDMG, the CDED data was used to generate the terrain elevation inputs for each CALMET grid point, as well as the base elevations of the model emission sources and receptors.

6.2.1 Terrain

Terrain features affect atmospheric turbulence and local meteorological circulation. Atmospheric turbulence creates eddies for plume dispersion. Local meteorological circulation determines local transport pathways of air emissions. Both influence the ambient air concentrations.

The 1:50,000 terrain data from the Canadian Digital Elevation Model (CDEM) was obtained from Natural Resources Canada. The regional topography is shown on Figure 3.

- The Station has a base elevation of 640 masl.
- The highest point in the modelling domain is 1,164 masl, located approximately 5.6 km east northeast of the Station.
- The lowest point is 640 masl, located approximately 4.9 km north northwest of the Station.

The terrain within the vicinity of the Station is complex, with higher elevations on either side of the Whitehorse River, which flows north-northwest to south-southeast. Whitehorse is surrounded by mountains, with Canyon Mountain to the east, Mount Sumanik to the northwest, Golden Horn Mountain to the south, and Mount McIntyre to the west.

6.2.2 Land Use

Land use characteristics for each grid cell were gathered from a variety of land use-related information (i.e., "Vegetation Inventory – 5K") made available from the Government of Yukon's online geospatial data portal called "GeoYukon" (2019). Figure 8 shows the land use data used in the CALMET modelling.

6.3 Meteorology

CALMET was used to generate the meteorological fields for the time period from January 1, 2016, through December 31, 2020. The CALMET model was run in observation-only mode. Surface weather observations were extracted from the nearest observational weather station at the international airport in Whitehorse – "Whitehorse A" station operated by NAV Canada (WMO ID: 71964). In addition, upper air soundings were retrieved from the upper air station located in Whitehorse, also operated by NAV Canada – for meteorology in the vertical layers above the surface in order to resolve the three-dimensional meteorology in the CALMET modelling.

The CALMET domain for the Project was a 15 km by 15 km domain, as presented in Figure 6. The CALMET model was run with a 200 m horizontal grid resolution. The modelling domain and grid resolution were chosen so that the main topographical features expected to influence the three-dimensional diagnostic meteorological fields around the Station are adequately captured.

The meteorological data input and CALMET output for the modelling period were assessed following the Quality Assurance and Quality Control (QA/QC) procedures outlined in Section 9 of the BC AQDMG. Appendix B provides the user-specified input switches and the results of detailed analyses of key meteorological parameters (such as wind rose, wind vectors, ambient temperature, atmospheric stability and mixing height) conducted on this meteorological dataset.

6.3.1 Observed Meteorological Data

Surface weather stations that record hourly meteorological data within the CALMET domain include one station, Whitehorse A, operated by NAV Canada (WMO ID: 71964). The available meteorological data collected from January 1, 2016, through December 31, 2020, at this surface station was used as input to the CALMET model executed in observation-only mode. Upper air data from the Whitehorse station (WMO ID: 71964) was retrieved for the modelling period and used as meteorological input to resolve three-dimensional meteorology in the CALMET modelling. The location of the Whitehorse surface and upper air stations are displayed as part of Figure 6.

CALMET requires a measured data value for every hour from at least one meteorological station in order to simulate the three-dimensional fields. Missing data procedures were implemented when required, according to the BC AQDMG. When required, the upper air data was filled with data from the two nearest stations, Yakutat and Anchorage, Alaska. The basic meteorological parameters required by the CALMET model were gathered from the surface station and prepared into a CALMET-ready surface data file (SURF.DAT) which includes the following meteorological parameters: wind speed, wind direction, temperature, relative humidity, and station pressure.

Figure 7 illustrates the windrose compiled from the surface wind data observed at Whitehorse A from 2016 to 2020, which shows the prevailing wind patterns. The months included in the seasonal wind roses follow Table 6-1, with Winter 1 and Winter 2 being combined for the winter windrose.

6.3.2 Seasonal Categories

Seasonal parameters were specified for each month based on the seasonal categories outlined in Table 6-1. According to the BC AQDMG for a latitude of 60°N - 65°N, the seasonal categories are defined as follows:

- Season 1: Midsummer with lush vegetation.
- Season 2: Autumn with cropland that has not been harvested.
- Season 3: Winter 1, late autumn after frost, no snow on the ground.
- Season 4: Winter 2, snow on the ground and subfreezing.
- Season 5: Transitional spring with partially green short annuals.

Table 6-1 Seasonal Categories for GEO.DAT used in CALMET

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seasonal Category	4	4	4	4	4	5	1	2	2	3	4	4

6.4 CALPUFF Model Options

The model options used follow the default regulatory options recommended in the BC AQDMG and are presented in Appendix C.

6.5 Receptors

6.5.1 Receptor Grid

Gridded receptors were created for the modelling domain. Dense receptor grids (20 m spacing) were created on and near the boundary to capture the maximum impact. The receptor grids are shown in Figure 4. The receptor spacing is as follows:

- 20 m spacing in the general area of maximum impact and the property boundary.
- 50 m spacing within 0.5 km from the boundary.
- 250 m spacing from 0.5 to 2 km from the boundary.
- 500 m spacing from 2 to the edge of the domain.

Following the BC AQDMG, all receptors located within the boundary of the Station were excluded from the model predictions. A flagpole height of 1.5 m was used in the modelling to represent the breathing height of humans.

6.5.2 Sensitive Receptors

Sensitive receptors, such as the hospital, schools and the nearest residential location as shown in Table 6-2 and Figure 5, were included in the air dispersion modelling.

Table 6-2 Sensitive Receptors

Description	Universal Transverse Mercator		Elevation m
	Easting (m)	Northing (m)	
Nearest Residence	497827	6729321	641
Christ the King Elementary School	498063	6729897	643
Grey Mountain Primary School	498813	6729569	657
F.H. Collins Secondary School	497813	6730641	642
Selkirk Elementary School	497938	6730311	645
Whitehorse General Hospital	497619	6731520	643

6.6 Building Effect

Buildings or other solid structures may impact the dispersion of air emissions in the vicinity of a source due to the formation of turbulent eddies on the downwind side of the building or structure. On the downwind side of a building or structure, a recirculating cavity of air forms, and it does not mix with the surrounding air efficiently. This cavity has the potential to reduce plume rise and impact air contaminant dispersion. The flow that is affected by the obstruction is known as the “wake”.

Building downwash was included in this assessment, and the building downwash parameters were created using the United States Environmental Protection Agency (US EPA) Building Profile Input Program (BPIP-PRIME). A simplified version of the Station plot plan used to develop the BPIP-PRIME input is shown on Figure 2. The corresponding building / structure dimensions are presented in Table 6-3. The input file to the BPIP program is provided in Appendix D.

Table 6-3 Building / Structure Dimensions

Building / Structure Name	Width (X) (m)	Length (Y) (m)	Height (m)
Diesel Plant	69.0	18.3	9.5
Fuel Tank	12.1 (diameter)		13.4
S150 Substation Building	8.0	12.4	5.0
IT Trailer	12.3	7.5	4.0
Main Office	28.5	35.8	13.2
Electricians Trailer	13.5	7.5	4.0
Drafting Trailer	20.3	4.5	4.0
P125	15.9	37.9	8.4
WH4	24.8	19.4	10.5
Storage	12.1	9.8	4.0
P125 Intake Hoists	12.0	16.8	7.2
E-House	11.6	5.7	4.3

Building / Structure Name	Width (X) (m)	Length (Y) (m)	Height (m)
LNG Generator (WG1)	6.2	17.6	4.3
LNG Generator (WG2)	6.2	17.6	4.3
LNG Generator (WG3)	6.2	17.6	4.3
LNG Tank 1	22.5	3.5	4.2
LNG Tank 2	22.5	3.5	4.2
LNG Tank 3	22.5	3.5	4.2
WD8 & WD9 Source Building	14.5	14.7	6.5
Electrical Room	7.3	6.5	6.5
Temporary Diesel Generator (YM1)	2.4	14.5	4.3
Temporary Diesel Generator (YM2)	2.4	14.5	4.3
Temporary Diesel Generator (YM3)	2.4	14.5	4.3
Temporary Diesel Generator (YM4)	2.4	14.5	4.3
Temporary Diesel Generator (YM5)	2.4	14.5	4.3
Temporary Diesel Generator (YM6)	2.4	14.5	4.3
Temporary Diesel Generator (YM7)	2.4	14.5	4.3
Temporary Diesel Generator (YM8)	14.5	2.4	4.3
Temporary Diesel Generator (YM9)	14.5	2.4	4.3
Temporary Diesel Generator (YM10)	14.5	2.4	4.3

6.7 NO_x to NO_2 Conversion

The Ozone Limiting Method (OLM) was used for NO_x to NO_2 conversion in this assessment, as recommended in the BC GNDM. The OLM assumes the conversion of NO_x to NO_2 in the atmosphere can be limited by the ambient O_3 concentration as well as taking into consideration the thermal NO_2 produced in the stack. The in-stack thermal NO_2 emissions are determined based on the NO_2/NOx in-stack ratio (ISR). The slightly more conservative equilibrium ratio (ER) of 1.0 was used for this assessment.

The OLM conversion calculation is based on the equation below:

$$[NO_2] \quad = \text{ ISR} * [NO_x] \quad + \text{the lesser of } \left([O_3] \quad or \ (ER - ISR_i) * [NO_x] \quad \right) + baseline\ [NO_2]$$

The concentration in the above equations is in molar values or parts per billion. The ambient O_3 concentrations used in the OLM simulation were from the Whitehorse AQ Station for the modelling period (2016 to 2020). Where required, missing O_3 data was filled following the methods recommended in the BC GNDM.

To satisfy the requirement in the BC GNDM, the results of NO_2 from the Total NO_x to NO_2 TCM are also presented in this report.

ISR used in the assessment are listed in Table 6-4. ISR were from the recommended ISR values based on the equipment and fuel type in the BC GNDM.

Table 6-4 Emission Source In-stack-ratio

Emission Source	ISR	Determination Method
Engine – Natural Gas	0.083	Table B-1 of BC GNDM
Engine – Diesel	0.187	Table B-1 of BC GNDM

7 RESULTS AND DISCUSSION

The following section presents air dispersion modelling results associated with the Station. The maximum predicted concentrations, based on the statistical form presented in Table 3-1, for the modelled scenarios, along with baseline ambient concentrations, were compared to applicable standards to assess potential impact on the local air quality. The maximum predicted concentration isopleths in the study area for the Station are shown in Appendix E.

7.1 Results of NO_2

The maximum predicted 1-hour and annual NO_2 concentrations, as well as at each sensitive receptor, are summarized in Table 7-1. The NO_2 concentrations reported are from the OLM for the NO_x to NO_2 conversion. In addition, the TCM for the Station only are also presented.

The baseline ambient concentrations considered in the assessment are elevated, with the 1-hour baseline at 65% of the current YAAQS and 93% of the 2025 YAAQS. When the baseline is added to the maximum predicted 1-hour and annual NO_2 concentrations from the Station for all scenarios the predicted results are above the YAAQS For the 1-hour averaging period, most of the domain have predicted exceedances of the YAAQS. There are no predicted exceedances of the annual NO_2 YAAQS at the sensitive receptors. Without the baseline, the maximum predicted 1-hour NO_2 concentration for the *Expected Scenario* is below the YAAQS at all sensitive receptors except for the nearest residence.

The maximum predicted 1-hour NO_2 concentrations from the *Emergency (N-1) Scenario* at the sensitive receptors increased 10% to 50% from the *Expected Scenario*, and the annual increased 13% to 29%.

The 1-hour NO_2 MPOIs are located along the northwestern Station boundary. The 1-hour predicted exceedances cover most of the domain for both scenarios. The annual NO_2 MPOIs are located along the northern Station boundary and concentrations decrease quickly, moving away from the Station boundary. The annual predicted exceedances are within 700 m of the Station boundary for the *Expected Scenario* and within 1,400 m of the Station boundary for the *Emergency (N-1) Scenario*.

The NO_2 concentration isopleths for hourly and annual are presented in Appendix E: Figure E-1 to Figure E-4.

Table 7-1 Maximum Predicted NO_2 Concentrations

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m^3)	TCM Station Only Concentration (µg/m^3)	OLM Station Only Concentration (µg/m^3)	Baseline + OLM Station			YAAQS (µg/m^3)
						Concentration (µg/m^3)	% of YAAQS	% of 2025 YAAQS	
Expected Scenario	Maximum Point of Impingement	1-hour	1-hour: 73.3 Annual: 11.2	1809	213	287	254%	363%	Current: 1-hour: 113 Annual: 32 2025: 1-hour: 79 Annual: 23
		Annual		248	50.3	61.4	192%	267%	
	Nearest Residence	1-hour		709	122	196	173%	248%	
		Annual		11.0	4.2	15.4	48%	67%	
	Christ the King Elementary School	1-hour		353	101	175	155%	221%	
		Annual		5.1	3.1	14.3	45%	62%	
	Grey Mountain Primary School	1-hour		306	86	159	141%	201%	
		Annual		3.2	1.8	13.0	40%	56%	
	F.H. Collins Secondary School	1-hour		254	99	172	153%	218%	
		Annual		8.5	6.1	17.3	54%	75%	
	Selkirk Elementary School	1-hour		311	101	175	155%	221%	
		Annual		6.6	4.2	15.4	48%	67%	
	Whitehorse General Hospital	1-hour		199	93.0	166	147%	211%	
		Annual		8.7	6.8	17.9	56%	78%	
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	1-hour: 73.3 Annual: 11.2	5425	481	555	491%	702%	Current: 1-hour: 113 Annual: 32 2025: 1-hour: 79 Annual: 23
		Annual		692	89.3	100	314%	437%	
	Nearest Residence	1-hour		2086	222	295	261%	373%	
		Annual		37.1	8.2	19.3	60%	84%	
	Christ the King Elementary School	1-hour		959	134	208	184%	263%	
		Annual		16.2	5.9	17.1	53%	74%	
	Grey Mountain Primary School	1-hour		783	119	192	170%	243%	
		Annual		10.5	3.6	14.7	46%	64%	
	F.H. Collins Secondary School	1-hour		832	123	196	174%	249%	
		Annual		23.8	10.4	21.6	68%	94%	
	Selkirk Elementary School	1-hour		1001	128	202	178%	255%	
		Annual		20.0	7.5	18.7	58%	81%	
	Whitehorse General Hospital	1-hour		623	110	184	163%	233%	
		Annual		22.9	11.9	23.1	72%	100%	

Note: Values shaded in gray indicate results above the applicable YAAQS.

7.2 Results of SO_2

The maximum predicted 1-hour and annual SO_2 concentrations, as well as at each sensitive receptor, are summarized in Table 7-2.

As no baseline SO_2 data was available near the Station, the baseline values were not calculated for this air contaminant. Maximum predicted SO_2 concentrations for both the 1-hour and annual averaging periods are well below the YAAQS. The maximum predicted 1-hour concentrations for the *Expected Scenario* and the *Emergency (N-1) Scenario* are all less than 4% of the YAAQS, and the annual concentrations are all less than approximately 7% of the YAAQS.

The SO_2 concentration isopleths for hourly and annual are presented in Appendix E: Figure E-5 to Figure E-8. The isopleths show that the predicted concentrations decrease significantly with increased distance from the Station. The MPOIs are located along the north and northwest Station boundary.

7.3 Results of CO

The maximum predicted 1-hour and 8-hour CO concentrations, as well as at each sensitive receptor, are summarized in Table 7-3.

As no baseline CO data was available near the Station, the baseline values were not calculated for this air contaminant. Maximum predicted CO concentrations for both the 1-hour and 8-hour averaging periods are well below the BC Pollution Control Objective (used for reference purposes). The maximum predicted 1-hour and 8-hour concentrations for the Expected Scenario and the *Emergency (N-1) Scenario* are less than approximately 17% of the BC reference value.

The CO concentration isopleths for 1-hour and 8-hour are presented in Appendix E: Figure E-9 to Figure E-12. The isopleths show that the predicted concentrations decrease significantly with increased distance from the Station. The MPOIs are located along the western Station boundary.

7.4 Results of TSP

The maximum predicted 24-hour and annual TSP concentrations, as well as at each sensitive receptor, are summarized in Table 7-4.

The maximum predicted 24-hour and annual TSP concentrations for the *Expected Scenario* are below the YAAQS. The *Emergency (N-1) Scenario* maximum 24-hour TSP predicted concentration is above the YAAQS at the MPOI only, and there are no predicted exceedances of the annual TSP YAAQS. The estimated baseline ambient concentrations significantly contribute to the elevated values. The 24-hour baseline is 56% of the YAAQS. Without the baseline, the maximum predicted 24-hour TSP concentration for the *Emergency (N-1) Scenario* is below the YAAQS.

The TSP concentration isopleths for 24-hour and annual are presented in Appendix E: Figure E-13 to Figure E-16. The isopleths show that the predicted concentrations decrease significantly with increased distance from the Station. The MPOIs are located along the north and northwest Station boundary. The predicted exceedances for the *Emergency (N-1) Scenario* are located within 20 m of the Station Boundary.

Table 7-2 Maximum Predicted SO_2 Concentrations

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station			YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	% of 2025 YAAQS	
Expected Scenario	Maximum Point of Impingement	1-hour	-	3.5	3.5	1.9%	2.1%	Current: 1-hour: 183 Annual: 13 2025: 1-hour: 170 Annual: 11
		Annual	-	0.44	0.44	3.4%	4.0%	
	Nearest Residence	1-hour	-	1.4	1.4	0.8%	0.8%	
		Annual	-	0.02	0.02	0.1%	0.2%	
	Christ the King Elementary School	1-hour	-	0.67	0.67	0.4%	0.4%	
		Annual	-	0.01	0.01	0.1%	0.1%	
	Grey Mountain Primary School	1-hour	-	0.61	0.61	0.3%	0.4%	
		Annual	-	0.01	0.01	0.0%	0.1%	
	F.H. Collins Secondary School	1-hour	-	0.52	0.52	0.3%	0.3%	
		Annual	-	0.02	0.02	0.1%	0.1%	
	Selkirk Elementary School	1-hour	-	0.59	0.59	0.3%	0.3%	
		Annual	-	0.01	0.01	0.1%	0.1%	
	Whitehorse General Hospital	1-hour	-	0.40	0.40	0.2%	0.2%	
		Annual	-	0.02	0.02	0.1%	0.1%	

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station			YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	% of 2025 YAAQS	
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	-	7.1	7.1	3.9%	4.2%	Current: 1-hour: 183 Annual: 13 2025: 1-hour: 170 Annual: 11
		Annual	-	0.85	0.85	6.6%	7.8%	
	Nearest Residence	1-hour	-	2.7	2.7	1.5%	1.6%	
		Annual	-	0.04	0.04	0.3%	0.4%	
	Christ the King Elementary School	1-hour	-	1.3	1.3	0.7%	0.8%	
		Annual	-	0.02	0.02	0.1%	0.2%	
	Grey Mountain Primary School	1-hour	-	1.1	1.1	0.6%	0.7%	
		Annual	-	0.01	0.01	0.1%	0.1%	
	F.H. Collins Secondary School	1-hour	-	1.1	1.1	0.6%	0.7%	
		Annual	-	0.03	0.03	0.2%	0.3%	
	Selkirk Elementary School	1-hour	-	1.3	1.3	0.7%	0.7%	
		Annual	-	0.02	0.02	0.2%	0.2%	
	Whitehorse General Hospital	1-hour	-	0.79	0.79	0.4%	0.5%	
		Annual	-	0.03	0.03	0.2%	0.3%	

Table 7-3 Maximum Predicted CO Concentration

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		BC Pollution Control Objective* (µg/m³)
					Concentration (µg/m³)	% of BC Pollution Control Objective	
Expected Scenario	Maximum Point of Impingement	1-hour	-	2,451	2,451	17%	1-hour: 14,300 8-hour: 5,500
		8-hour	-	884	884	16%	
	Nearest Residence	1-hour	-	324	324	2.3%	
		8-hour	-	78.1	78.1	1.4%	
	Christ the King Elementary School	1-hour	-	152	152	1.1%	
		8-hour	-	33.9	33.9	0.6%	
	Grey Mountain Primary School	1-hour	-	132	132	0.9%	
		8-hour	-	21.5	21.5	0.4%	
	F.H. Collins Secondary School	1-hour	-	99.2	99.2	0.7%	
		8-hour	-	34.6	34.6	0.6%	
	Selkirk Elementary School	1-hour	-	141	141	1.0%	
		8-hour	-	32.6	32.6	0.6%	
	Whitehorse General Hospital	1-hour	-	113	113	0.8%	
		8-hour	-	27.6	27.6	0.5%	

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		BC Pollution Control Objective* (µg/m³)
					Concentration (µg/m³)	% of BC Pollution Control Objective	
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	-	2,456	2,456	17%	1-hour: 14,300 8-hour: 5,500
		8-hour	-	884	884	16%	
	Nearest Residence	1-hour	-	386	386	2.7%	
		8-hour	-	96.3	96.3	1.8%	
	Christ the King Elementary School	1-hour	-	156	156	1.1%	
		8-hour	-	44.7	44.7	0.8%	
	Grey Mountain Primary School	1-hour	-	150	150	1.0%	
		8-hour	-	32.6	32.6	0.6%	
	F.H. Collins Secondary School	1-hour	-	117	117	0.8%	
		8-hour	-	41.1	41.1	0.7%	
	Selkirk Elementary School	1-hour	-	160	160	1.1%	
		8-hour	-	34.1	34.1	0.6%	
	Whitehorse General Hospital	1-hour	-	115	115	0.8%	
		8-hour	-	36.2	36.2	0.7%	

Note: * There are no YAAQS established for CO. The Pollution Control Objectives (used for reference purposes) from the nearest jurisdiction – British Columbia (BC Ministry of Environment and Climate Change Strategy, 2021), were chosen as the air quality criteria for CO in this assessment.

Table 7-4 Maximum Predicted TSP Concentrations

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	
Expected Scenario	Maximum Point of Impingement	24-hour	24-hour: 67.3 Annual: 17.0	30.0	97.3	81%	24-hour: 120 Annual: 60
		Annual		8.4	25.3	42%	
	Nearest Residence	24-hour		6.5	73.8	62%	
		Annual		0.4	17.3	29%	
	Christ the King Elementary School	24-hour		2.3	69.6	58%	
		Annual		0.2	17.1	29%	
	Grey Mountain Primary School	24-hour		2.7	70.0	58%	
		Annual		0.1	17.1	28%	
	F.H. Collins Secondary School	24-hour		2.8	70.1	58%	
		Annual		0.3	17.2	29%	
	Selkirk Elementary School	24-hour		2.4	69.7	58%	
		Annual		0.2	17.2	29%	
	Whitehorse General Hospital	24-hour		2.2	69.5	58%	
		Annual		0.3	17.3	29%	

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	24-hour: 67.3 Annual: 17.0	73.5	141	117%	24-hour: 120 Annual: 60
		Annual		21.2	38.2	64%	
	Nearest Residence	24-hour		19.3	86.6	72%	
		Annual		1.1	18.1	30%	
	Christ the King Elementary School	24-hour		5.8	73.1	61%	
		Annual		0.5	17.4	29%	
	Grey Mountain Primary School	24-hour		7.4	74.7	62%	
		Annual		0.3	17.3	29%	
	F.H. Collins Secondary School	24-hour		7.3	74.6	62%	
		Annual		0.7	17.7	29%	
	Selkirk Elementary School	24-hour		6.3	73.7	61%	
		Annual		0.6	17.5	29%	
	Whitehorse General Hospital	24-hour		5.5	72.8	61%	
		Annual		0.7	17.6	29%	

Note: Values shaded in gray indicate results above the applicable YAAQS.

7.5 Results of $PM_{2.5}$

The maximum predicted 24-hour and annual $PM_{2.5}$ concentrations, as well as at each sensitive receptor, are summarized in Table 7-5.

The baseline ambient concentrations of $PM_{2.5}$ considered in the assessment are elevated, with the 24-hour baseline at 65% of the YAAQS, and the annual baseline at 50% of the YAAQS. The maximum predicted 24-hour and annual $PM_{2.5}$ concentrations for the *Expected Scenario* and *Emergency (N-1) Scenario* are above the YAAQS, however, there are no predicted exceedances at the sensitive receptors. Without the baseline, the maximum predicted 24-hour and annual $PM_{2.5}$ concentrations for the *Expected Scenario* and the annual concentration for the *Emergency (N-1) Scenario* are below the YAAQS.

The $PM_{2.5}$ concentration isopleths for 24-hour and annual are presented in Appendix E: Figure E-17 to Figure E-20. The isopleths show that the predicted concentrations decrease significantly with increased distance from the Station. The MPOIs are located along the north and northwest Station boundary. The 24-hour predicted exceedances are within 30 m of the Station boundary for the *Expected Scenario* and within 185 m of the Station boundary for the *Emergency (N-1) Scenario*. The annual predicted exceedances are within 10 m of the Station boundary for the *Expected Scenario* and within 140 m of the Station boundary for the *Emergency (N-1) Scenario*.

7.6 Results of PM_{10}

The maximum predicted 24-hour PM_{10} concentration, as well as at each sensitive receptor, are summarized in Table 7-6.

The maximum predicted 24-hour PM_{10} concentrations for the *Expected Scenario* and *Emergency (N-1) Scenario* are above the YAAQS. The estimated baseline ambient concentrations significantly contribute to the elevated values. The 24-hour baseline is 70% of the YAAQS. Without the baseline, the maximum predicted 24-hour concentration for the *Expected Scenario* and the *Emergency (N-1) Scenario* are below the YAAQS.

The PM_{10} concentration isopleths for 24-hour are presented in Appendix E: Figure E-21 to Figure E-22. The isopleths show that the predicted concentrations decrease significantly with increased distance from the Station. The MPOIs are located along the northwest Station boundary. The 24-hour predicted exceedances are within 20 m of the Station boundary for the *Expected Scenario* and within 220 m of the Station boundary for the *Emergency (N-1) Scenario*.

Table 7-5 Maximum Predicted $PM_{2.5}$ Concentrations

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	
Expected Scenario	Maximum Point of Impingement	24-hour	24-hour: 17.5 Annual: 4.4	14.7	32.2	119%	24-hour: 27 Annual: 8.8
		Annual		4.9	9.3	106%	
	Nearest Residence	24-hour		1.3	18.8	70%	
		Annual		0.2	4.6	52%	
	Christ the King Elementary School	24-hour		0.5	18.0	67%	
		Annual		0.1	4.5	51%	
	Grey Mountain Primary School	24-hour		0.5	18.0	67%	
		Annual		0.1	4.5	51%	
	F.H. Collins Secondary School	24-hour		0.7	18.2	68%	
		Annual		0.2	4.6	52%	
	Selkirk Elementary School	24-hour		0.6	18.1	67%	
		Annual		0.1	4.5	52%	
	Whitehorse General Hospital	24-hour		0.7	18.2	67%	
		Annual		0.2	4.6	52%	

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (μg/m³)	Station Only Concentration (μg/m³)	Baseline + Station		YAAQS (μg/m³)
					Concentration (μg/m³)	% of YAAQS	
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	24-hour: 17.5 Annual: 4.4	28.4	45.9	170%	24-hour: 27 Annual: 8.8
		Annual		10.0	14.4	164%	
	Nearest Residence	24-hour		3.4	20.9	77%	
		Annual		0.5	4.9	56%	
	Christ the King Elementary School	24-hour		1.3	18.8	70%	
		Annual		0.2	4.6	53%	
	Grey Mountain Primary School	24-hour		1.1	18.6	69%	
		Annual		0.1	4.6	52%	
	F.H. Collins Secondary School	24-hour		1.6	19.1	71%	
		Annual		0.3	4.8	54%	
	Selkirk Elementary School	24-hour		1.5	19.0	70%	
		Annual		0.3	4.7	53%	
	Whitehorse General Hospital	24-hour		1.4	18.9	70%	
		Annual		0.3	4.7	54%	

Note: Values shaded in gray indicate results above the applicable YAAQS.

Table 7-6 Maximum Predicted PM_{10} Concentrations

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station		YAAQS (µg/m³)
					Concentration (µg/m³)	% of YAAQS	
Expected Scenario	Maximum Point of Impingement	24-hour	24-hour: 35.0	20.7	55.7	111%	24-hour: 50
	Nearest Residence	24-hour		4.6	39.6	79%	
	Christ the King Elementary School	24-hour		1.6	36.6	73%	
	Grey Mountain Primary School	24-hour		1.9	36.9	74%	
	F.H. Collins Secondary School	24-hour		1.9	36.9	74%	
	Selkirk Elementary School	24-hour		1.7	36.7	73%	
	Whitehorse General Hospital	24-hour		1.6	36.6	73%	

Scenarios	Location	Averaging Period	Baseline Ambient Concentration (µg/m³)	Station Only Concentration (µg/m³)	Baseline + Station Concentration (µg/m³)	Baseline + Station % of YAAQS	YAAQS (µg/m³)
Emergency (N-1) Scenario	Maximum Point of Impingement	24-hour	24-hour: 35.0	41.9	76.9	154%	24-hour: 50
	Nearest Residence	24-hour		11.2	46.2	92%	
	Christ the King Elementary School	24-hour		3.5	38.5	77%	
	Grey Mountain Primary School	24-hour		4.4	39.4	79%	
	F.H. Collins Secondary School	24-hour		4.3	39.3	79%	
	Selkirk Elementary School	24-hour		3.8	38.8	78%	
	Whitehorse General Hospital	24-hour		3.3	38.3	77%	

Note: Values shaded in gray indicate results above the applicable YAAQS.

7.7 Discussion

As previously discussed in Sections 1.1 and 5.1, for both the Expected Scenario and the Emergency (N-1) Scenario, maximum emissions from all operating sources are only expected to occur for a small number of hours each year. However, the conservative modelling approach employed assessed the impact of these maximum emissions occurring in every hour of the year to ensure that the worst-case combination of emissions and meteorology were identified and assessed.

It is important to understand the percentage of time in a year that the combination of worst-case emissions and prevailing meteorological conditions could combine to produce an exceedance of the YAAQS. To assess this, the contingent frequency of exceedance was calculated for the 1-hour or 24-hour averaging period where applicable. The count presented is the highest number of times over a year that the combination of worst-case emissions and prevailing meteorology resulted in predicted concentrations over the YAAQS with the baseline air quality concentrations included.

For the air contaminants with predicted exceedances of the YAAQS, the contingent frequency of exceedance was calculated for the 1-hour or 24-hour averaging period where applicable. The count presented is the highest number of times a receptor had predicted concentrations over the YAAQS with the baseline air quality concentrations included in any one-year modelling period.

This contingent frequency of exceedance is conservative as it does not take into account the actual operational frequency of the various units, as described in Section 1.1 and 5.5, which is lower.

For 1-hour NO_2, the contingent frequency of exceedance at the sensitive receptors ranged from 1.1 to 5.4% for the *Expected Scenario* and 2.9% to 12% for the *Emergency (N-1) Scenario* (Table 7-7).

Table 7-8 presents the contingent frequency of exceedance for TSP, $PM_{2.5}$ and PM_{10}. For 24-hour TSP, the contingent frequency of exceedance at the MPOI receptor for the *Emergency (N-1) Scenario* was 6%. For 24-hour $PM_{2.5}$, the contingent frequency of exceedance at the MPOI receptor for the *Expected Scenario* was 21.6% and 54.1% for the *Emergency (N-1) Scenario*. The *Emergency (N-1) Scenario* also had a contingent frequency of exceedance of 0.3% at the nearest residence. For 24-hour PM_{10}, the contingent frequency of exceedance at the MPOI receptor for the *Expected Scenario* was 5.8% and 40.4% for the *Emergency (N-1) Scenario*.

Table 7-7 Contingent Frequency of Exceedance for NO_2

Scenarios	Location	Averaging Period	Current YAAQS		2025 YAAQS	
			Count	Contingent Frequency of Exceedance (%)	Count	Contingent Frequency of Exceedance (%)
Expected Scenario	Maximum Point of Impingement	1-hour	4,551	51.8%	5,306	60.4%
	Nearest Residence	1-hour	352	4.0%	887	10.1%
	Christ the King Elementary School	1-hour	238	2.7%	869	9.9%
	Grey Mountain Primary School	1-hour	98	1.1%	581	6.6%
	F.H. Collins Secondary School	1-hour	472	5.4%	1,669	19.1%
	Selkirk Elementary School	1-hour	311	3.6%	1,147	13.1%
	Whitehorse General Hospital	1-hour	438	5.0%	2,185	24.9%
Emergency (N-1) Scenario	Maximum Point of Impingement	1-hour	4,961	56.5%	5,995	68.2%
	Nearest Residence	1-hour	601	6.8%	1,440	16.4%
	Christ the King Elementary School	1-hour	495	5.6%	1,396	15.9%
	Grey Mountain Primary School	1-hour	252	2.9%	975	11.1%
	F.H. Collins Secondary School	1-hour	930	10.6%	2,379	27.1%
	Selkirk Elementary School	1-hour	582	6.6%	1,859	21.2%
	Whitehorse General Hospital	1-hour	1,050	12.0%	2,995	34.1%

Note: The contingent frequency of exceedances is for the 100^{th} percentile and does not follow the statistical form listed in Table 3-1.

Table 7-8 Contingent Frequency of Exceedance for Particulates (TSP, $PM_{2.5}$, PM_{10})

Scenarios	Location	Averaging Period	TSP		$PM_{2.5}$		PM_{10}	
			Count	Contingent Frequency of Exceedance (%)	Count	Contingent Frequency of Exceedance (%)	Count	Contingent Frequency of Exceedance (%)
Expected Scenario	Maximum Point of Impingement	24-hour	-	-	79	21.6%	21	5.8%
	Nearest Residence	24-hour	-	-	-	-	-	-
	Christ the King Elementary School	24-hour	-	-	-	-	-	-
	Grey Mountain Primary School	24-hour	-	-	-	-	-	-
	F.H. Collins Secondary School	24-hour	-	-	-	-	-	-
	Selkirk Elementary School	24-hour	-	-	-	-	-	-
	Whitehorse General Hospital	24-hour	-	-	-	-	-	-
Emergency (N-1) Scenario	Maximum Point of Impingement	24-hour	22	6.0%	198	54.1%	148	40.4%
	Nearest Residence	24-hour	-	-	1	0.3%	-	-
	Christ the King Elementary School	24-hour	-	-	-	-	-	-
	Grey Mountain Primary School	24-hour	-	-	-	-	-	-
	F.H. Collins Secondary School	24-hour	-	-	-	-	-	-
	Selkirk Elementary School	4-hour	-	-	-	-	-	-
	Whitehorse General Hospital	24-hour	-	-	-	-	-	-

Note: The contingent frequency of exceedances is for the 100^{th} percentile and does not follow the statistical form listed in Table 3-1.

The assessment has predicted that station emissions may result in predicted air contaminant concentrations that exceed the YAAQS, and therefore there is a potential for the Station operations to impact the local ambient air quality during periods when maximum station loads and associated maximum emissions coincide with periods of prevailing meteorology that limit effective dispersion of air contaminants. All predicted exceedances for particulate YAAQS are predicted to occur in a small, localized area directly adjacent to the Station. NO_2 YAAQS exceedances are predicted both near the station and at sensitive receptor locations throughout the modelling domain, largely due to the high baseline NO_2 levels in the airshed.

8 CONCLUSION

The assessment evaluated the potential air quality impacts associated with thermal electricity emissions from the Yukon Energy Corporation Whitehorse Rapids Generating Station in Whitehorse, Yukon, using the CALPUFF air dispersion modelling suite. The assessment focused on NO_2, SO_2, CO, $PM_{2.5}$, PM_{10}, TSP, and DPM emissions.

In addition to evaluating the ambient air quality impacts, another objective of the air quality assessment was to evaluate the potential human health risks. The modelling results were provided to the WSP Environmental Risk Assessment Team to prepare a Human Health Risk Assessment (WSP, 2023).

Air quality dispersion modelling predictions, following the statistical form in Table 3-1 along with the baseline air quality concentrations considered, were compared with the YAAQS and the BC Pollution Control Objectives (used for reference purposes) for CO. The results showed that, for all scenarios, the maximum predicted concentrations for SO_2 and CO were well below the YAAQS and BC Pollution Control Objectives at all receptors. With regard to total, fine and coarse particulate matter (TSP, $PM_{2.5}$ and PM_{10}), the maximum predicted concentrations exceeded the YAAQS in some scenarios and averaging periods, however, the predicted exceedances are in the immediate vicinity of the Station boundary (less than 220m) and decrease quickly to below the YAAQS moving away from the Station boundary. There are no predicted exceedances at the sensitive receptors for TSP, $PM_{2.5}$ or PM_{10}. For NO_2, the baseline ambient concentrations considered in the assessment are elevated, with the 1-hour baseline at 65% of the current YAAQS and 93% of the 2025 YAAQS. When the baseline is added to the maximum predicted 1-hour and annual NO_2 concentrations from the Station for all scenarios the predicted results are above the YAAQS. There are predicted 1-hour exceedances over most of the domain for both scenarios; however, there are no predicted annual exceedances at the sensitive receptors. The maximum points of impingement (worst-case receptors) for all contaminants were all found near the Station. As there are no air quality standards for DPM, DPM results are not presented in this assessment. DPM was modelled to provide predicted concentrations to the Human Health Risk Assessment (WSP, 2023).

Given that the *Emergency (N-1) Scenario* has increased power generation, the cumulative predicted air contaminant concentrations were higher than those of the *Expected Scenario*. However, the Emergency (N-1) Scenario is expected to occur rarely, only when the ambient temperature is colder than -30 °C for a cumulative total of 1 to 5 days during a 2-week period and when Yukon Energy loses its single largest source of electricity supply and/or transmission at the time. N-1 conditions have occurred, but based on historic data, these conditions only occur once in approximately 20 years.

The *Expected Scenario* uses the best available technology for the most frequently used units. One further option available to Yukon Energy to reduce emissions would be to reduce Station capacity, which would not allow Yukon Energy to meet the required demands under the current configuration of their network of generators.

Finally, it is important to note that the modelling results represent the worst-case potential air quality impacts based upon the Station's maximum operating conditions occurring concurrently with worst-case meteorological conditions. As such, the model predicted air contaminant concentrations are considered conservative. Additionally, the modelled emissions scenarios were very conservative compared to the expected annual operations at the Station. For the *Expected Scenario*, the permanent units were modelled as operating every hour of the year instead of the much shorter operational frequency described in Section 1.1. For the *Emergency (N-1) Scenario*, emissions were conservatively modelled every hour of the year for permanent units and every hour from December 1 to April 30 for the mobile diesel units instead of the estimated cumulative total of 1 to 5 days during a 2-week period that may occur once in approximately 20 years. The typical Station emissions are expected to be lower as compared to the emission scenarios considered in this assessment.

9 REFERENCES

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FIGURES

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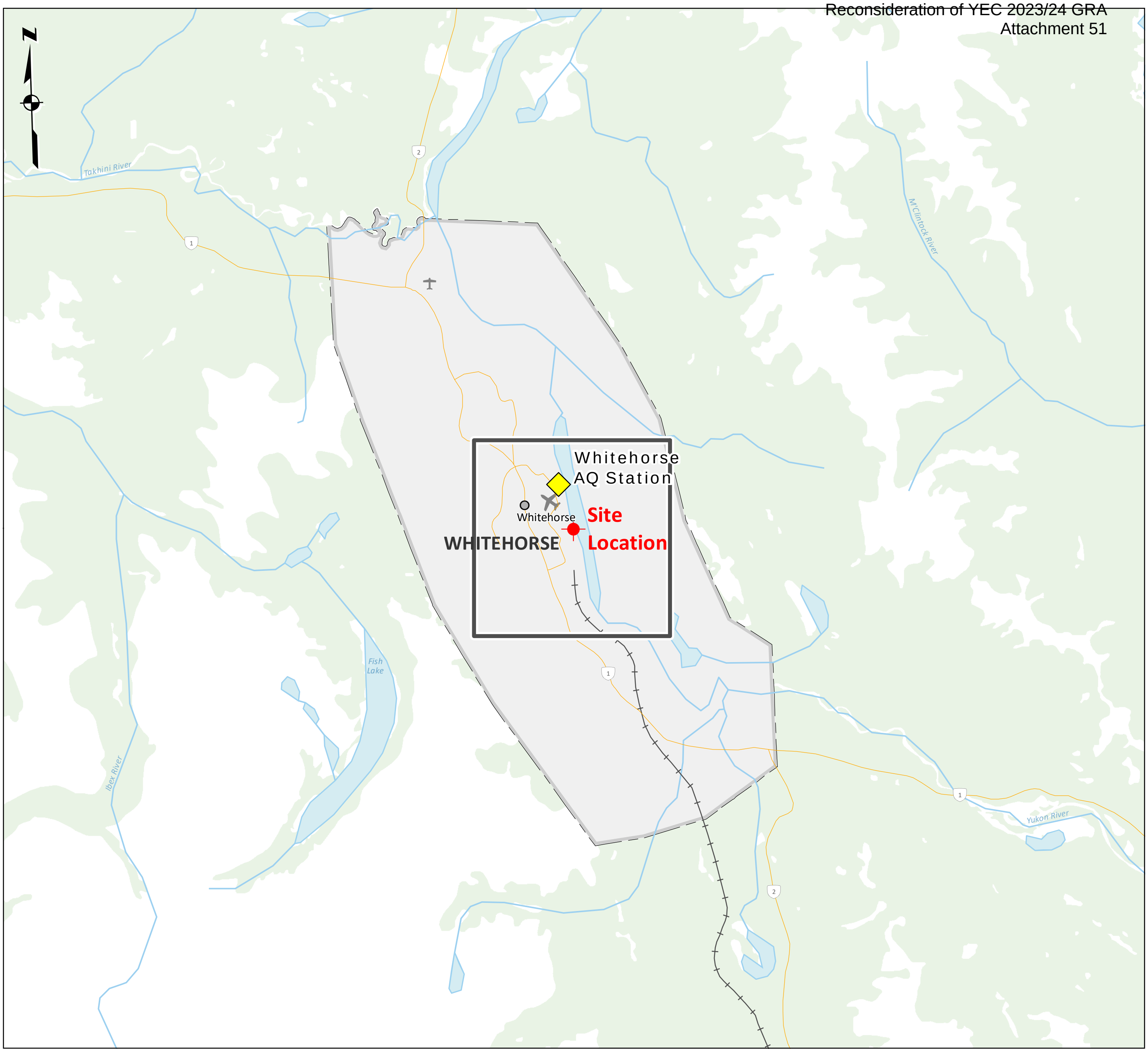


Legend

Activity
- Site Location
- Whitehorse AQ Station
- Modelling Domain (10 km x 10 km)

Water Features
- Major Lake/River
- Perennial Creeks/Streams

Municipal
- Major Urban Centre

Transportation
- Paved Roads
- Railways
- Airport
- Airfield

Environmental
- Vegetation

Scale: 1:300,000

0 3 6 9 12 15 Km

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

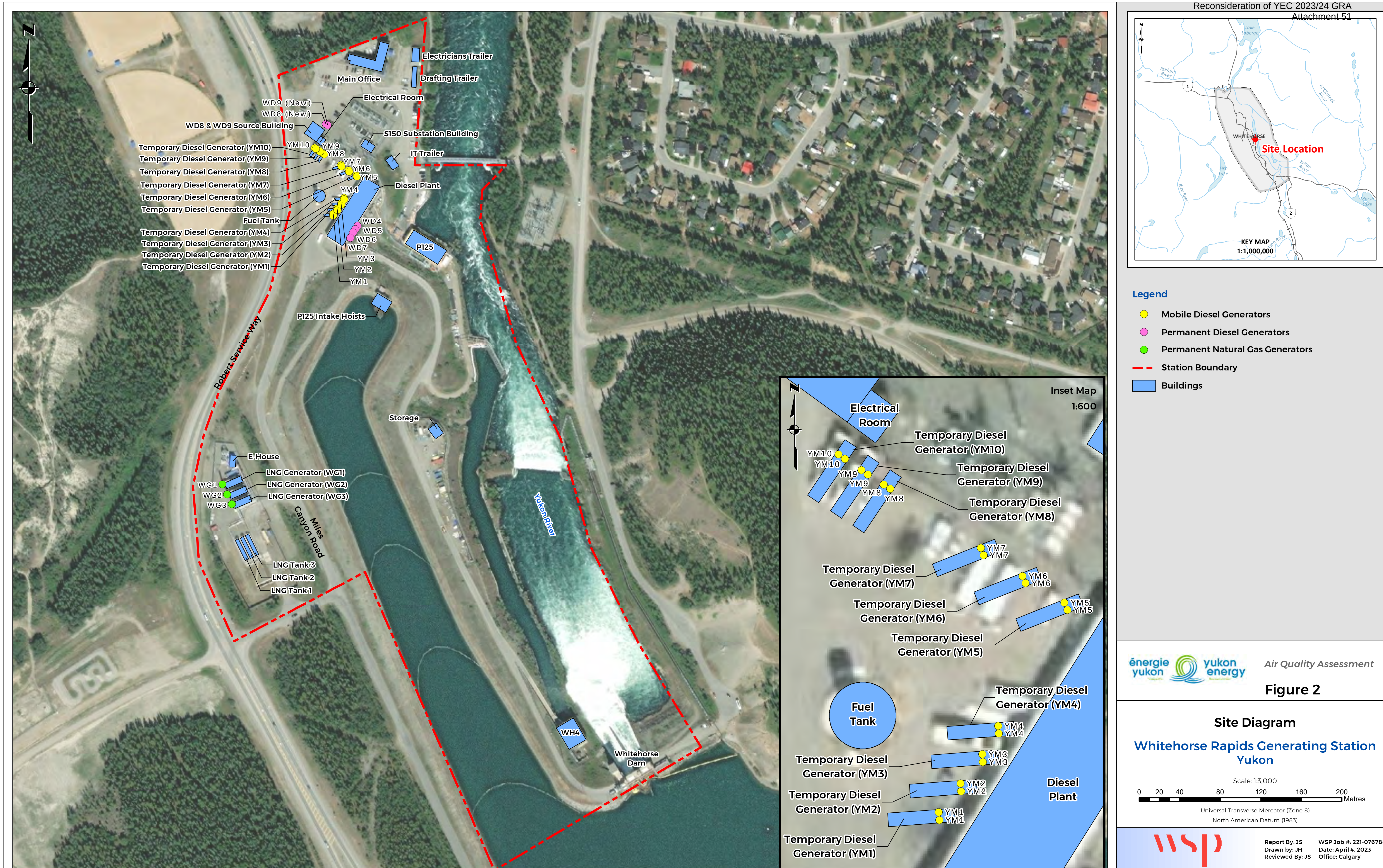
wsp

Site Location Map

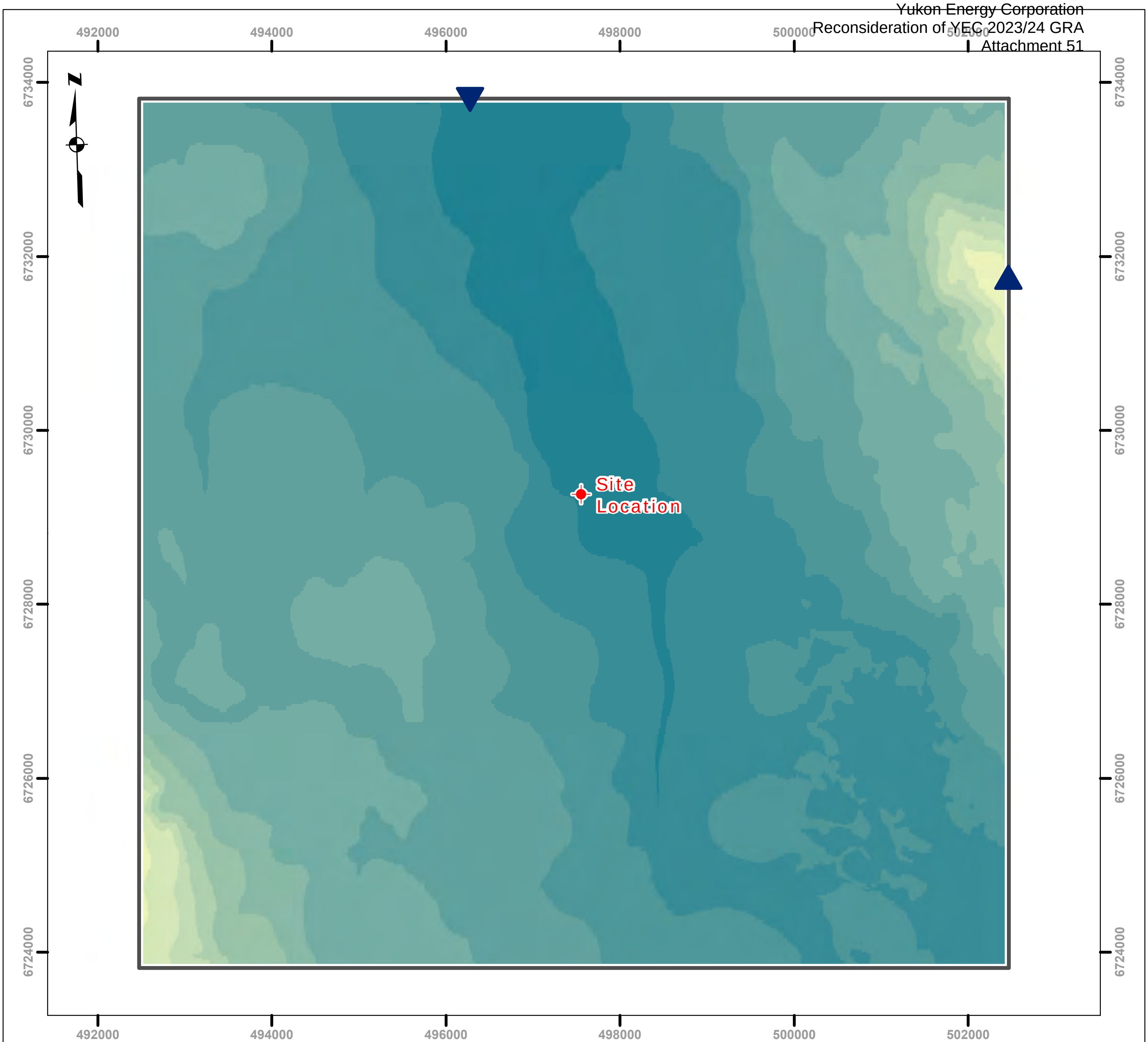
Whitehorse Rapids Generating Station Yukon

énergie yukon / yukon energy

Figure 1



Notes:Imagery Source: ESRI Imagery Service [2021]



Legend

Elevation (m)

650, 700, 750, 800, 850, 900, 950, 1,000, 1,050, 1,100, 1,150, 1,200

- Site Location (640 m)
- Maximum Elevation (1164 m)
- Minimum Elevation (640 m)
- Modelling Domain (10 km x 10 km)

Scale: 1:65,000

0 0.7 1.4 2.1 2.8 3.5 Km

Universal Transverse Mercator (Zone 8)

North American Datum (1983)

wsp

Regional Topographic Map

Whitehorse Rapids Generating Station Yukon

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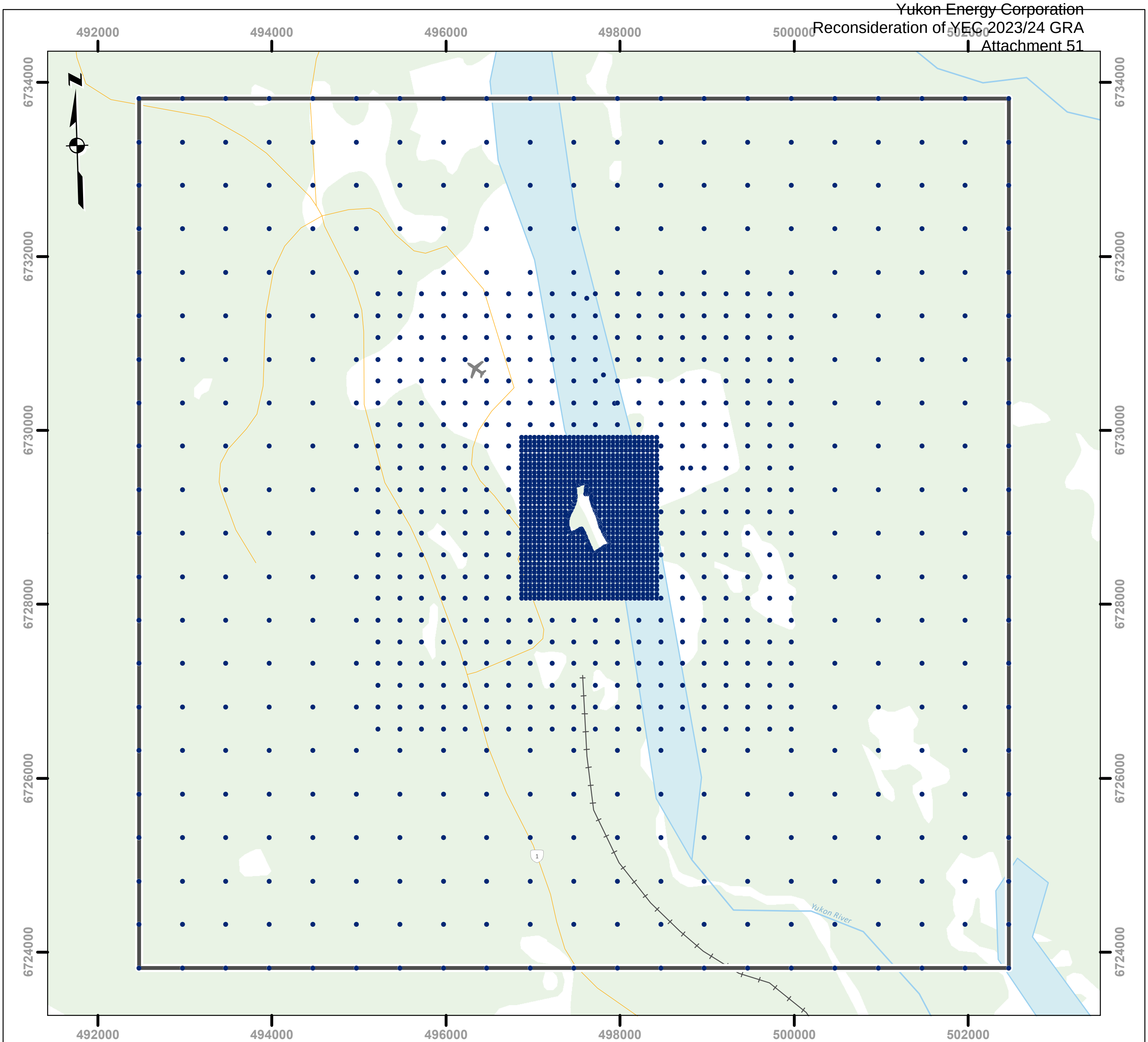
Figure 3



Legend

Gridded Receptors

Modelling Domain (10 km x 10 km)

Scale: 1:65,000

0 1 2 3 Km

Universal Transverse Mercator (Zone 8)

North American Datum (1983)

Gridded Receptors In Model Domain

Whitehorse Rapids
Generating Station

Yukon

Figure 4

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00

Legend

- Sensitive Receptors
- Station Boundary

Scale: 1:25,000

0 200 400 600 800 1,000 Meters

Universal Transverse Mercator (Zone 8)

North American Datum (1983)

wsp

Sensitive Receptors In Model Domain

Whitehorse Rapids Generating Station Yukon

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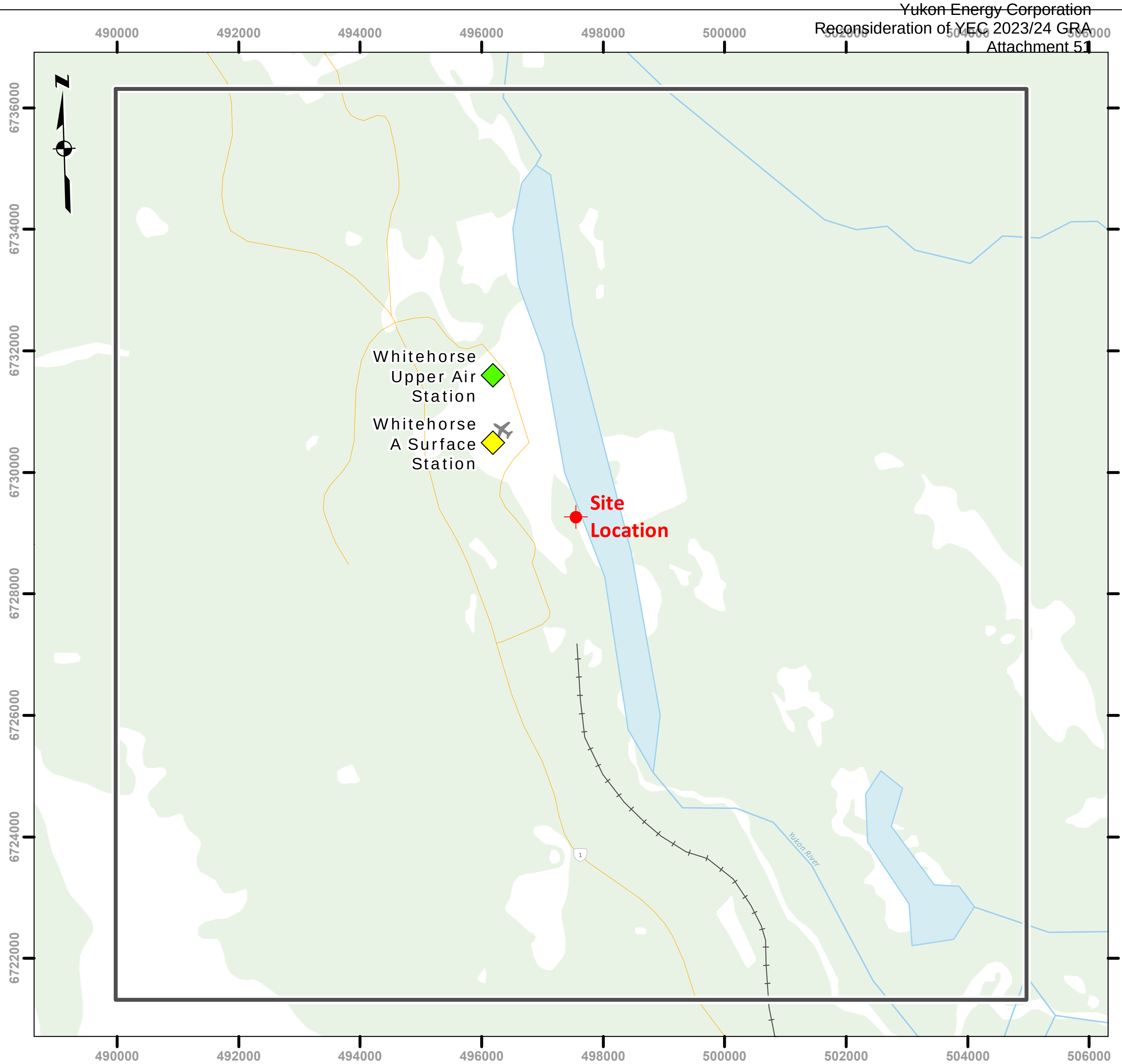
Figure 5



Legend

- Site Location
- Whitehorse A Surface Station
- Whitehorse Upper Air Station
- CALMET Domain (15 km x 15 km)

Scale: 1:95,000

0 1 2 3 Km

Universal Transverse Mercator (Zone 8)

North American Datum (1983)

wsp

CALMET Domain

Whitehorse Rapids Generating Station Yukon

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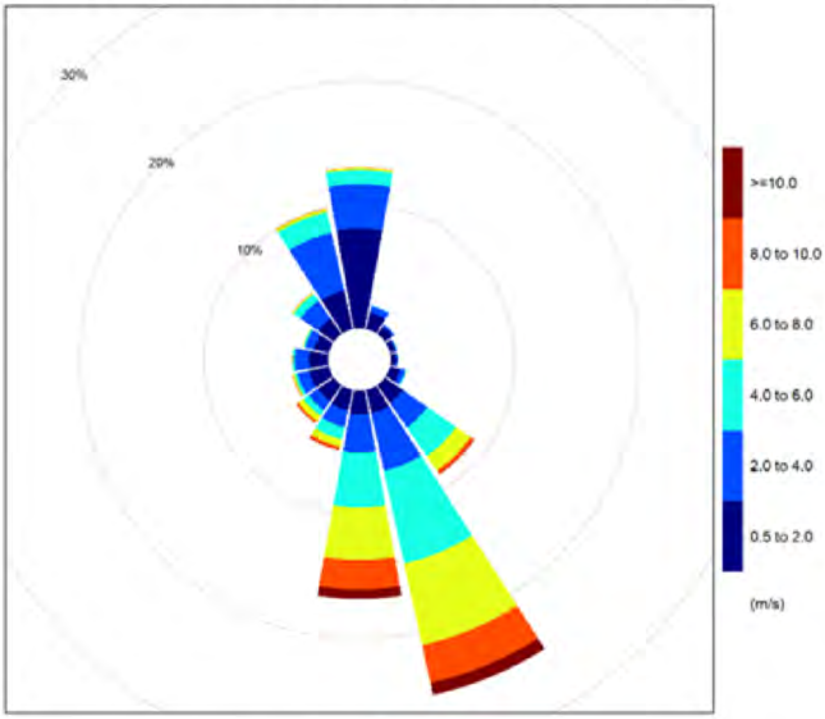
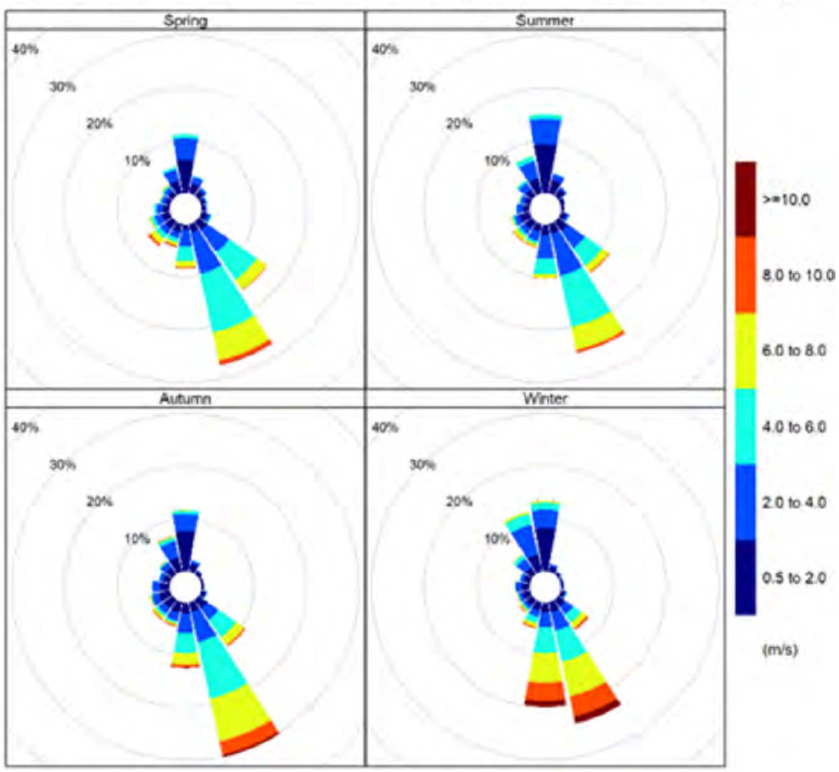
Figure 6

Observed Wind Rose (January 1, 2016 - December 31, 2020)



Calms (<0.5m/s) = 2.18 %

Observed Seasonal Wind Rose (January 1, 2016 - December 31, 2020)



Calms (<0.5m/s): Spring: 1.61 %, Summer: 1.53 %, Autumn: 1.75 %, Winter: 2.45 %

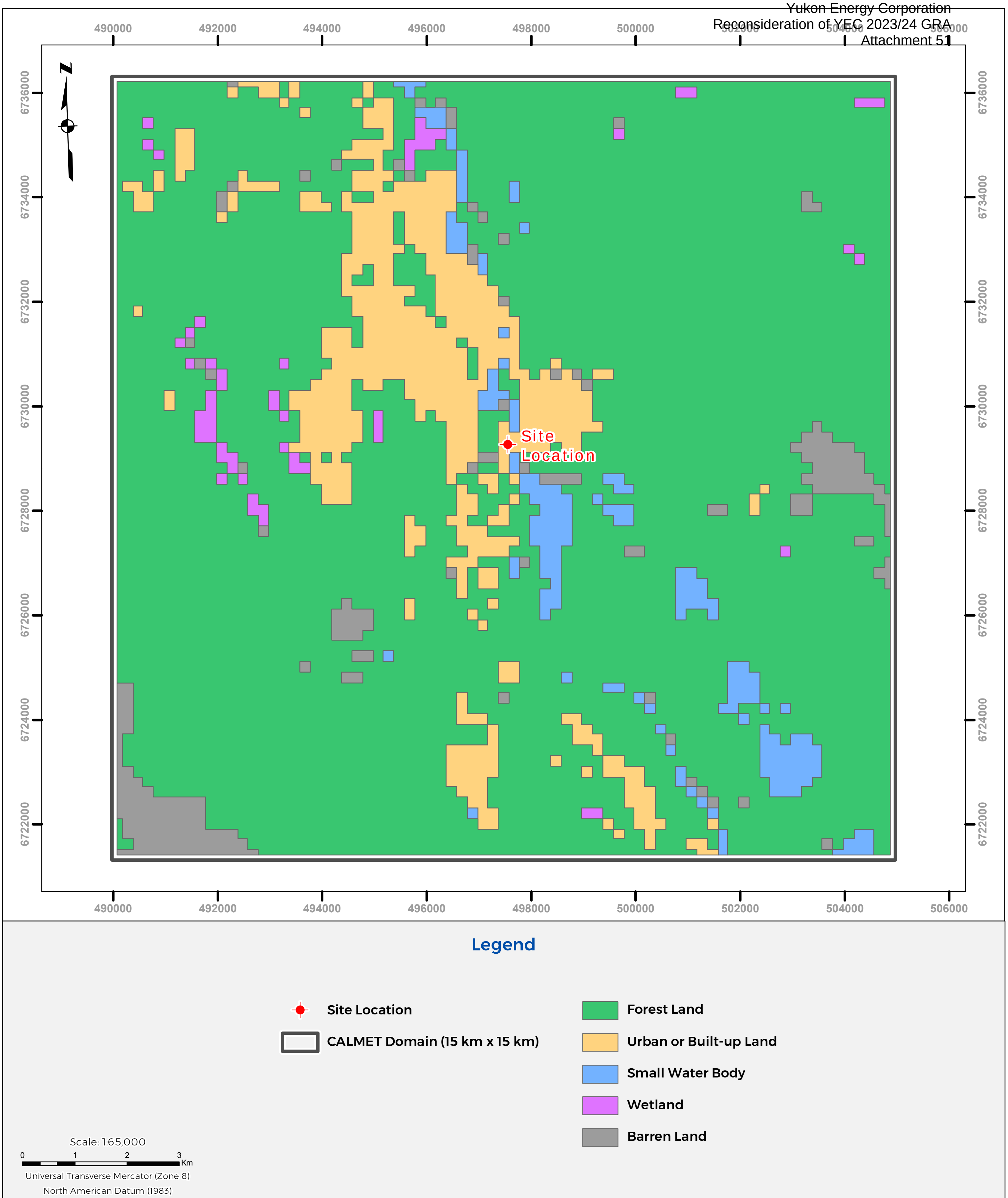
wsp

Surface Station Windrose

Whitehorse Rapids
Generating Station
Yukon

énergie yukon | yukon energy

Figure 7



Land Use Map

Whitehorse Rapids Generating Station
Yukon

Figure 8

APPENDIX

A EMISSIONS

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APPENDIX A

A1 STATION EMISSIONS

This appendix details emissions for the Yukon Energy Corporation (Yukon Energy) Whitehorse Rapids Generating Station (the Station) in Whitehorse, Yukon.

A1.1 Engine Characteristics and Emissions Factors

Table 1-1 provides a summary of all of the generators at the Station during the analysis period for this assessment. WG1 – 3, and WD4 – 7 are currently in operation today, while WD8 and 9 are expected to be constructed Q2 and Q3 in 2024 with commissioning in time for use winter 2024/2025 (i.e., Q4 2024). YM1 – 10 are representative of the temporary mobile diesel generators previously used at the station.

Table 1-1 Summary of Generator Engine Types

ENGINE ID	ENGINE MODEL	FUEL TYPE / TIER	STATUS	OUTPUT UNIT POWER GENERATION (MW)
WG1	GE Jenbacher JMC 624 GS-NL	Natural Gas	Permanent	4.375
WG2	GE Jenbacher JMC 624 GS-NL	Natural Gas	Permanent	4.375
WG3	GE Jenbacher JMC 624 GS-NL	Natural Gas	Permanent	4.375
WD4	Electro-Motive Diesel 20C	Diesel / Pre-Tier	Permanent	2.5
WD5	Electro-Motive Diesel 20C	Diesel / Pre-Tier	Permanent	2.5
WD6	Electro-Motive Diesel 20C	Diesel / Pre-Tier	Permanent	2.5
WD7	CAT 3612	Diesel / Pre-Tier	Permanent	3.3
WD8	CAT C175-16 with SCR	Diesel / Tier 4	Permanent	2.6
WD9	CAT C175-16 with SCR	Diesel / Tier 4	Permanent	2.6
YM1	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM2	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM3	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM4	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM5	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM6	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM7	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM8	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM9	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825
YM10	CAT 3516 in XQ2000 package	Diesel / Tier 2	Mobile	1.825

Table 1-2 on the following page provides details on the power-output based emissions factors (g/kWh) for all in-scope contaminants, for each different engine type. Emission factors are drawn from a range of sources, including onsite emissions test data, manufacturers specifications, US EPA literature, and BC Ministry of Environment and Climate Change Strategy guidance. Table colour coding and the associated legend detail the data sources.

APPENDIX A

Table 1-2 Summary of Generator Emissions Factors

ENGINE ID	EMISSION FACTORS G/KWH							
	TSP	$PM_{2.5}$	PM_{10}	NO_X	NO_2	NO	CO	SO_2
WG1	0.040	0.020	0.040	1.851	0.346	0.982	4.06	0.003
WG2	0.040	0.020	0.040	1.851	0.346	0.982	4.06	0.003
WG3	0.040	0.020	0.040	1.851	0.346	0.982	4.06	0.003
WD4	0.426	0.199	0.215	13.25	1.100	7.92	0.729	0.021
WD5	0.426	0.328	0.370	12.01	0.997	7.18	0.209	0.022
WD6	0.426	0.325	0.348	12.21	1.014	7.30	0.114	0.019
WD7	0.426	0.053	0.060	7.12	0.591	4.26	0.208	0.004
WD8	0.027	0.027	0.027	0.670	0.056	0.401	0.670	0.017
WD9	0.027	0.027	0.027	0.670	0.056	0.401	0.670	0.017
YM1	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM2	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM3	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM4	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM5	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM6	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM7	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM8	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM9	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017
YM10	0.040	0.040	0.040	6.06	0.503	3.62	0.490	0.017

Legend

Grey	Based directly on Table 7-4 in *"Whitehorse Diesel - Natural Gas Conversion Project YESAA Project Proposal - August 2013 Rev. 1".*
Steel blue	Based on stack test results reported in *Levelton Consultants Ltd. 2011. Emissions Testing at Yukon Energy's Whitehorse Rapids Generating Station (WRGS).*
Bright blue	Taken from US EPA AP-42 "3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines", Table 3.4.1.
Green	Based on Table 2 in SafetyPower *"ecoCUBE® SCR Emission Control System for (2) x CAT C175-16 (2,600kW) Diesel Generator Sets"* document.
Orange	Based on CAT 3516C Engine specs, Emissions* (Potential Site Variation) https://s7d2.scene7.com/is/content/Caterpillar/CM20210908-88a2e-200dc.
Yellow	Based on average SO_2 EF for existing diesel engines (WD4-7) from emissions testing results.
Pink	*Guidance on NO_2 Dispersion Modelling in British Columbia*, Table B-1 Reciprocating engines ISR: natural gas: 0.187; diesel 0.083. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/modelling_guidance_nitrogen_dioxide.pdf.

APPENDIX A

In order to produce the emission rates required as an input for dispersion modelling, the emissions factors in Table 1-2 were used as inputs to the following equation:

$$ER_c = EF_c \times P \times LF \times \frac{(1000\ kW/MW)}{3600\ s/hr}$$

Where:

ER_c is the emission rate of contaminant c in g/s;

EF_c is the emission factor of contaminant c in g/kWh;

P is the rated generator power output in MW;

LF is the load factor of the generator, assumed for 1.0 for conservatism.

A1.2 Scenario Emissions Rates

A1.2.1 Expected Scenario

For the *Expected Scenario*, the three permanent natural gas generators (WG1 – 3), the two new Tier 4 permanent diesel generators (WD8 and 9), and two of the permanent diesel generators (WD4 and 5) or two mobile diesel generators (YM 1 and 2) were conservatively modelled at full capacity to meet the peak expected load of 21 MW. The expected case was modelled for two variations (two of the permanent diesel generators or two mobile diesel generators), and the variation with the highest predicted concentrations was determined to be the permanent diesel generators (WD4 and 5). Emission rate data for this case is presented in Table 1-3 below. Note that WD4 and 5 had higher aggregate emission rates relative to WD 6 and 7, so they were used to further ensure the conservatism of the emissions estimate and associated predicted air quality impacts.

Table 1-3 Expected Scenario – Emissions Rates by Generator

ENGINE ID	OUTPUT UNIT POWER GENERATION (MW)	EMISSION RATE (G/S)							
		TSP	$PM_{2.5}$	PM_{10}	NO_X	NO_2	NO	CO	SO_2
WG1	4.375	0.049	0.024	0.049	2.25	0.421	1.19	4.93	0.004
WG2	4.375	0.049	0.024	0.049	2.25	0.421	1.19	4.93	0.004
WG3	4.375	0.049	0.024	0.049	2.25	0.421	1.19	4.93	0.004
WD4	2.5	0.296	0.138	0.149	9.200	0.764	5.503	0.506	0.015
WD5	2.5	0.296	0.228	0.257	8.340	0.692	4.988	0.145	0.015
WD8	2.6	0.019	0.019	0.019	0.484	0.040	0.290	0.484	0.012
WD9	2.6	0.019	0.019	0.019	0.484	0.040	0.290	0.484	0.012
Total	**23.3**	**0.776**	**0.478**	**0.591**	**25.26**	**2.80**	**14.65**	**16.4**	**0.065**

APPENDIX A

A1.2.2 Emergency (N-1) Scenario

For the *Emergency (N-1) Scenario*, the three permanent natural gas generators (WG1 – 3), the two new Tier 4 permanent diesel generators (WD8 and 9) and all four of the permanent diesel generators (WD4 - 7) were conservatively modelled at full capacity for all hours. Seven of the ten mobile diesel generators (YM1 – 7) were also included in the modelling in order to meet the required 41 MW peak (N-1) load. Emission rate data for this case is presented in Table 1-4 below. Note that only seven of the total ten mobile diesel generators were required to meet the emergency (N-1) peak load, so YM1-7 were selected in preference to YM8-10, as they are located slightly closer to the permanent generators, so were assessed to have a slightly higher potential to produce more conservative predicted air quality impacts.

Table 1-4 Emergency (N-1) Scenario – Emissions Rates by Generator

ENGINE ID	OUTPUT UNIT POWER GENERATION (MW)	EMISSION RATE (G/S)							
		TSP	$PM_{2.5}$	PM_{10}	NO_X	NO_2	NO	CO	SO_2
WG1	4.375	0.049	0.024	0.049	2.250	0.421	1.193	4.930	0.004
WG2	4.375	0.049	0.024	0.049	2.250	0.421	1.193	4.930	0.004
WG3	4.375	0.049	0.024	0.049	2.250	0.421	1.193	4.930	0.004
WD4	2.5	0.296	0.138	0.149	9.200	0.764	5.503	0.506	0.015
WD5	2.5	0.296	0.228	0.257	8.340	0.692	4.988	0.145	0.015
WD6	2.5	0.296	0.226	0.242	8.480	0.704	5.072	0.079	0.014
WD7	3.3	0.390	0.049	0.055	6.530	0.542	3.906	0.191	0.004
WD8	2.6	0.019	0.019	0.019	0.484	0.040	0.290	0.484	0.012
WD9	2.6	0.019	0.019	0.019	0.484	0.040	0.290	0.484	0.012
YM1	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM2	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM3	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM4	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM5	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM6	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
YM7	1.825	0.020	0.020	0.020	3.072	0.255	1.837	0.248	0.008
Total	**41.9**	**1.604**	**0.894**	**1.029**	**61.8**	**5.83**	**36.49**	**18.42**	**0.140**

APPENDIX

B METEOROLOGY

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APPENDIX B

The CALMET model was run in observation-only mode in the modelling domain (described in Section 6) to generate the meteorological parameters required by CALPUFF. The meteorological data and CALMET output for the modelling period were assessed following the Quality Assurance and Quality Control (QA/QC) procedures outlined in Section 9 of the *British Columbia Air Quality Dispersion Modelling Guideline* (BC AQDMG) (British Columbia Ministry of Environment and Climate Change Strategy, 2022a). A description of the CALMET methods and data sets follows.

B1 CALMET QA/QC

B1.1 Meteorological Data

There is one meteorological station that measures surface and upper air within the CALMET modelling domain used in establishing baseline meteorological conditions, namely:

– Whitehorse A station operated by NAV Canada (WMO ID: 71964).

Table B1-1 below summarizes general information for this surface and upper air meteorological station.

Table B1-1 Summary of Meteorological Station Considered for Baseline Meteorological Conditions

Monitoring Station	Operator	Data Available	Easting (m, UTM Zone 8)	Northing (m, UTM Zone 8)	Elevation (masl*)	Parameters Monitored
Whitehorse Airport station	NAV Canada	December 3, 2012 to present	496180	6730489	706	Temperature, relative humidity, wind direction, wind speed, pressure, visibility, and upper air soundings.

Notes: *Metres above sea level.

The annual and seasonal wind roses shown in Figure B1-1 were generated using observational data from the Whitehorse A station for the period between January 1, 2016, to December 31, 2020. The months included in the seasonal wind roses are according to the BC AQDMG for a latitude of 60°N - 65°N, with Winter 1 and Winter 2 being combined for the winter windrose. The wind roses show that the winds generally correspond with expected wind flows in the region, with the station's wind patterns also accounting for topographical effects on wind near the station.

APPENDIX B

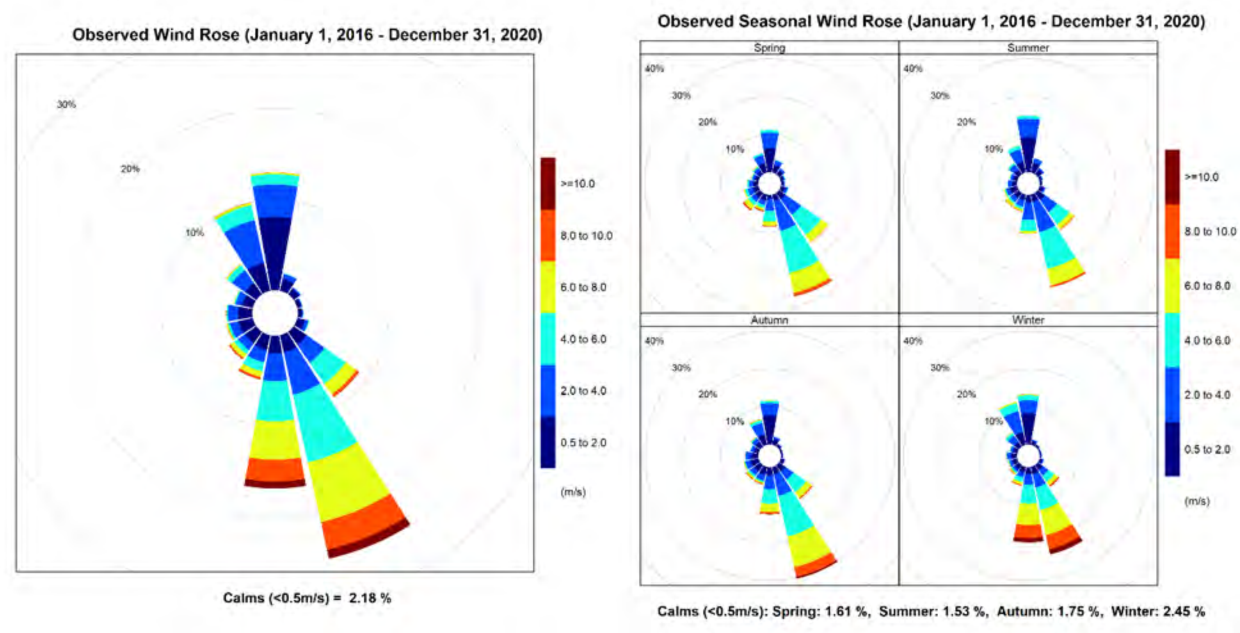


Figure B1-1 Observed Wind Roses at Whitehorse A Station – January 1, 2016 to December 31, 2020

B1.2 CALMET Geophysical Input Data

The data used in the CALMET model for the site and modelling domain is shown in Figures 3 and Figure 6, and the land use data is shown in Figure 8.

B1.3 CALMET Output

Meteorological parameters such as wind, atmospheric stability and mixing height dictate how air contaminants are transported and dispersed in the atmosphere. To evaluate the CALMET meteorological parameters used in the dispersion modelling assessment, key parameters, specifically temperature, wind speed and direction, as well as atmospheric stability and mixing heights, were extracted for the 5-year modelling period at the CALMET grid point representing the location of the Whitehorse Rapids Generating Station. This section presents the summary of the QA/QC results.

B1.3.1 Temperature

Figure B1-2 shows the average monthly surface temperature at the CALMET extracted, representing the location of the Whitehorse Rapids Generating Station. Figure B1-3 shows the average hourly temperature at the same point. Both monthly and diurnal CALMET extracted temperatures fall into anticipated temperature ranges and exhibit expected seasonal and diurnal variations. As prognostic data was not used as input into CALMET, the CALMET results match the observed data.

APPENDIX B

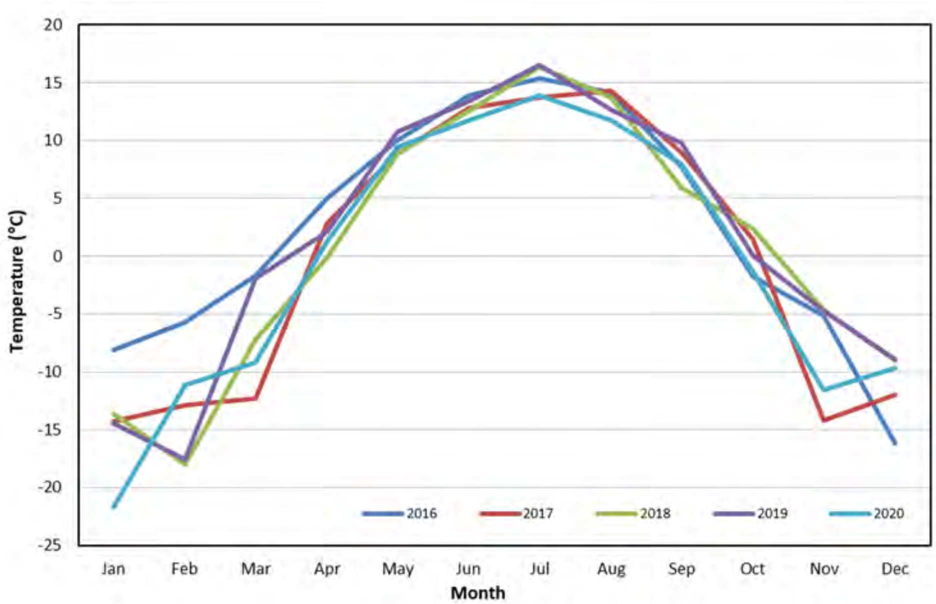


Figure B1-2 Monthly Temperature Variation at Extracted Point from CALMET Domain

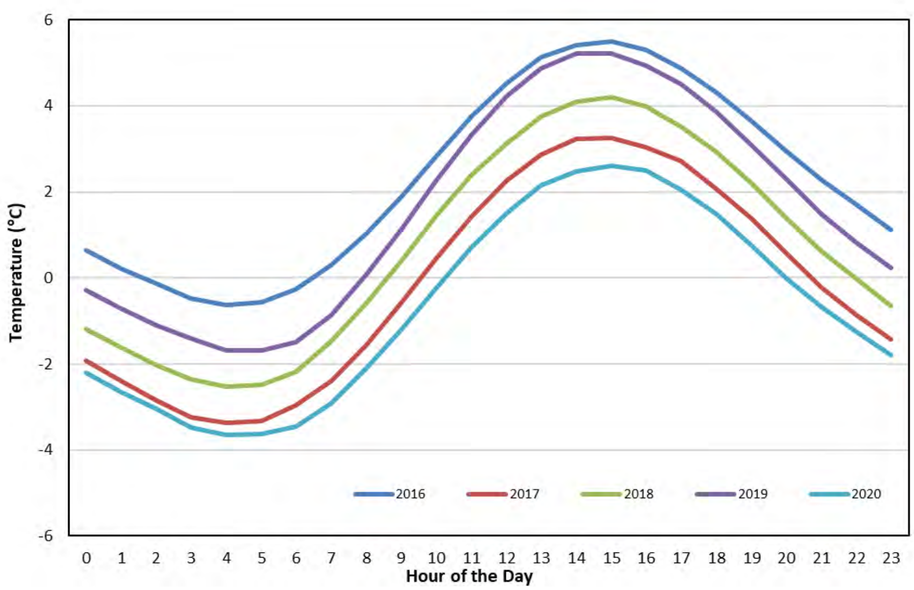


Figure B1-3 Diurnal Temperature Variation at Extracted Point from CALMET

APPENDIX B

B1.3.2 Wind Speed

Representative wind data are required for dispersion modelling, as model predictions will be significantly affected if appropriate data are not utilized. Dispersion model predictions of ground level concentrations at a given point are strongly influenced by wind direction and wind speed.

The frequency distribution of wind speed at the CALMET extracted point is shown below in Figure B1-4. The average monthly and diurnal wind speeds at CALMET extracted point within the modelling domain are shown in Figure B1-5 and in Figure B1-6, respectively.

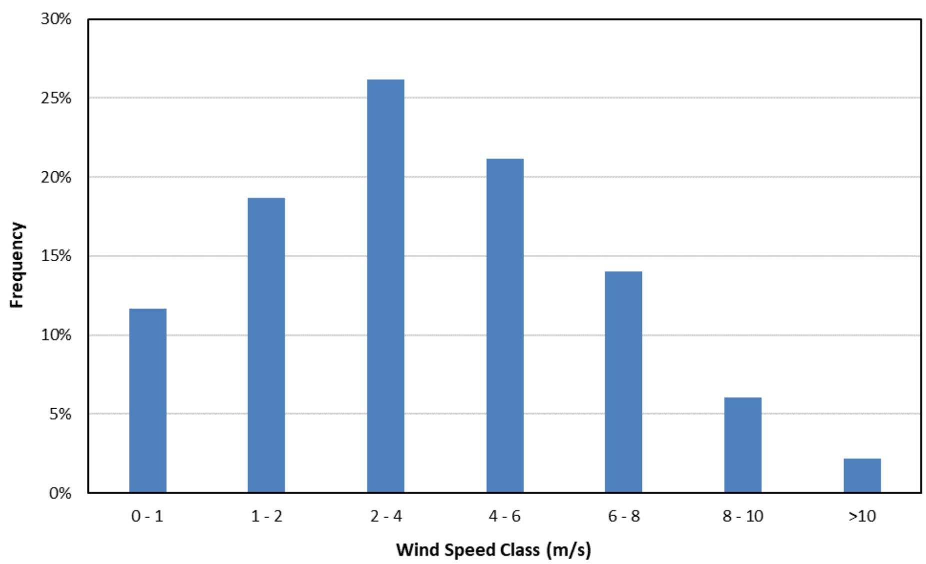


Figure B1-4 Wind Speed Frequency at Extracted Point from CALMET Domain

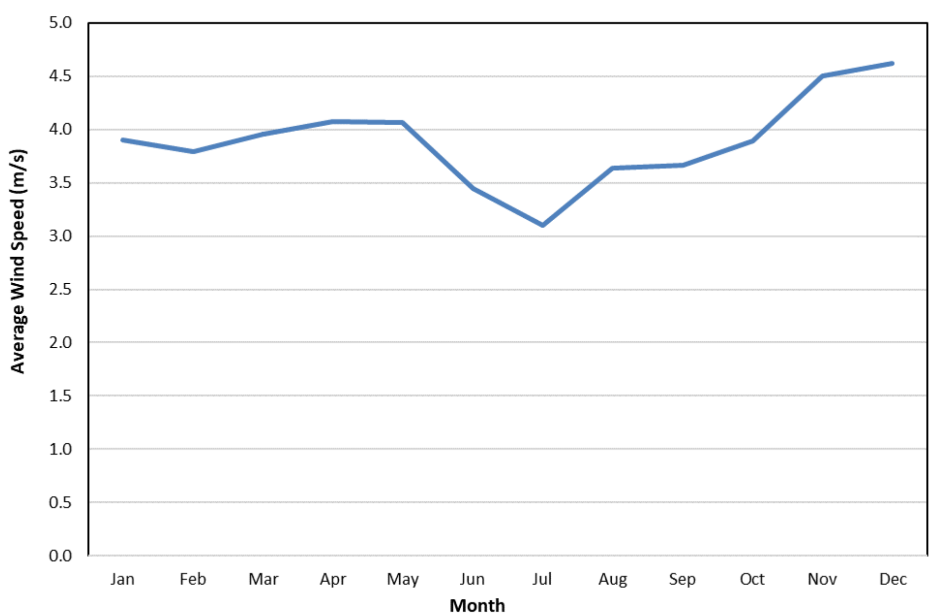


Figure B1-5 Monthly Wind Speed Variation at Extracted Point from CALMET Domain

APPENDIX B

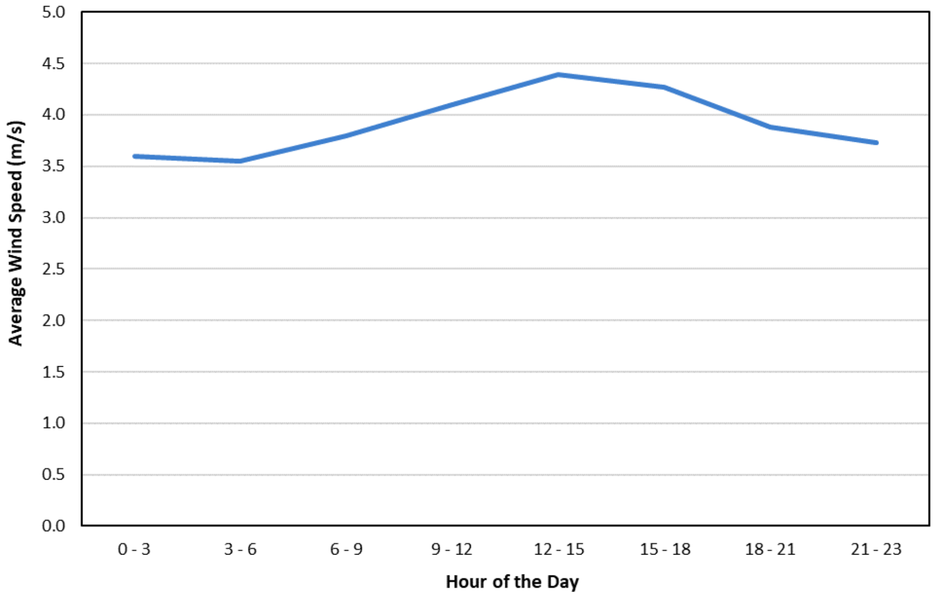


Figure B1-6 Diurnal Wind Speed Variation at Extracted Point from CALMET Domain

B1.3.3 Wind Rose

The following figure (Figure B1-7) shows wind roses for the 5-year modelling period extracted from CALMET at the selected referenced location in the modelling domain. Wind roses generated for the modelling period shows flow patterns expected in this area, with prevailing winds from the south-east direction. This annual wind rose shows fair agreement with the observed wind roses such that south-east winds are predominant (Figure B1-8).

The differences between wind roses generated from observational data and CALMET extracted winds illustrate CALMET's adjustments of the initial guess field based on terrain, land use, and seasonal geophysical parameters.

APPENDIX B

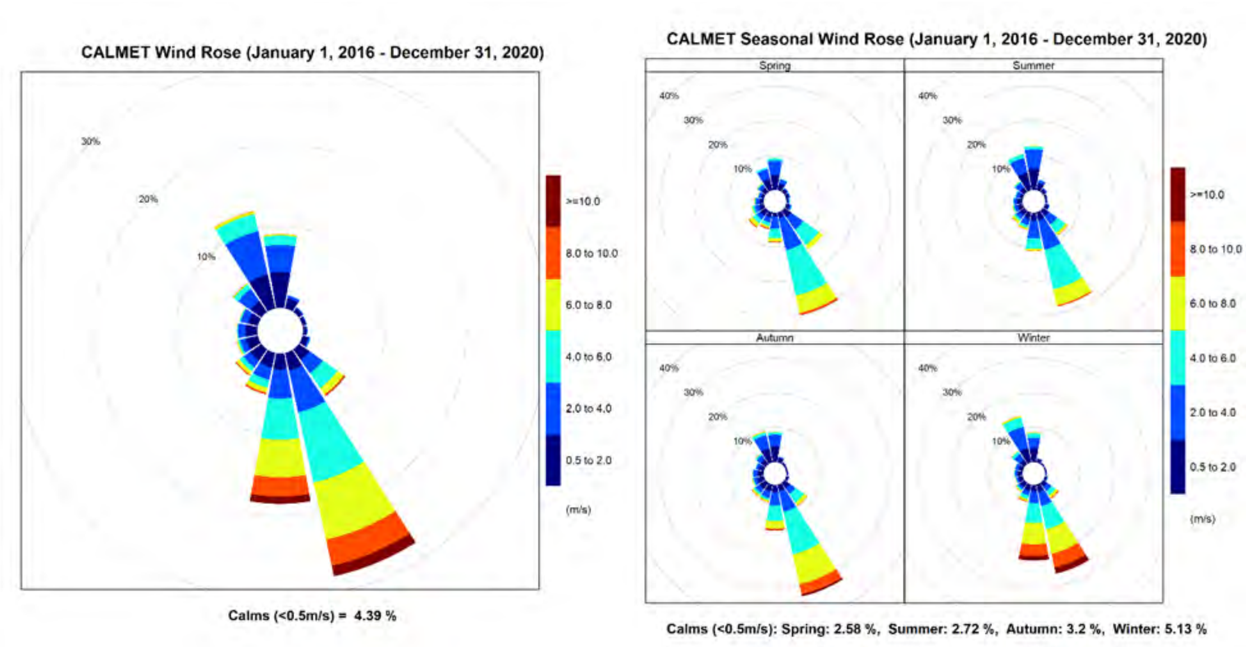


Figure B1-7 CALMET Extracted Wind Rose – January 1, 2016 to December 31, 2020

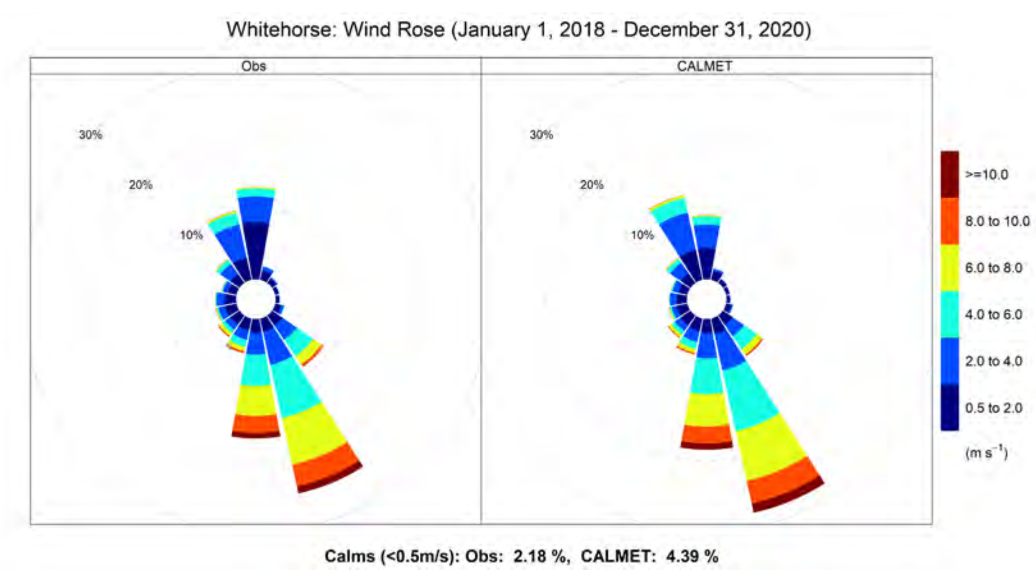


Figure B1-8 Annual Observed and CALMET Extracted Wind Roses Comparison – January 1, 2016 to December 31, 2020

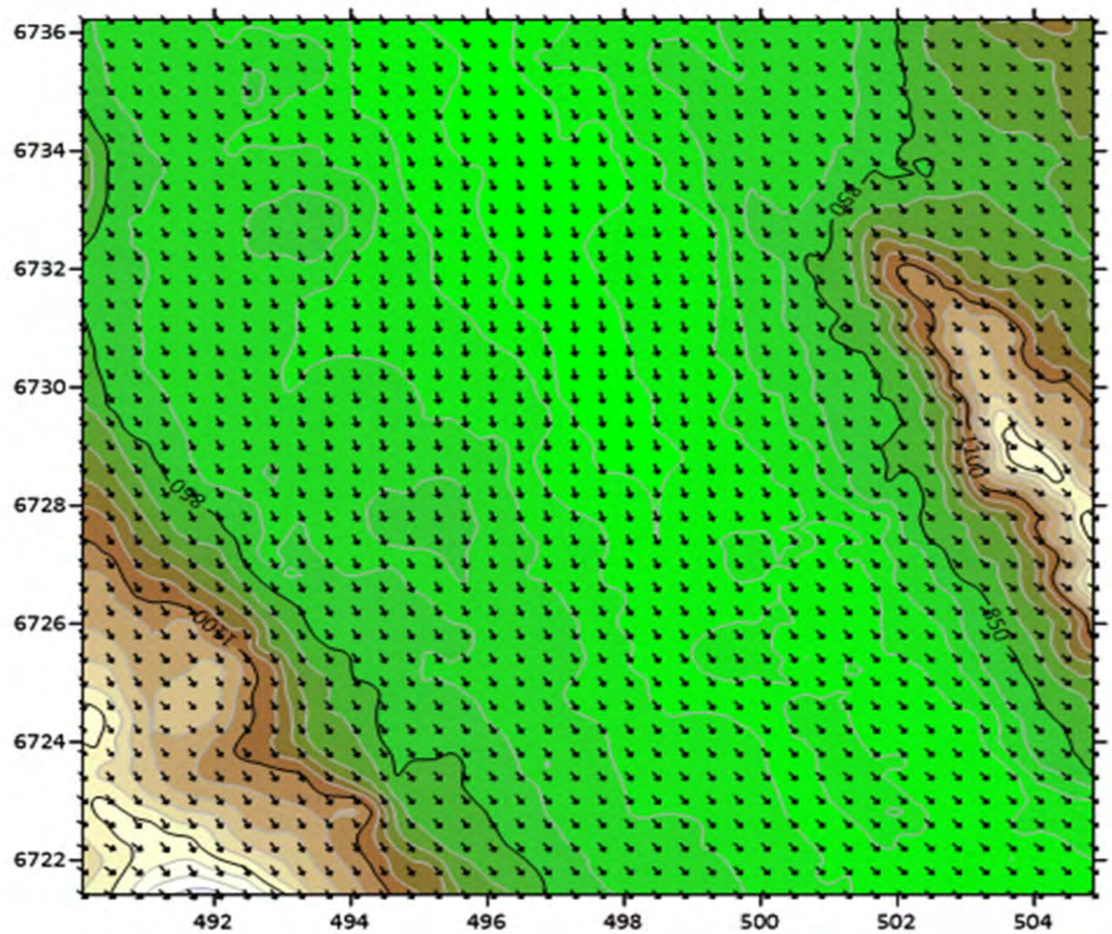
APPENDIX B

B1.3.4 Wind Fields

Representative CALMET wind fields at the surface, mid, and top vertical CALMET layers for the modelling domain are presented in this section for select summer (Figure B1-9 through Figure B1-11) and winter (Figure B1-12 to Figure B1-14) 1-hour periods in which thermally driven flows would be expected.

The wind fields representing daytime meteorological conditions in the summer show flow patterns expected from thermally driven flows during that time characterized by terrain channelling, upslope winds, unstable conditions, and higher wind speeds. The winter wind fields were extracted during relatively calm and stable nighttime conditions and showed expected downslope flows.

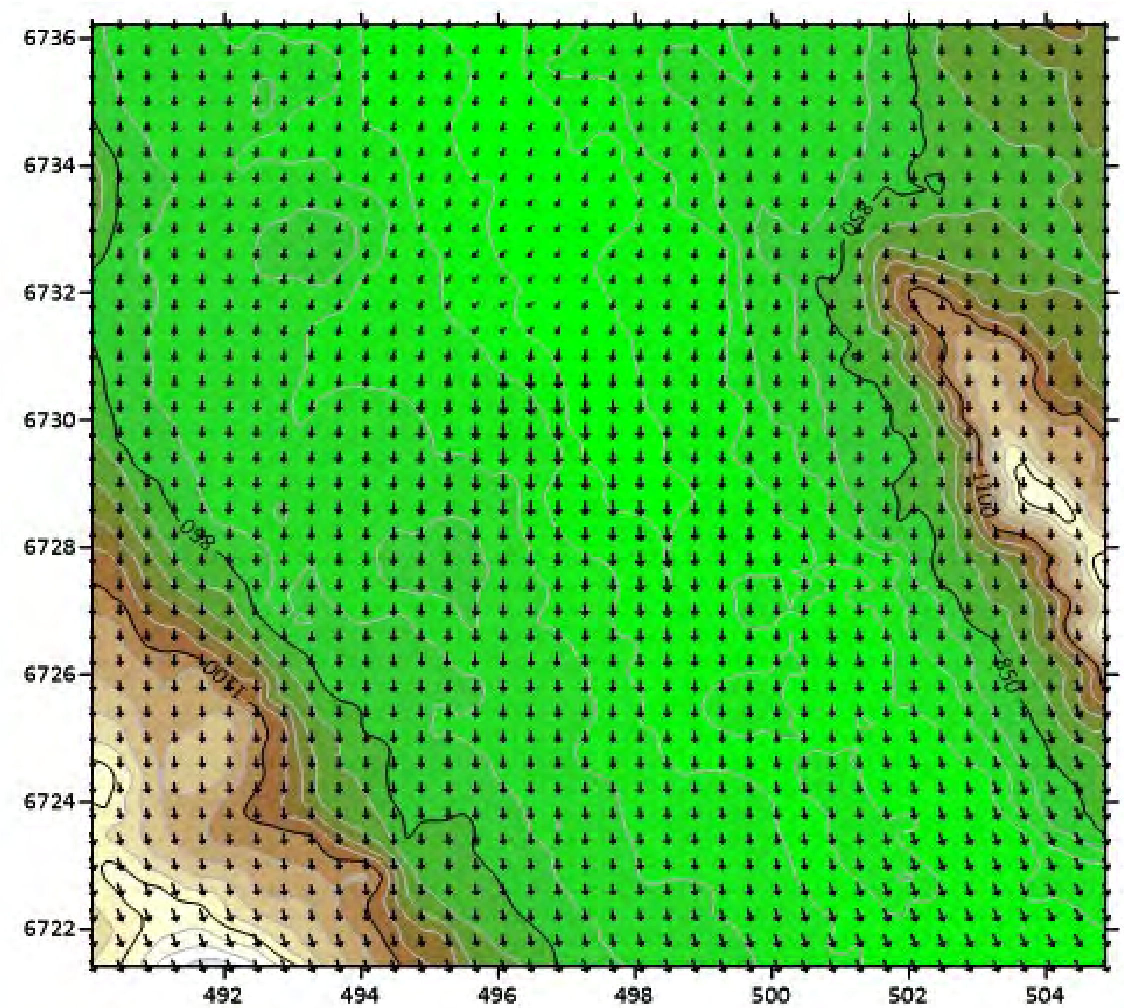
Wind field plots for the selected periods indicate that at the surface, CALMET resolves terrain effects and produces reasonable wind fields. CALMET winds in the layers aloft tend to be more uniform with higher wind speeds.



Scale of Wind Arrows	
Minimum: 1.15 m/s (0.05 inches)	Maximum: 5 m/s (0.15 inches)

Figure B1-9 CALMET Wind Field Plot for the Surface Level on July 20, 2018 at 12:00 within the Modelling Domain

APPENDIX B



Scale of Wind Arrows	
Minimum: 1.15 m/s (0.05 inches)	Maximum: 5.5 m/s (0.15 inches)

Figure B1-10 CALMET Wind Field Plot for the Mid Level on July 20, 2018 at 12:00 within the Modelling Domain

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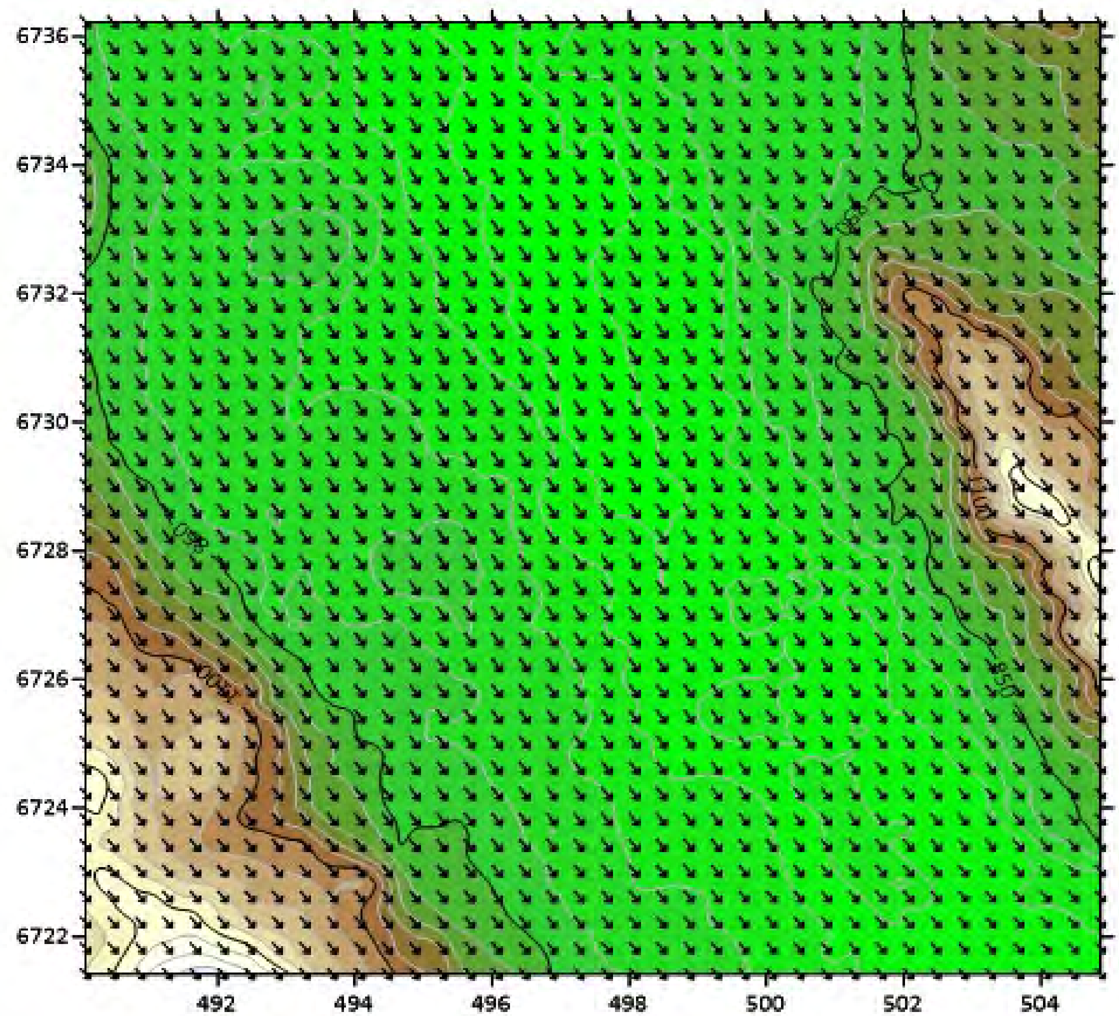

Scale of Wind Arrows	
Minimum: 1.15 m/s (0.05 inches)	Maximum: 5.5 m/s (0.15 inches)

Figure B1-11 CALMET Wind Field Plot for the Top Level on July 20, 2018 at 12:00 within the Modelling Domain

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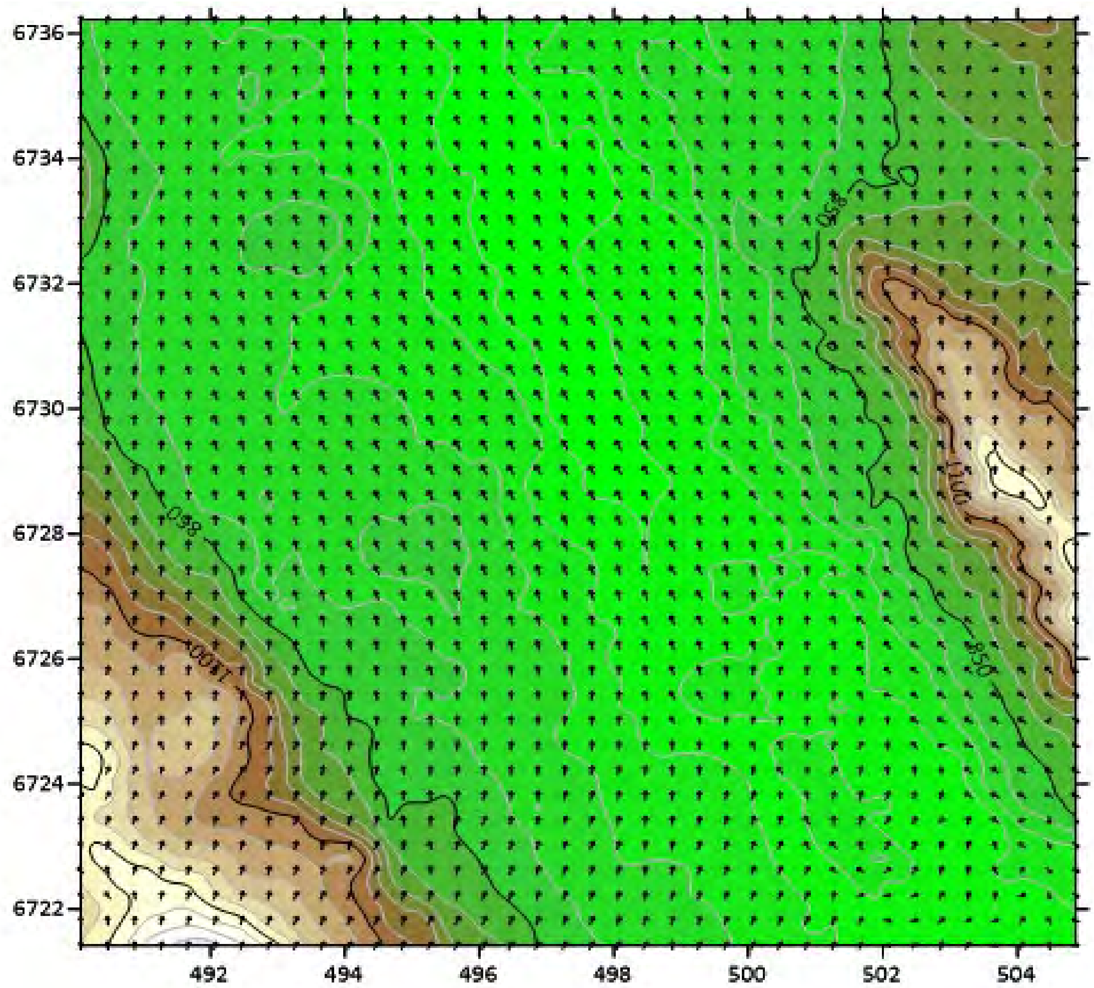

Scale of Wind Arrows	
Minimum: 0.1 m/s (0.05 inches)	Maximum: 6.32 m/s (0.15 inches)

Figure B1-12 CALMET Wind Field Plot for the Surface Level on January 30, 2016 at 03:00 within the Modelling Domain

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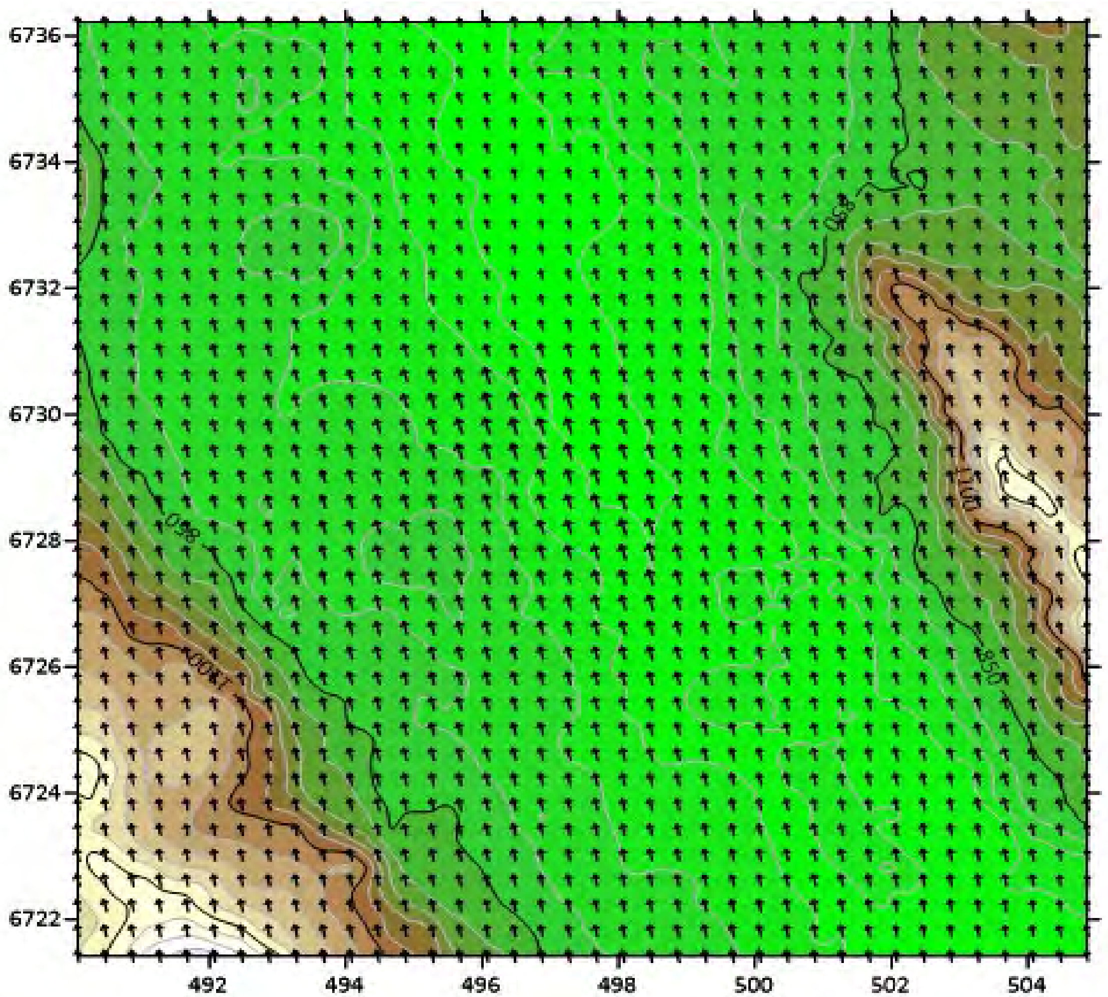

Scale of Wind Arrows	
Minimum: 0.1 m/s (0.05 inches)	Maximum: 6.32 m/s (0.15 inches)

Figure B1-13 CALMET Wind Field Plot for the Mid Level on January 30, 2016 at 03:00 within the Modelling Domain

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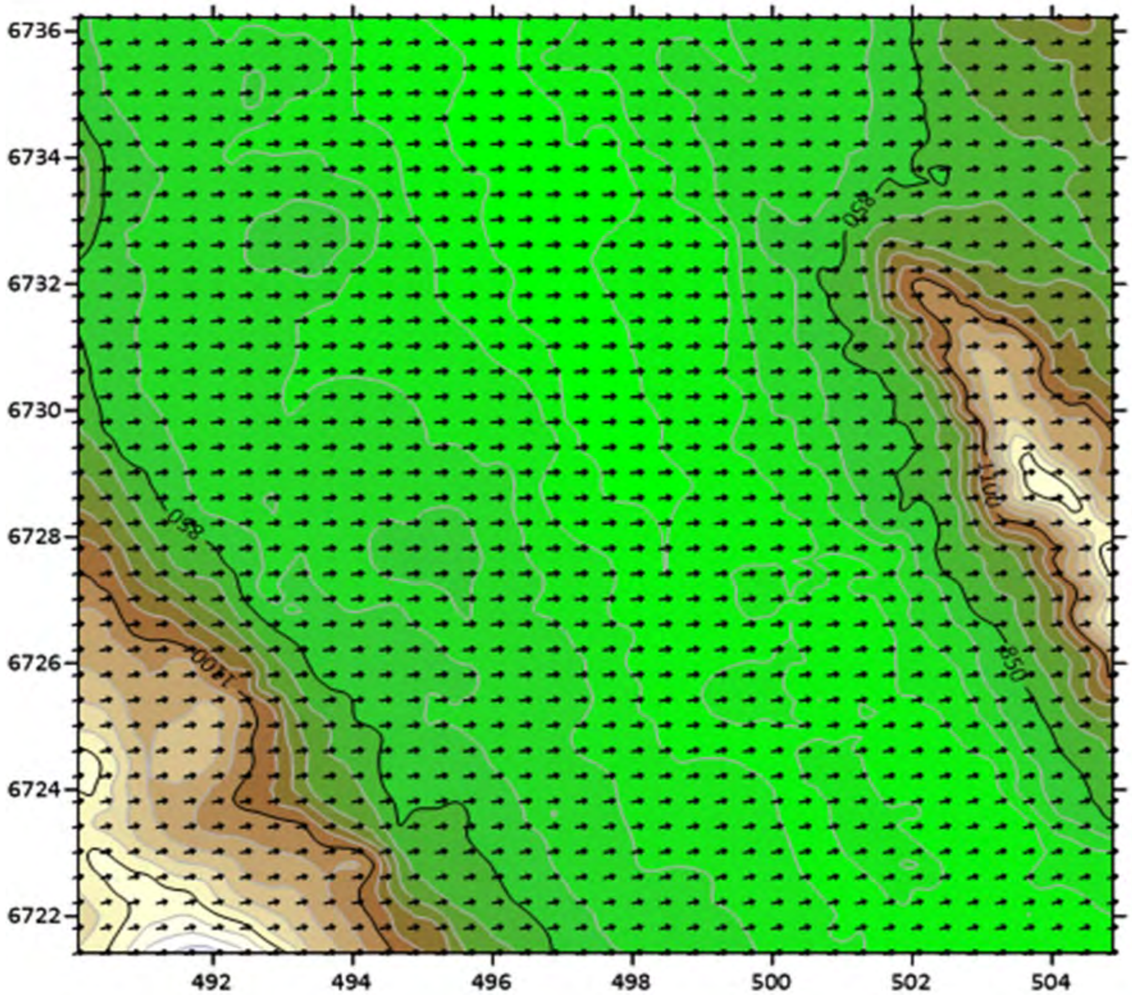

Scale of Wind Arrows	
Minimum: 0.1 m/s (0.05 inches)	Maximum: 6.32 m/s (0.15 inches)

Figure B1-14 CALMET Wind Field Plot for the Top Level on January 30, 2016 at 03:00 within the Modelling Domain

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B1.3.5 Stability Classes

Atmospheric stability represents the degree to which the atmosphere resists turbulence and vertical motion. Stability classes, as a means to describe atmospheric stability, were extracted from CALMET output to provide an indication of the atmospheric turbulence in the planetary boundary layer in the modelling domain. The stability classes range from unstable (Classes 1 and 2) through neutral (Classes 3 and 4) to stable (Classes 5 and 6). Generally, unstable conditions are associated with daytime thermal turbulence, while stable conditions are primarily associated with nighttime surface cooling, which produces temperature inversions and suppresses turbulence at lower levels. Neutral conditions are mostly associated with high wind speeds and/or overcast sky conditions.

The frequency distribution of predicted stability classes over the entire 5-year modelling period at CALMET extracted point in the modelling domain is shown in Figure B1-15, which shows higher occurrences of neutral (stability class 4) conditions. The distribution of diurnal atmospheric stability classes is shown in Figure B1-16, which shows expected diurnal atmospheric stability patterns in the modelling domain, with neutral and stable conditions occurring during nighttime hours and unstable and neutral conditions occurring during daytime.

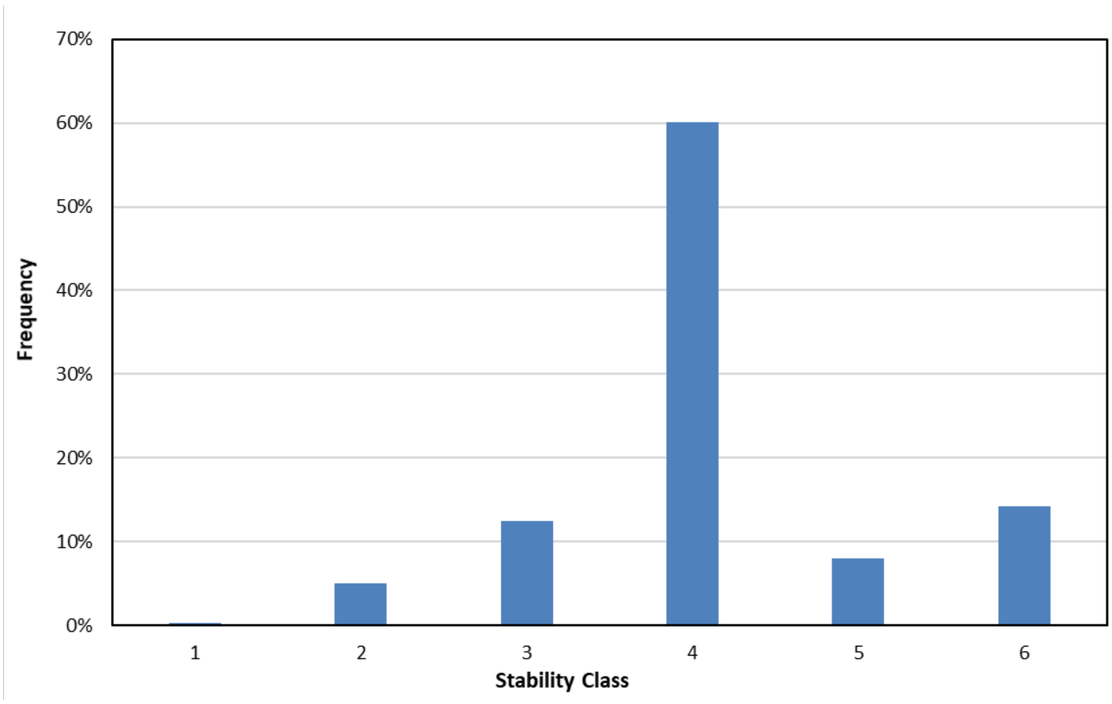

Figure B1-15 Frequency Distribution of Stability Classes from CALMET Extracted Point within the Modelling Domain (2016 – 2020)

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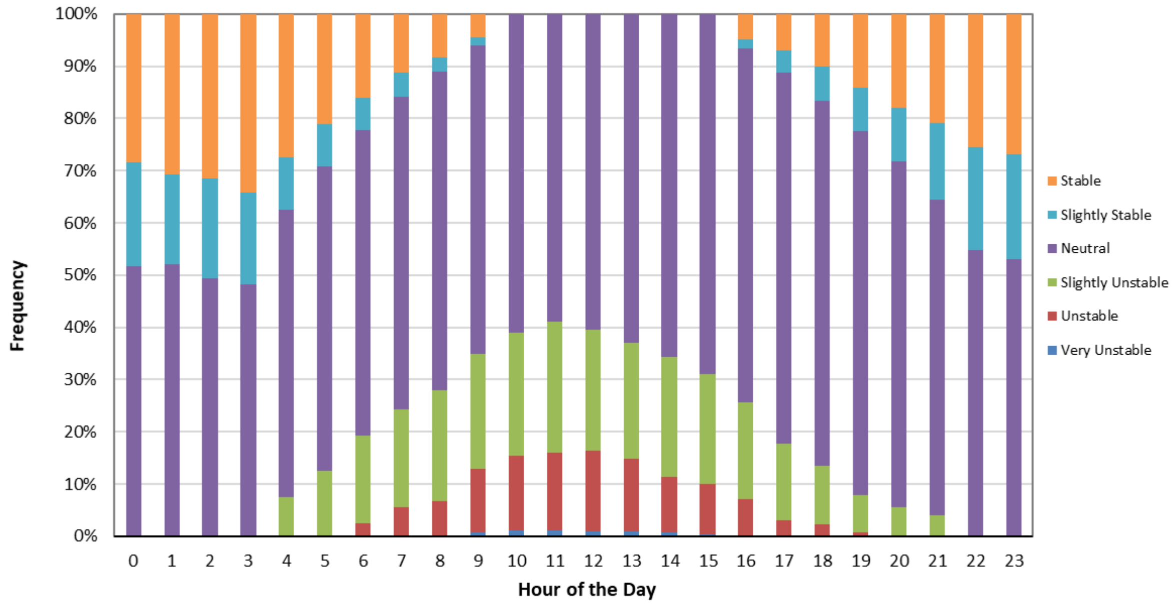

Figure B1-16 CALMET Extracted Diurnal Stability Class Distribution (2016 – 2020)

B1.3.6 Mixing Heights

Predicted atmospheric mixing height statistics from CALMET are shown in Figure B1-17 through Figure B1-19 for the CALMET extracted points within the modelling domain representing the facility and the surface station shown in Table 1 1. Figure B1-17 shows the monthly mixing height variations. Figure B1-18 shows the diurnal mixing height variation, with the expected trend of higher mixing heights throughout the daytime compared to the nighttime. Figure B1-19 shows the frequency distribution over the 5-year modelling period of all the mixing heights predicted by the CALMET model at the Station and surface station (extracted).

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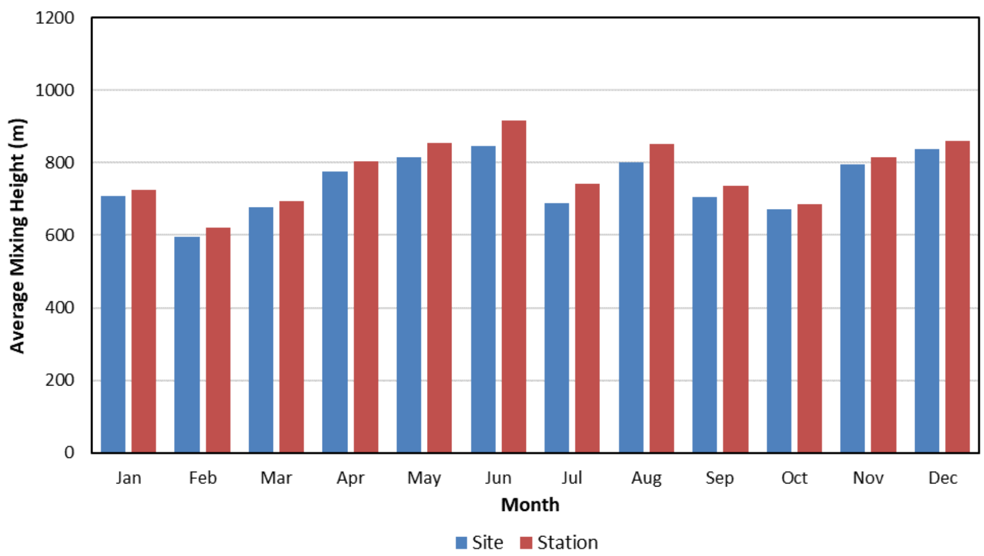

Figure B1-17 CALMET Extracted Monthly Mixing Height Variation at the Facility and the Surface Station Location (extracted)

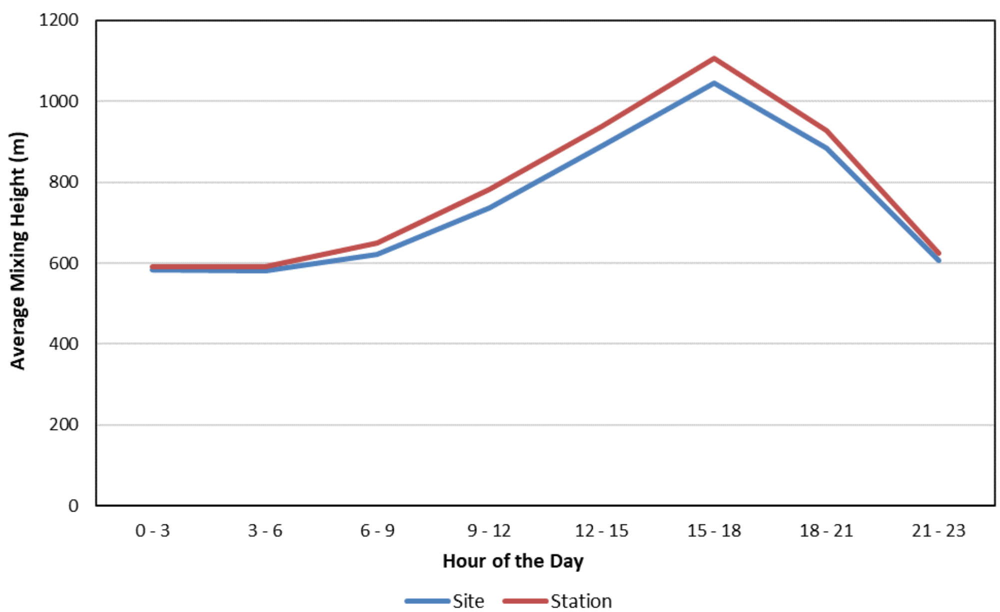

Figure B1-18 CALMET Extracted Diurnal Mixing Height Variation at the Facility and the Surface Station Location (extracted)

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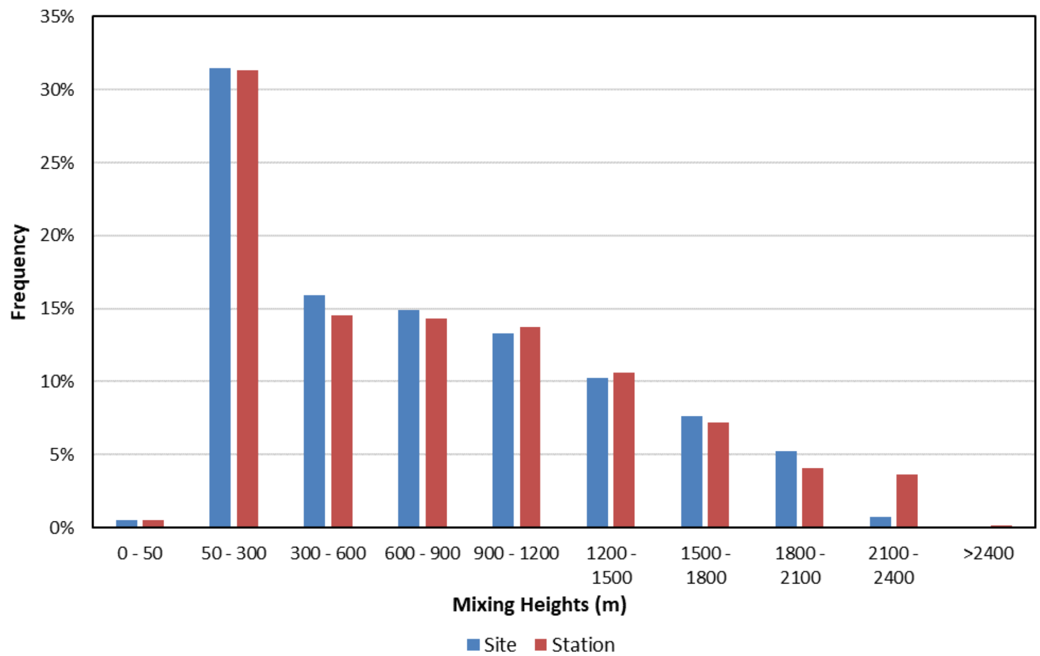

Figure B1-19 CALMET Extracted Mixing Height Frequency Distribution at the Facility and the Surface Station Location (extracted)

B2 CALMET METHODOLOGY

B2.1 CALMET Input Switches

The CALMET model has a number of user-specified input switches and options that determine how the model handles terrain effects, interpolation of observational input data, etc. The differences in the modelled and measured meteorological fields were examined, and this analysis was used to determine which model options were appropriate for the modelling period.

Table B2-1 provides the user-specified input switches used for the CALMET modelling.

Table B2-1 Selected CALMET Model Options

CALMET Model Option	Parameter	Option Selected	AQDMG Default
Determines whether observation data are used, or in combination with NWP model output or NWP data only	NOOBS	0 (Observation Only Mode)	No default
Cloud Data Option: 1,2,3,4	MCLOUD	1	✓
Wind field model selection variable	IWFCOD	1 (Yes)	✓
Compute Froude number adjustment effects?	IFRADJ	1 (Yes)	✓

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CALMET Model Option	Parameter	Option Selected	AQDMG Default
Compute kinematic effects?	IKINE	0 (No)	✓
Use O'Brien procedure for adjustment of the vertical velocity?	IOBR	0 (No)	✓
Compute slope flows?	ISLOPE	1 (Yes)	✓
Extrapolate surface wind observations to upper layers?	IEXTRP	-4	✓
Extrapolate calm winds aloft?	ICALM	0 (No)	✓
Layer-dependent biases	BIAS	-1, -1, -0.5, -0.3, 0, 0, 0, 0, 0, 0	No default
Minimum distance between upper air station and surface station for which extrapolation of surface winds will be allowed	RMIN2	-1 (Set to -1 for IEXTRP = +/- 4)	✓
Gridded prognostic wind field model output fields	IPROG	0 (No)	✓
Time step (hrs) of the NWP output used as input data	ISTEPPGS	3600	✓
Use coarse CALMET fields as initial guess fields?	IGFMET	0	✓
Use varying radius of influence?	LVARY	T (only one surface station has to cover entire domain)	✓
Maximum radius of influence over land of the surface layer	RMAX1	5.0	No default
Maximum radius of influence over land aloft	RMAX2	10.0	No default
Maximum radius of influence over water	RMAX3	Unused	No default
Minimum radius of influence used in the wind field interpolation	RMIN	0.1	✓
Radius of influence of terrain features	TERRAD	5	No default
Distance from a surface station at which the station observations and 1st guess field are equally weighted	R1	5.0	No default
Distance from an upper air station at which the observations and 1st guess field are equally weighted	R2	10.0	No default
Relative weighting of the prognostic wind field data	RPROG	0	No default
Maximum acceptable divergence in the divergence minimum procedure.	DIVLIM	$5*10^{-6}$	✓
Maximum number of iterations in the divergence minimum procedure.	NITER	50	✓

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CALMET Model Option	Parameter	Option Selected	AQDMG Default
Number of passes in the smoothing procedure	NSMTH	2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 0, 0	✓
Maximum number of stations used in each layer for the interpolation of data to a grid point	NINTR2	99, 99, 99, 99, 99, 99, 99, 99, 99, 99, 0, 0	✓
Critical Froude number	CRITFN	1	✓
Empirical factor controlling the influence of kinematic effects	ALPHA	0.1	✓
Multiplicative scaling factor for extrapolation of surface observations to upper layers	FEXTR2	Unused	✓
Number of barriers to interpolation of the wind fields	NBAR	0	✓
Level (1 to NZ) up to which barriers apply.	KBAR	10	✓
X and Y coordinates of barriers	XBBAR, YBBAR, XEBAR, YEBAR	Unused	✓
Diagnostic module surface temperature option	IDIOPT1	0 (Compute internally from hourly surface observations or prognostic fields)	✓
Diag module sfc station to use for the sfc temp (stn ID).	ISURFT	-1 (2-D spatially varying surface temperatures)	✓
Diagnostic module domain-averaged lapse rate option	IDIOPT2	0 (Compute internally from (at least) twice-daily upper air observations or prognostic fields	✓
Diagnostic module upper air station to use for lapse rate to use	IUPT	1	✓
Depth through which the domain-scale lapse rate is computed	ZUPT	200	✓
Initial guess field wind components	IDIOPT3	0	✓
Upper air station to use for domain-scale winds	IUPWND	1	✓
Bottom and top of layer through which the initial guess winds are computed	ZUPWND	Unused	✓
Observed surface wind components for wind field module.	IDIOPT4	0 (Read wind speed and wind direction from a surface data file (SURF.DAT). DIAG.DAT not used.)	✓
Observed upper air wind components	IDIOPT5	0 (Read WS, WD from an upper air data file).	✓
Use Lake Breeze Module?	LLBREZE	F (No, do not use Lake Breeze Module)	✓
# of boxes defining region	NBOX	Unused	✓

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CALMET Model Option	Parameter	Option Selected	AQDMG Default
X Grid line 1 defining the region of interest X Grid line 2 defining the region of interest	XG1, XG2	Unused	✓
Y Grid line 1 defining the region of interest Y Grid line 2 defining the region of interest	YG1, YG2	Unused	✓
X Point defining the coastline (straight line)	XBCST	Unused	✓
Y Point defining the coastline (straight line)	YBCST	Unused	✓

APPENDIX

C CALPUFF DISPERSION MODEL TECHNICAL DETAILS

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The CALPUFF (Version 7.2.1) model was used for this assessment. The application of the CALPUFF dispersion model was in accordance with the *British Columbia Air Quality Dispersion Modelling Guideline* (BC AQDMG) (British Columbia Ministry of Environment and Climate Change Strategy, 2022a) and the *British Columbia Nitrogen Dioxide Modelling Guidance* (BC NDMG) (British Columbia Ministry of Environment and Climate Change Strategy, 2022b). This appendix provides additional technical details of the CALPUFF model used for the Yukon Energy Corporation Whitehorse Rapids Generating Station air quality assessment.

C1 MODEL APPLICATION

C1.1 Modelling Domain and Study Area

The CALPUFF model requires the user to define a computation domain (also referred to as the modelling domain). Predictions of air contaminant concentrations for receptors were made within the modelling domain. The CALPUFF modelling domain was set to a 10 km × 10 km centred on the Station.

The CALPUFF domain coordinates are as shown in Table C1-1 and sown on Figure 1.

Table C1-1 Coordinates of CALPUFF Domain

Domain Corners	Universal Transverse Mercator	
	Easting (m)	Northing (m)
Southwest	489970	6721319
Northwest	489970	6736319
Northeast	504970	6736319
Southeast	504970	6721319

Notes: Universal Transverse Mercator Zone 8, North American Datum 83.

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C1.2 Model Configuration

The air dispersion modelling included the following features:

- For the *Expected Scenario*, to account for the worst-meteorological conditions during the 5-year (2016-2020) modelling period, the permanent generators were conservatively modelled at full capacity for all hours. A second variation was modelled where the 2 permanent diesel generators are swapped out for 2 mobile natural gas generators each hour from December 1 to April 30. The typical operation is:
  - permanent natural gas units: All three units are used in the winter from December through April; in the shoulder months (May and November), typically only one unit is used.
  - new Tier 4 permanent diesel generators: these two units will only run in the winter (December through April) and will not run continuously. During those months, the units would run for approximately 24 hours (nonconsecutively) within a two-week period.
  - permanent diesel generators or temporary mobile diesel generators: Only two of these units are run at one time, only during the winter (December to April), and they would not run continuously. During those months, the units would run for approximately six hours (nonconsecutively) within a two-week period.
- For the *Emergency (N-1) Scenario*, permanent generators were conservatively modelled at full capacity for all hours, and the mobile natural gas generators were conservatively modelled each hour from December 1 to April 30 to account for the worst-meteorological conditions during the 5-year (2016-2020) modelling period, instead of the estimate by Yukon Energy that the N-1 event would occur only when the ambient temperature is colder than -30°C for a cumulative total of one to five days during a two week period, and based on historical data only occurring once in 20 years.

In addition to the *Expected Scenario* and *Emergency (N-1) Scenario*, all thermal units are operated for short periods (1-2 hours) on a monthly basis throughout the year for maintenance/operational readiness purposes. Since there are very short term non-continuous events, the maintenance operations were not included as a scenario in the modelling.

C2 MODEL OPTIONS

The CALPUFF control file has 20 input groups, as listed in Table C2-1. For many of the options, default values are used, except those recommended in the BC AQDMG (British Columbia Ministry of Environment and Climate Change Strategy, 2022a). Table C2-2 to Table C2-5 identify the input parameters, the default options, and the values used for the assessment.

Table C2-1 CALPUFF Input Groups

Input Group	Description	Applicable to Project
0	Input and Output File Names	Yes
1	General run control parameters	Yes
2	Technical options	Yes

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Input Group	Description	Applicable to Project
3	Species list	Yes
4	Map Projection and Grid control parameters	Yes
5	Output Options	Yes
6	Subgrid scale complex terrain inputs	No
7	Chemical parameters for dry deposition of gases	No
8	Size parameters for dry deposition of particles	No
9	Miscellaneous dry deposition parameters	No
10	Wet Deposition Parameters	No
11	Chemistry Parameters	No
12	Misc. Dispersion and Computational Parameters	Yes
13	Point source parameters	Yes
14	Area source parameters	No
15	Line source parameters	No
16	Volume source parameters	No
17	FLARE source control parameters (variable emissions file)	No
18	Road Emissions parameters	No
19	Emission rate scale-factor tables	Yes (mobile units)
20	Non-gridded (discrete) receptor information	Yes

Table C2-2 Selected CALPUFF Model Options

CALPUFF Model Option	Parameter	Option Selected	AQDMG Default
Vertical distribution used in the near field	MGAUSS	1 (Gaussian)	✓
Terrain adjustment method	MCTADJ	3 (Partial plume path adjustment)	✓
Subgrid-Scale complex terrain flag	MCTSG	0 (Not Modelled)	✓
Near-field puffs modelled as elongated?	MSLUG	0 (No)	✓
Transitional Plume Rise modelled?	MTRANS	1 (Yes)	✓
Stack-tip downwash?	MTIP	1 (Yes)	✓
Method selected to compute plume rise for point sources not subject to downwash	MRISE	1 (Briggs plume rise)	✓
Apply stack-tip downwash to FLARE sources?	MTIP_FL	0 (No)	✓
Plume rise module for FLARE sources	MRISE_FL	2 (Numerical rise module)	✓
Method used to simulate building downwash?	MBDW	2 (Prime)	✓
Vertical wind shear modelled above stack top?	MSHEAR	0 (No)	✓
Puff splitting allowed?	MSPLIT	0 (No)	✓

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CALPUFF Model Option	Parameter	Option Selected	AQDMG Default
Chemical Transformation Scheme?	MCHEM	0 (Not Modelled)	✓
Aqueous phase transformation flag (only used in MCHEM =1 or 3)	MAQCHEM	Unused	✓
Liquid Water Content flag	MLWC	Unused	✓
Wet removal modelled?	MWET	0 (No)	✓
Dry deposition modelled?	MDRY	0 (No)	✓
Gravitational settling (plume tilt)?	MTILT	0 (Plume Tilt Not Modelled)	✓
Method used to compute dispersion coefficients	MDISP	2 (Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.)	✓
Sigma measurements used?	MTURBVW	Unused	✓
Back-up method used to compute dispersion when measured turbulence data are missing	MDISP2	Unused	✓
Method used for Lagrangian time scale for σy	MTAULY	0 (Lagrangian time scale (617.284s))	✓
Advective-Decay timescale for turbulence	MTAUADV	0 (No Turbulence Advection)	✓
Method used to compute turbulence σv and σw profiles	MCTURB	1 (Use Standard CALPUFF Routines)	✓
PG sigma y,z adjusted for roughness?	MROUGH	0 (No)	✓
Partial plume penetration of elevated inversion?	MPARTL	1 (Yes)	✓
Partial plume penetration from buoyant area sources?	MPARTLBA	1 (Yes)	✓
Strength of temperature inversion provided in PROFILE.DAT extended records?	MTINV	0 (No)	✓
Probability Distribution Function used for dispersion under convective conditions?	MPDF	1 (Yes)	✓
Sub-grid TIBL module used for shore line?	MSGTIBL	0 (No)	✓
Boundary conditions (concentration) modelled?	MBCON	0 (No)	✓
Individual source contributions saved?	MSOURCE	0 (No)	✓
Configure for FOG Model output?	MFOG	0 (No)	✓
Test options specified to see if they conform to regulatory values?	MREG	0 (No)	✓
Minimum turbulence velocities, sigma v and sigma w for each stability class over land and water	SVMIN, SWMIN	CALPUFF Defaults	✓

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Table C2-3 Input Group 3a - Species List

CSPEC	Modelled (0=no, 1=yes)	Emitted (0=no, 1=yes)	Dry deposition (0=none, 1=computed gas, 2=computed particle, 3=user-specified)	Output group Number (0=None, 1=1st CGRUP, 2=2nd CGRUP, 3= etc.)
CO	1	1	0	0
NO_X	1	1	0	0
NO_2	1	1	0	0
NO	1	1	0	0
SO_2	1	1	0	0
TSP	1	1	0	0
PM_{10}	1	1	0	0
$PM_{2.5}$	1	1	0	0

Table C2-4 Input Group 4 - Map Projection and Grid Control Parameters

Parameter	Default	Project	Description
PMAP	UTM	UTM	Map projection: Universal Transverse Mercator
FEAST	0.0	Not used	False Easting (km) at the projection origin
FNORTH	0.0	Not used	False Easting (km) at the projection origin
IUTMZN	-	8	UTM Zone (1 to 60)
UTMHEM	N	N	Northern hemisphere UTM projection
RLAT0	-	Not used	Latitude (decimal degrees) of projection origin
RLON0	-	Not used	Longitude (decimal degrees) of projection origin
XLAT1	-	Not used	Matching parallel(s) of latitude (decimal degrees) for projection
XLAT2	-	Not used	Matching parallel(s) of latitude (decimal degrees) for projection
DATUM	WGS-84	NAR-C	NIMA Datum Region - Canada
NX	-	75	Number of X grid cells in meteorological grid
NY	-	75	Number of Y grid cells in meteorological grid
NZ	-	12	Number of vertical layers in meteorological grid
DGRIDKM	-	0.2	Grid spacing (km)
ZFACE	-	.0, 20.0, 40.0, 60.0, 80.0, 100.0, 150.0, 200.0, 500.0, 1000.0, 1500.0, 2200.0, 3000.0	Cell face heights in meteorological grid (m) – same as CALMET
XORIGKM	-	489.96967	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)

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Parameter	Default	Project	Description
YORIGKM	-	6721.31896	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
IBCOMP	-	1	X index of lower left corner of the computational grid
JBCOMP	-	1	Y index of lower left corner of the computational grid
IECOMP	-	75	X index upper right corner of the computational grid
JECOMP	-	75	Y index upper right corner of the computational grid
LSAMP	T	F	Sampling grid is not used
IBSAMP	-	Not used	X index of lower left corner of the sampling grid
JBSAMP	-	Not used	Y index of lower left corner of the sampling grid
IESAMP	-	Not used	X index of upper right corner of the sampling grid
JESAMP	-	Not used	Y index of upper right corner of the sampling grid
MESHDN	1	Not used	Nesting factor of the sampling grid

Table C2-5 Input Group 12 - Misc. Dispersion and Computational Parameters

Parameter	Default	Project	Description
SYTDEP	550	550	Horizontal size of a puff in metres beyond which the time dependant dispersion equation of Heffter is used
MHFTSZ	0	0	Do not use Heffter formulas for sigma z
JSUP	5	5	Stability class used to determine dispersion rates for puffs above boundary layer
CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
CONK2	0.1	0.1	Vertical dispersion constant for neutral/stable conditions
TBD	0.5	0.5	Use ISC transition point for determining the transition point between the Schulman-Scire to Huber-Snyder Building Downwash scheme
IURB1	10	10	Lower range of land use categories for which urban dispersion is assumed
IURB2	19	19	Upper range of land use categories for which urban dispersion is assumed
XMXLEN	1.0	1.0	Maximum length of emitted slug in meteorological grid units

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Parameter	Default	Project	Description
XSAMLEN	1.0	1.0	Maximum travel distance of slug or puff in meteorological grid units during one sampling unit
MXNEW	99	99	Maximum number of puffs or slugs released from one source during one-time step
MXSAM	99	99	Maximum number of sampling steps during one-time step for a puff or slug
NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise
SYMIN	1.0	1.0	Minimum sigma y for a new puff/slug (m)
SZMIN	1.0	1.0	Minimum sigma z for a new puff/slug (m)
SZCAP_M	5,000,000	5,000,000	Maximum sigma z (m) allowed to avoid numerical problem in calculating virtual time or distance.
CDIV	0.0,0.0	0.0,0.0	Divergence criteria for dw/dz in met cells
NLUTIBL	4	4	Search radius for nearest land and water cells
WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions (m/s)
XMAXZI	3,000.0	3,000.0	Maximum mixing height in metres
XMINZI	50.0	50.0	Minimum mixing height in metres
WSCAT	1.54	1.54	wind speed category 1 (m/s)
	3.09	3.09	wind speed category 2 (m/s)
	5.14	5.14	wind speed category 3 (m/s)
	8.23	8.23	wind speed category 4 (m/s)
	10.80	10.80	wind speed category 5 (m/s)

Parameters				
Stability Class	Parameter			
	SVMIN (land, water)		SWMIN (land, water)	
	Minimum turbulence (σv) (m/s)		Minimum turbulence (σw) (m/s)	
	Default	**Current**	**Default**	**Current**
A	0.50, 0.37	0.50, 0.37	0.20, 0.20	0.20, 0.20
B	0.50, 0.37	0.50, 0.37	0.12, 0.12	0.12, 0.12
C	0.50, 0.37	0.50, 0.37	0.08, 0.08	0.08, 0.08
D	0.50, 0.37	0.50, 0.37	0.06, 0.06	0.06, 0.06
E	0.50, 0.37	0.50, 0.37	0.03, 0.03	0.03, 0.03
F	0.50, 0.37	0.50, 0.37	0.016, 0.016	0.016, 0.016
Stability Class	Parameter			
	PLX0		PPC	
	Wind speed profile exponent		Plume path coefficient	

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Parameter	Default	Project	Description	
	Default	Current	Default	Current
A	0.07	0.07	0.50	0.50
B	0.07	0.07	0.50	0.50
C	0.10	0.10	0.50	0.50
D	0.15	0.15	0.50	0.50
E	0.35	0.35	0.35	0.35
F	0.55	0.55	0.35	0.35
Parameter	**Default**	**Project**	**Description**	
PTG0	0.020	0.020	potential temperature gradient for E stability [K/m]	
	0.035	0.035	potential temperature gradient for F stability [K/m]	
SL2PF	10	10	Slug-to-puff transition criterion factor equal to sigma y/length of slug	
FCLIP	0.0	0.0	Receptor-specific puff/slug properties extrapolation: no extrapolation	
NSPLIT	3	3	Number of puffs that result every time a puff is split	
IRESPLIT	Hour 17=1	Hour 17=1	Time(s) of day when split puffs are eligible to be split once again	
ZISPLIT	100	100	Minimum allowable last hour's mixing height for puff splitting	
ROLDMAX	0.25	0.25	Maximum allowable ratio of last hour's mixing height and maximum mixing height experienced by the puff for puff splitting	
NSPLITH	5	5	Number of puff that result every time a puff is split (nsplith = 5 means that 1 puff splits into 5)	
SYSPLITH	1	1	Minimum sigma-y of puff before it may be horizontally split	
SHSPLITH	2	2	Minimum puff elongation rate (SYSPLITH/hr) due to wind shear, before it may be split	
CNSPLITH	0.0000001	0.0000001	Minimum concentration of each species in puff before it may be horizontally split	
EPSSLUG	0.0001	0.0001	Fractional convergence criterion for numerical SLUG sampling integration	
EPSAREA	0.000001	0.000001	Fractional convergence criterion for numerical AREA source integration	
DRISE	1.0	1.0	Trajectory step length for numerical rise integration	
HTMINBC	500	500	Minimum height (m) to which BC puffs are mixed as they are emitted at the release point if greater than this minimum – not used	

APPENDIX C

Parameter	Default	Project	Description
RSAMPBC	10	10	Search radius (km) about a receptor for sampling nearest BC puff
MDEPBC	1	1	Near-Surface depletion adjustment to concentration profile used when sampling boundary condition puffs

APPENDIX

D BPIP INPUT FILE

TABLE OF CONTENTS

APPENDIX D

D1 BPIP INPUT FILE

```
'bpip.inp'
'P'
'METERS'  1.00000000
'UTMY'  0.0000
 30
'DPLA'   1         640.000  'Diesel Plant'
 4          9.500
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           497575.365    6729250.436
           497538.452    6729192.025
           497522.930    6729201.834
'FTAN'   1         640.000  'Fuel Tank'
 8          13.400
           497515.305    6729247.147
           497519.596    6729245.370
           497521.373    6729241.079
           497519.596    6729236.788
           497515.305    6729235.011
           497511.015    6729236.788
           497509.237    6729241.079
           497511.015    6729245.370
'S150'   1         640.000  'S150 Substation Building'
 4          5.000
           497560.416    6729297.199
           497570.842    6729290.487
           497566.512    6729283.760
           497556.085    6729290.472
'ITTR'   1         640.000  'IT Trailer'
 4          4.000
           497586.780    6729280.980
           497593.980    6729270.990
           497587.880    6729266.670
           497580.680    6729276.660
'MOFF'   1         640.000  'Main Office'
 8          13.200
           497575.388    6729393.445
           497584.068    6729391.255
           497577.098    6729363.665
           497545.298    6729371.705
           497546.028    6729374.615
           497543.118    6729375.355
           497544.578    6729381.125
           497570.608    6729374.535
'ELTR'   1         640.000  'Electricians Trailer'
 4          4.000
           497607.214    6729387.066
           497614.559    6729386.742
           497614.001    6729373.287
           497606.513    6729373.626
'DRTR'   1         640.000  'Drafting Trailer'
 4          4.000
           497607.335    6729368.704
           497611.709    6729368.511
           497610.764    6729348.195
           497606.289    6729348.397
'P125'   1         640.000  'P125'
 4          8.400
           497608.700    6729207.630
           497641.030    6729187.460
           497632.030    6729173.630
           497600.150    6729194.180
'WH4'    1         642.000  'WH4'
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 4          10.500
          497765.859    6728726.662
          497778.347    6728705.283
          497761.588    6728695.493
          497749.099    6728716.872
'STOR'   1          640.000  'Storage'
 4          4.000
          497630.638    6729017.142
          497637.834    6729007.406
          497629.931    6729001.564
          497622.734    6729011.301
'P1IN'   1          640.000  'P125 Intake Hoists'
 4          7.200
          497572.864    6729145.233
          497587.257    6729136.554
          497581.036    6729126.236
          497566.642    6729134.914
'EHOU'   1          661.000  'E-House'
 4          4.300
          497427.650    6728985.770
          497433.327    6728985.576
          497432.930    6728973.934
          497427.253    6728974.128
'LGW1'   1          661.000  'LNG Generator (WG1)'
 4          4.300
          497437.968    6728965.132
          497440.427    6728959.472
          497424.288    6728952.460
          497421.829    6728958.121
'LGW2'   1          661.000  'LNG Generator (WG2)'
 4          4.300
          497442.466    6728955.078
          497444.925    6728949.418
          497428.786    6728942.406
          497426.327    6728948.066
'LGW3'   1          660.000  'LNG Generator (WG3)'
 4          4.300
          497446.567    6728945.950
          497449.026    6728940.289
          497432.887    6728933.278
          497430.428    6728938.938
'LNT1'   1          660.000  'LNG Tank 1'
 4          4.200
          497435.693    6728903.246
          497445.747    6728883.137
          497442.625    6728881.576
          497432.571    6728901.685
'LNT2'   1          660.000  'LNG Tank 2'
 4          4.200
          497440.588    6728905.362
          497450.642    6728885.254
          497447.520    6728883.693
          497437.466    6728903.801
'LNT3'   1          660.000  'LNG Tank 3'
 4          4.200
          497445.747    6728907.876
          497455.801    6728887.768
          497452.679    6728886.207
          497442.625    6728906.315
'WDSB'   1          640.000  'WD8 & WD9 Source Building'
 4          6.500
          497509.091    6729314.846
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            497520.975    6729306.184
            497512.442    6729294.476
            497500.558    6729303.138
'ELRM'   1        640.000  'Electrical Room'
 4          6.500
            497516.760    6729300.401
            497521.989    6729296.589
            497517.672    6729290.665
            497512.442    6729294.476
'TDG1'   1        640.000  'Temporary Diesel Generator (YM1)'
 4          4.300
            497517.556    6729223.172
            497532.002    6729224.204
            497532.173    6729221.812
            497517.727    6729220.780
'TDG2'   1        640.000  'Temporary Diesel Generator (YM2)'
 4          4.300
            497521.525    6729228.411
            497535.971    6729229.443
            497536.142    6729227.051
            497521.696    6729226.019
'TDG3'   1        640.000  'Temporary Diesel Generator (YM3)'
 4          4.300
            497525.494    6729233.729
            497539.940    6729234.761
            497540.111    6729232.369
            497525.665    6729231.337
'TDG4'   1        640.000  'Temporary Diesel Generator (YM4)'
 4          4.300
            497528.351    6729238.968
            497542.797    6729239.999
            497542.968    6729237.608
            497528.522    6729236.576
'TDG5'   1        640.000  'Temporary Diesel Generator (YM5)'
 4          4.300
            497543.194    6729258.732
            497554.386    6729263.018
            497555.277    6729260.693
            497544.085    6729256.406
'TDG6'   1        640.000  'Temporary Diesel Generator (YM6)'
 4          4.300
            497535.733    6729263.653
            497546.925    6729267.939
            497547.816    6729265.614
            497536.624    6729261.328
'TDG7'   1        640.000  'Temporary Diesel Generator (YM7)'
 4          4.300
            497528.034    6729268.733
            497539.226    6729273.019
            497540.116    6729270.694
            497528.924    6729266.408
'TDG8'   1        640.000  'Temporary Diesel Generator (YM8)'
 4          4.300
            497513.667    6729275.877
            497520.255    6729285.640
            497522.153    6729284.359
            497515.565    6729274.596
'TDG9'   1        640.000  'Temporary Diesel Generator (YM9)'
 4          4.300
            497509.698    6729278.576
            497516.286    6729288.339
            497518.184    6729287.058
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           497511.596    6729277.295
'TDG10'  1         640.000  'Temporary Diesel Generator (YM10)'
 4           4.300
           497505.571    6729281.274
           497512.159    6729291.038
           497514.056    6729289.757
           497507.468    6729279.994
 23
'WG1'         661.000   12.190    497420.051     6728957.008
'WG1'
'WG2'         661.000   12.190    497424.705     6728947.148
'WG2'
'WG3'         660.000   12.190    497429.300     6728937.339
'WG3'
'WD4'         640.000   12.000    497552.989     6729211.775
'WD4'
'WD5'         640.000   12.000    497550.837     6729208.316
'WD5'
'WD6'         640.000   12.000    497548.752     6729205.055
'WD6'
'WD7'         640.000   12.000    497545.865     6729199.869
'WD7'
'WD8'         640.000   15.000    497523.714     6729310.984
'WD8'
'WD9'         640.000   15.000    497522.021     6729312.069
'WD9'
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'YM1-a'
'YM1-b'       640.000   4.300     497529.223     6729222.054
'YM1-b'
'YM2-a'       640.000   4.300     497533.091     6729228.692
'YM2-a'
'YM2-b'       640.000   4.300     497533.193     6729227.286
'YM2-b'
'YM3-a'       640.000   4.300     497537.044     6729234.026
'YM3-a'
'YM3-b'       640.000   4.300     497537.146     6729232.620
'YM3-b'
'YM4-a'       640.000   4.300     497539.933     6729239.201
'YM4-a'
'YM4-b'       640.000   4.300     497540.036     6729237.795
'YM4-b'
'YM5-a'       640.000   4.300     497552.011     6729261.633
'YM5-a'
'YM5-b'       640.000   4.300     497552.531     6729260.322
'YM5-b'
'YM6-a'       640.000   4.300     497544.391     6729266.475
'YM6-a'
'YM6-b'       640.000   4.300     497544.911     6729265.164
'YM6-b'
'YM7-a'       640.000   4.300     497536.810     6729271.594
'YM7-a'
'YM7-b'       640.000   4.300     497537.330     6729270.284
'YM7-b'
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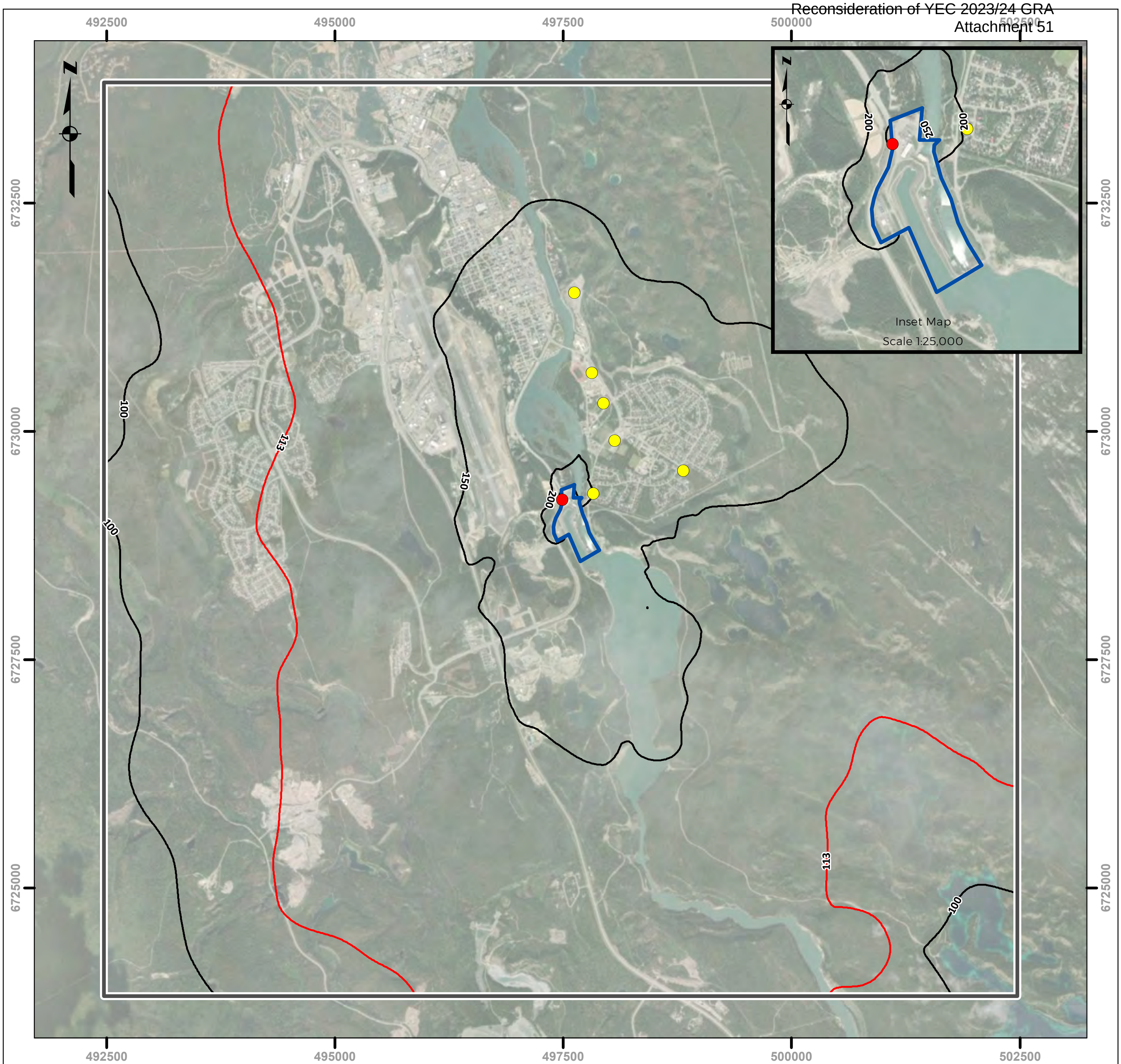
APPENDIX

E CONCENTRATION ISOPLETH



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration ($\mu g/m^3$): 73.3
2. Maximum Predicted Concentration ($\mu g/m^3$): 287
3. Contour levels: 100, 113, 150, 200, 250

References
1. YAAQS ($\mu g/m^3$): 113

wsp

Maximum Predicted 1-hour NO_2 Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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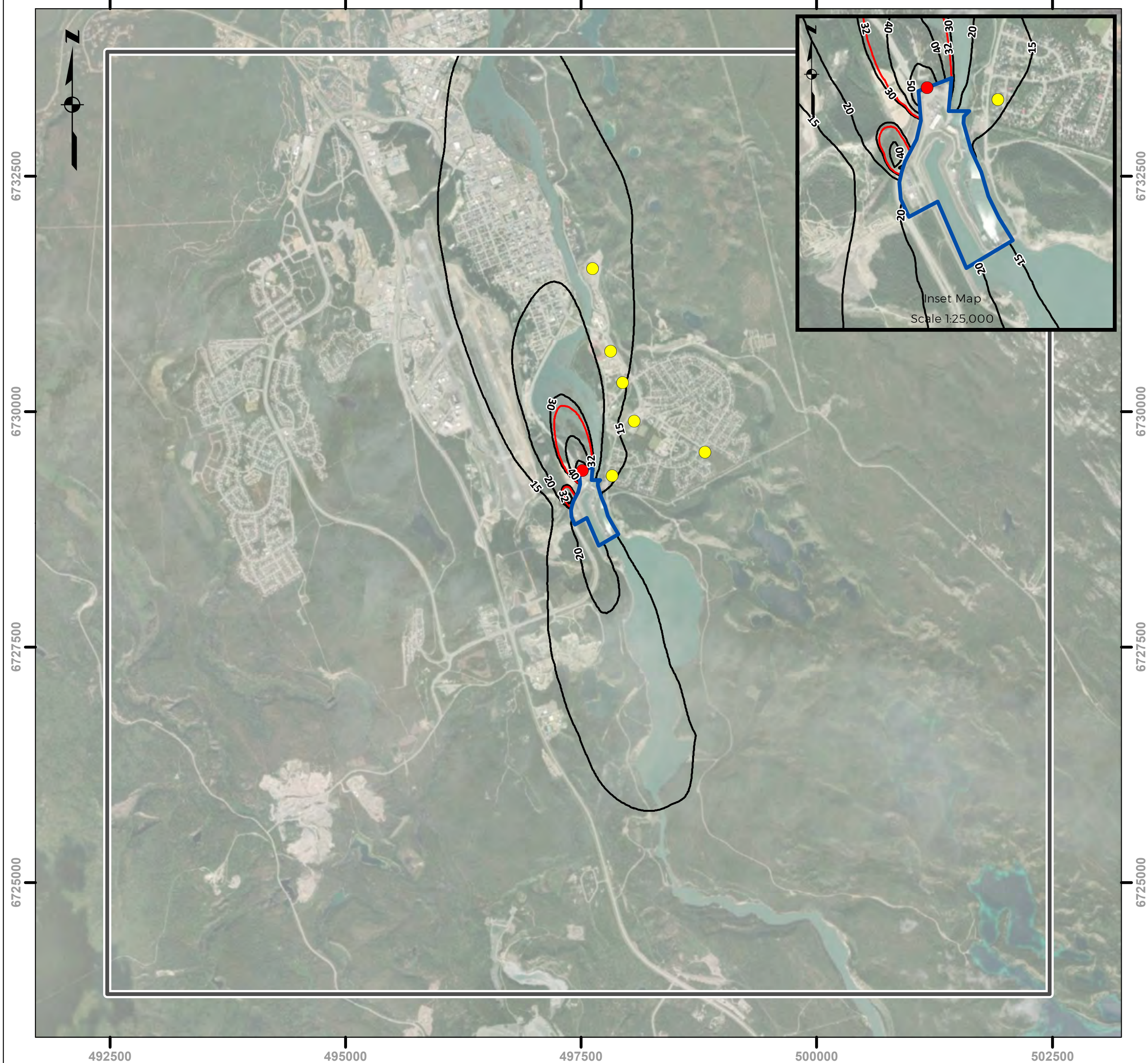
Figure E-1

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (µg/m^3): 11.2
2. Maximum Predicted Concentration (µg/m^3): 61.4
3. Contour levels: 15, 20, 30, 32, 40, 50

References
1. YAAQS (µg/m^3): 32

wsp

Maximum Predicted Annual NO_2 Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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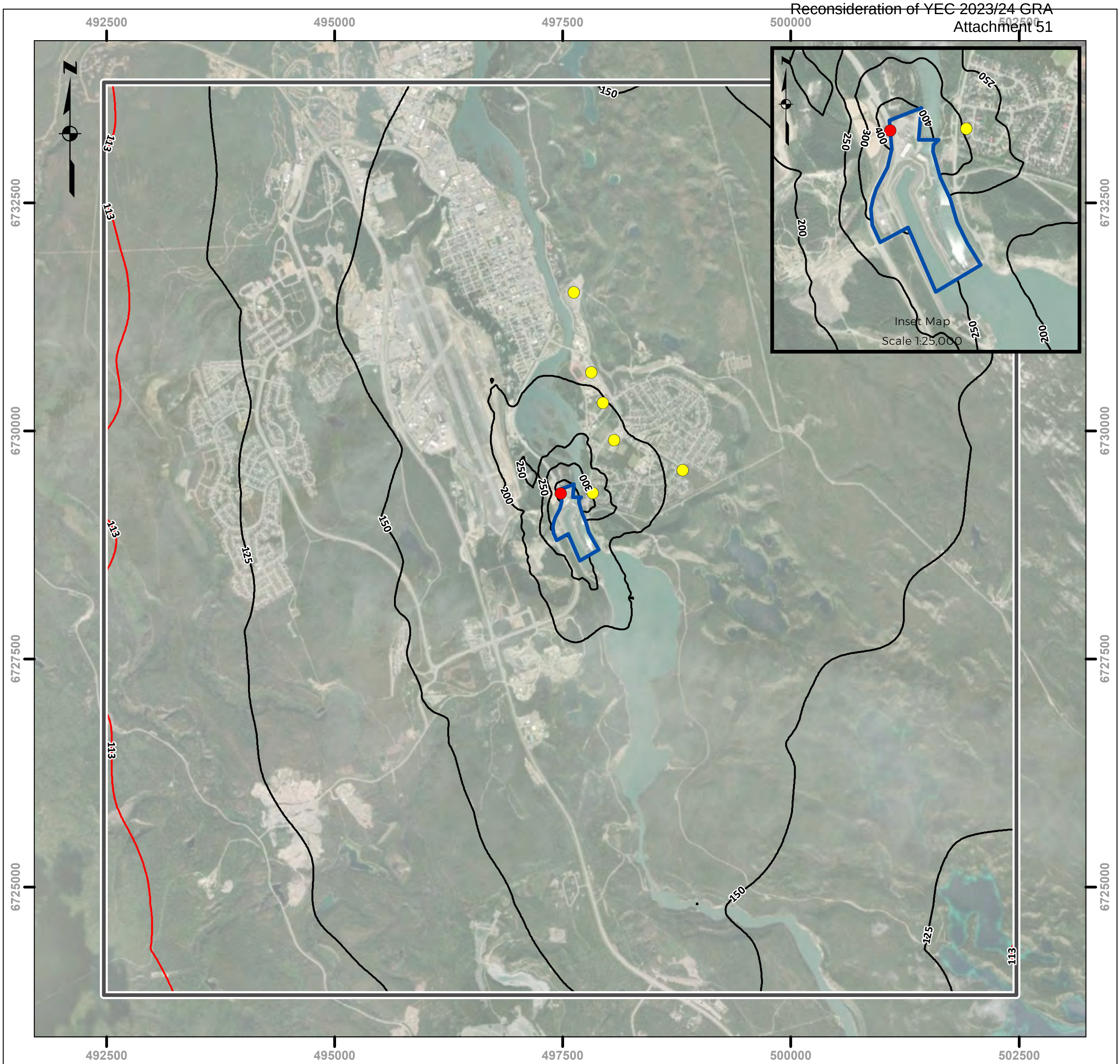
Figure E-2

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): 73.3
2. Maximum Predicted Concentration (μg/m^3): 555
3. Contour levels: 113, 125, 150, 200, 250, 300, 400

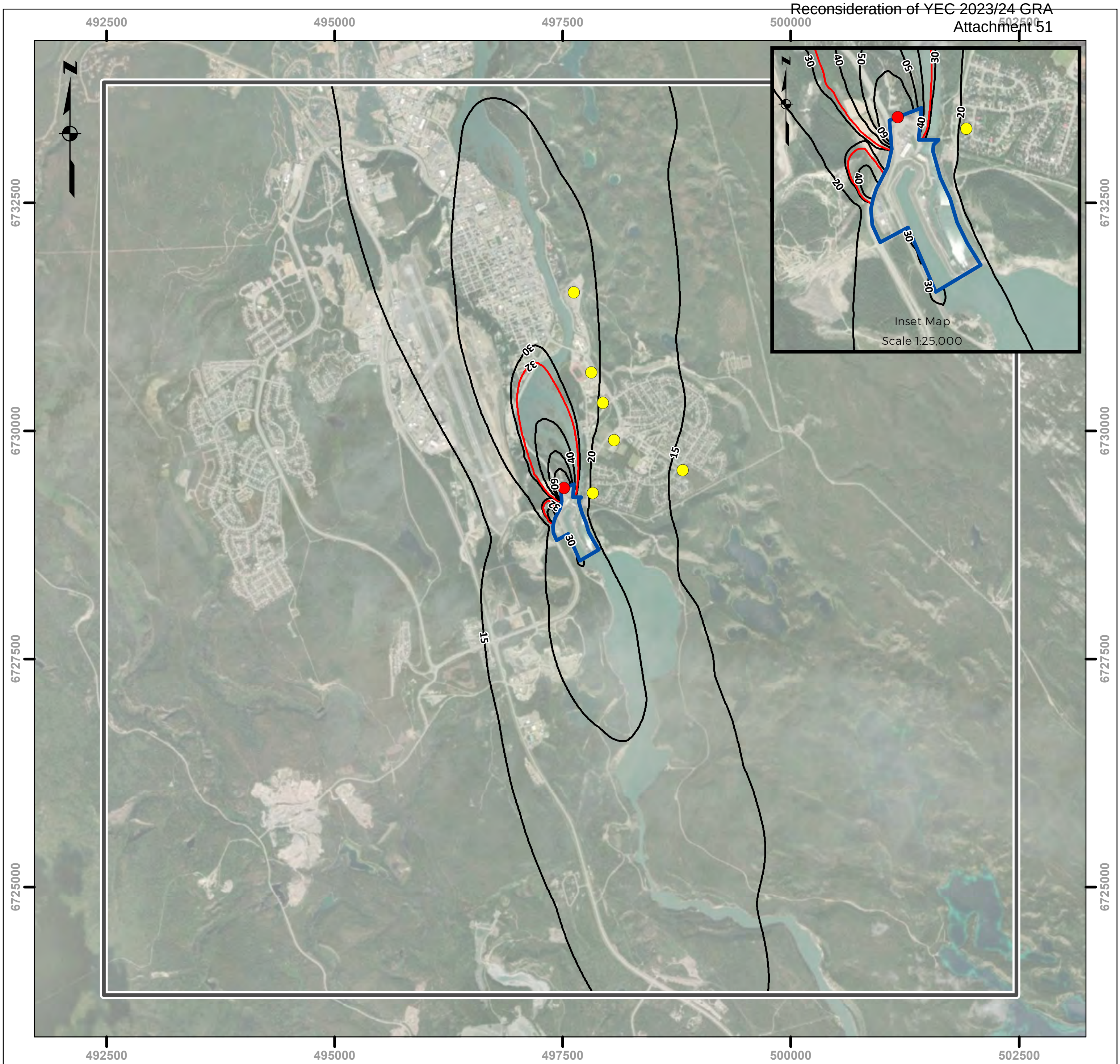
References
1. YAAQS (μg/m^3): 113

Maximum Predicted 1-hour NO_2 Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-3

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): 11.2
2. Maximum Predicted Concentration (μg/m^3): 100
3. Contour levels: 15, 20, 30, 32, 40, 50, 60

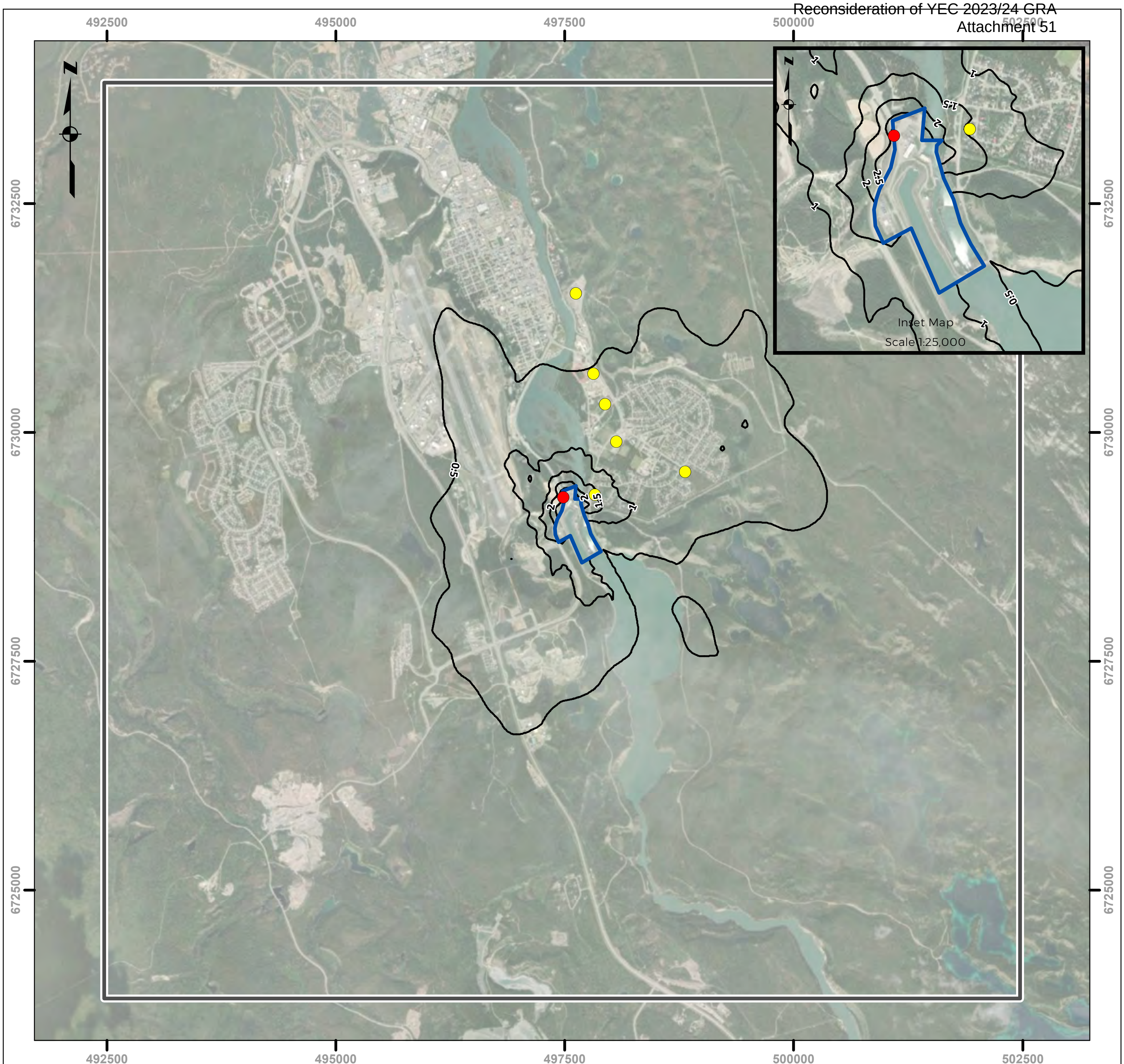
References
1. YAAQS (μg/m^3): 32

Maximum Predicted Annual NO_2 Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-4

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m³): -
2. Maximum Predicted Concentration (μg/m³): 3.5
3. Contour levels: 0.5, 1, 1.5, 2, 2.5, 3

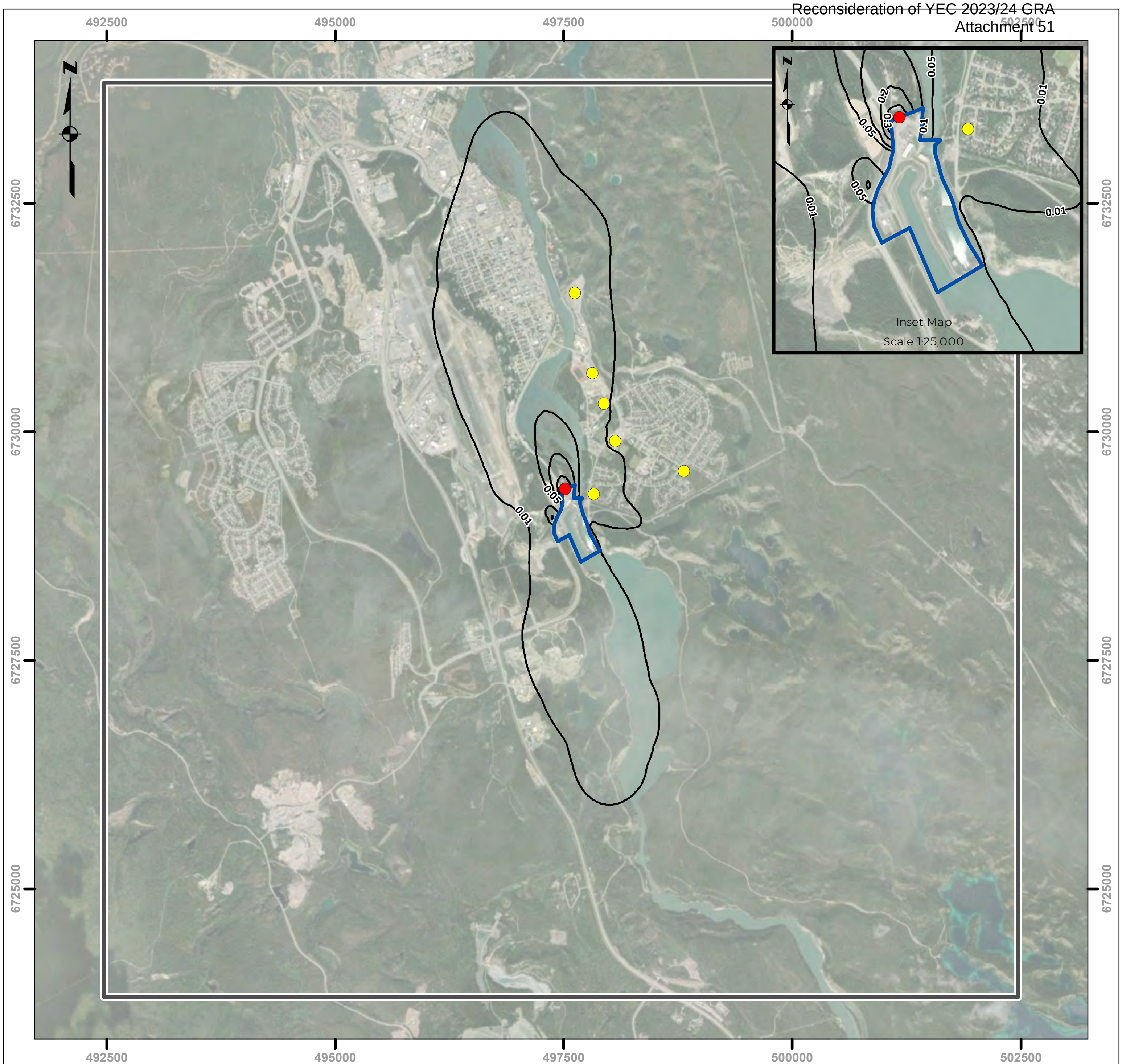
References
1. YAAQS (μg/m³): 183

Maximum Predicted 1-hour SO_2 Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-5

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): -
2. Maximum Predicted Concentration (μg/m^3): 0.44
3. Contour levels: 0.01, 0.05, 0.1, 0.2, 0.3

References
1. YAAQS (μg/m^3): 13

wsp

Maximum Predicted Annual SO_2 Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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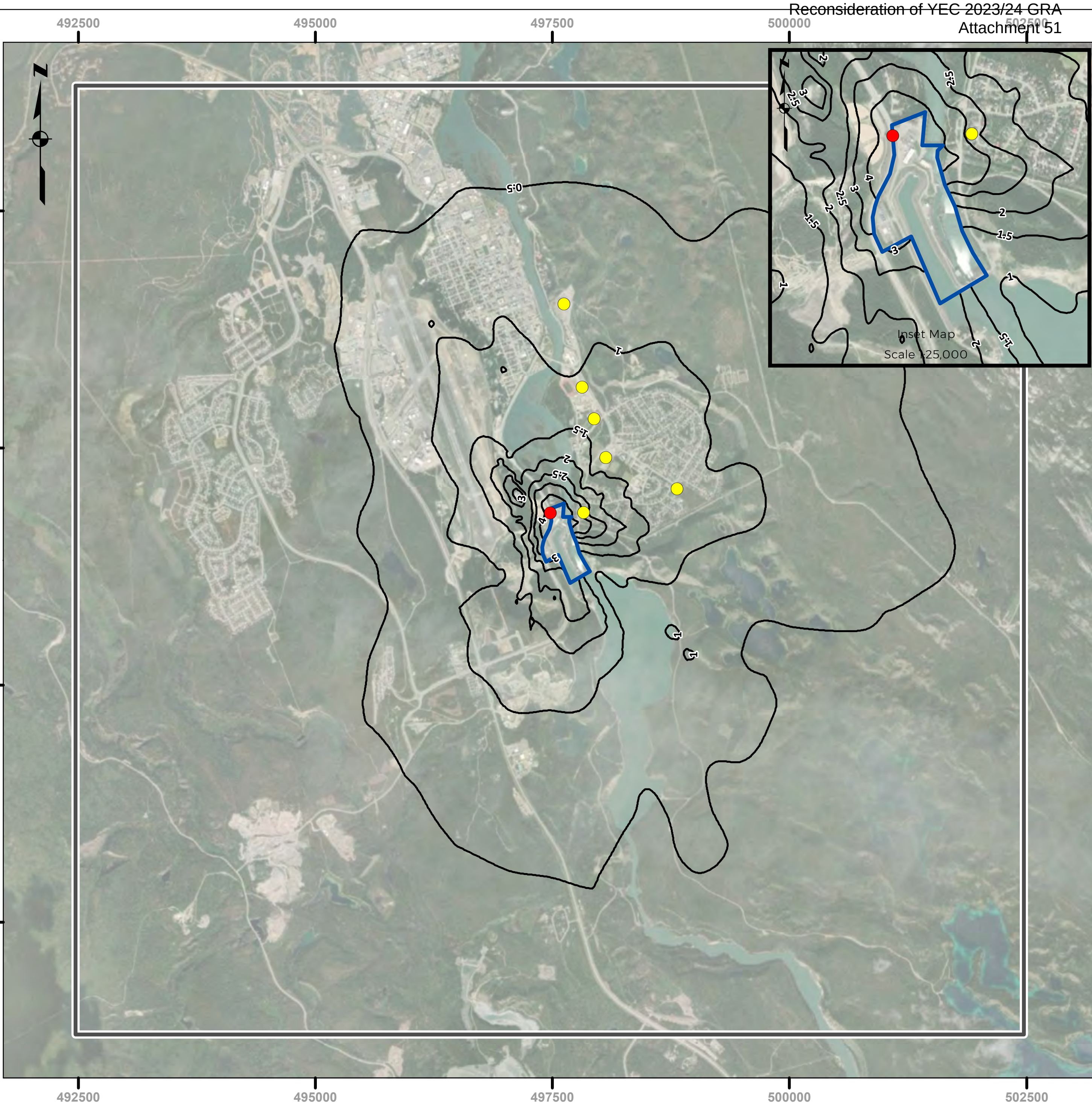
Figure E-6



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m³): -
2. Maximum Predicted Concentration (μg/m³): 7.1
3. Contour levels: 0.5, 1, 1.5, 2, 2.5, 3, 4

References
1. YAAQS (μg/m³): 183

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Maximum Predicted 1-hour SO_2 Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
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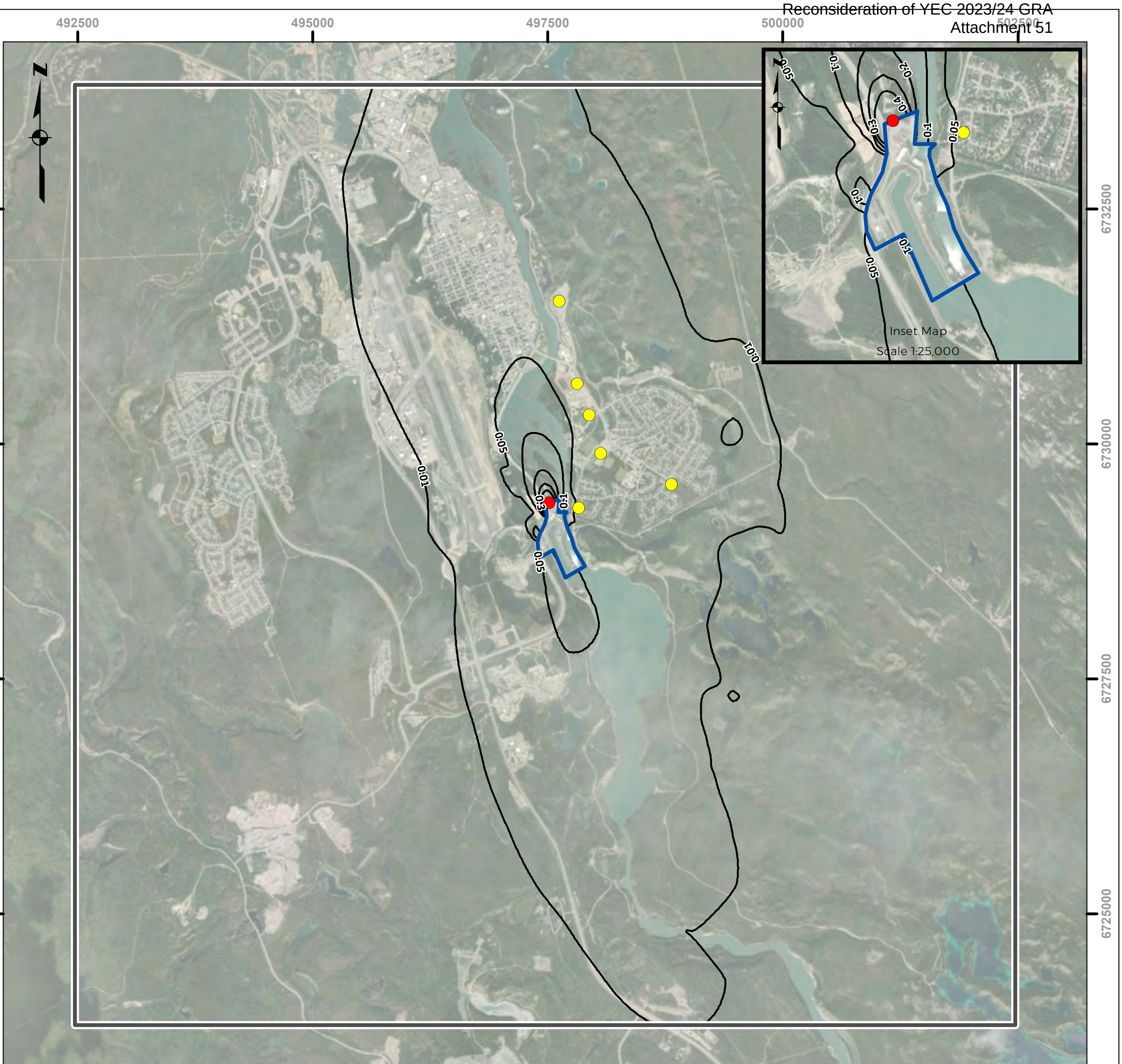
Figure E-7

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

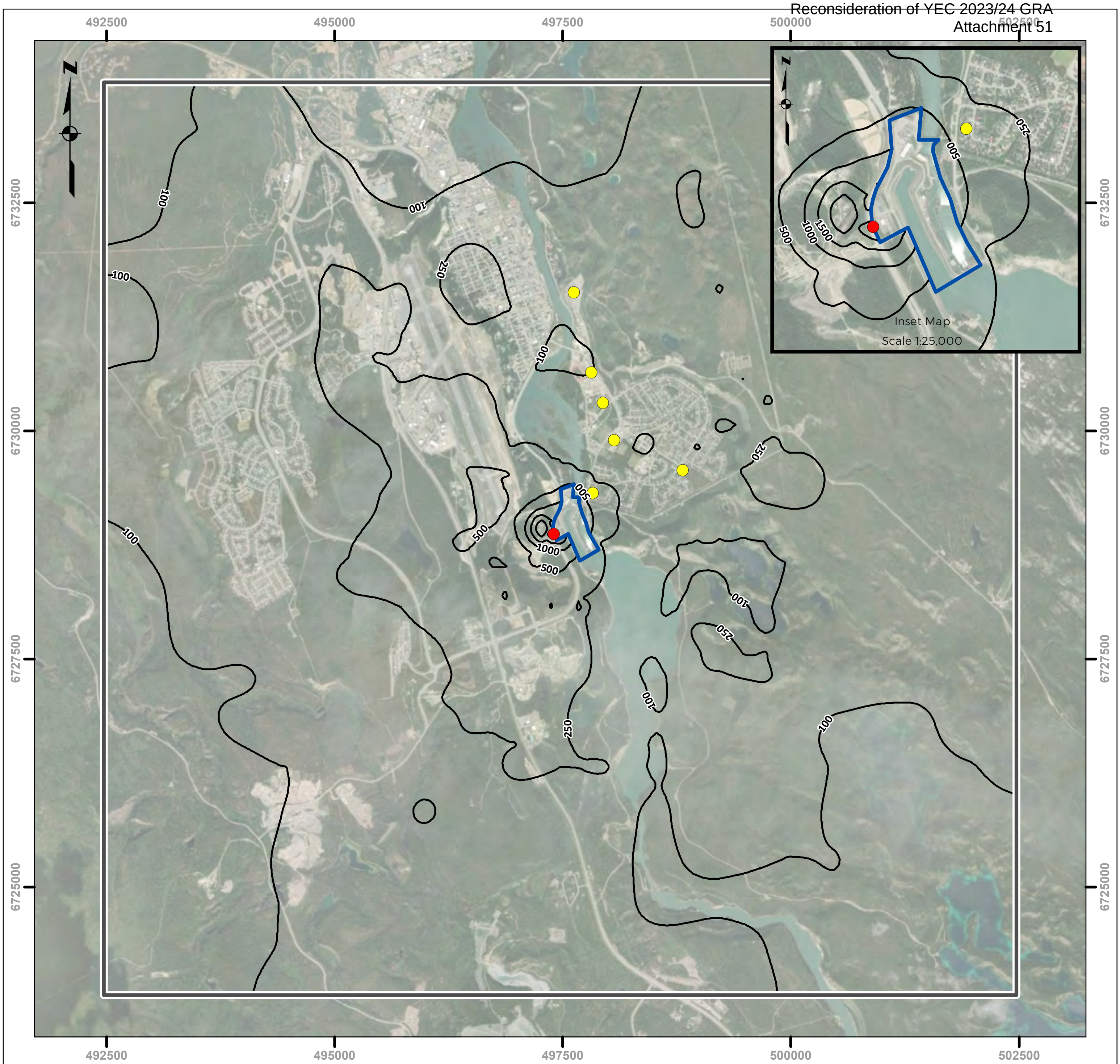
Notes
1. Ambient Background Concentration (μg/m^3): -
2. Maximum Predicted Concentration (μg/m^3): 0.85
3. Contour levels: 0.01, 0.05, 0.1, 0.2, 0.3, 0.4
References
1. YAAQS (μg/m^3): 13

Maximum Predicted Annual SO_2 Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-8

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

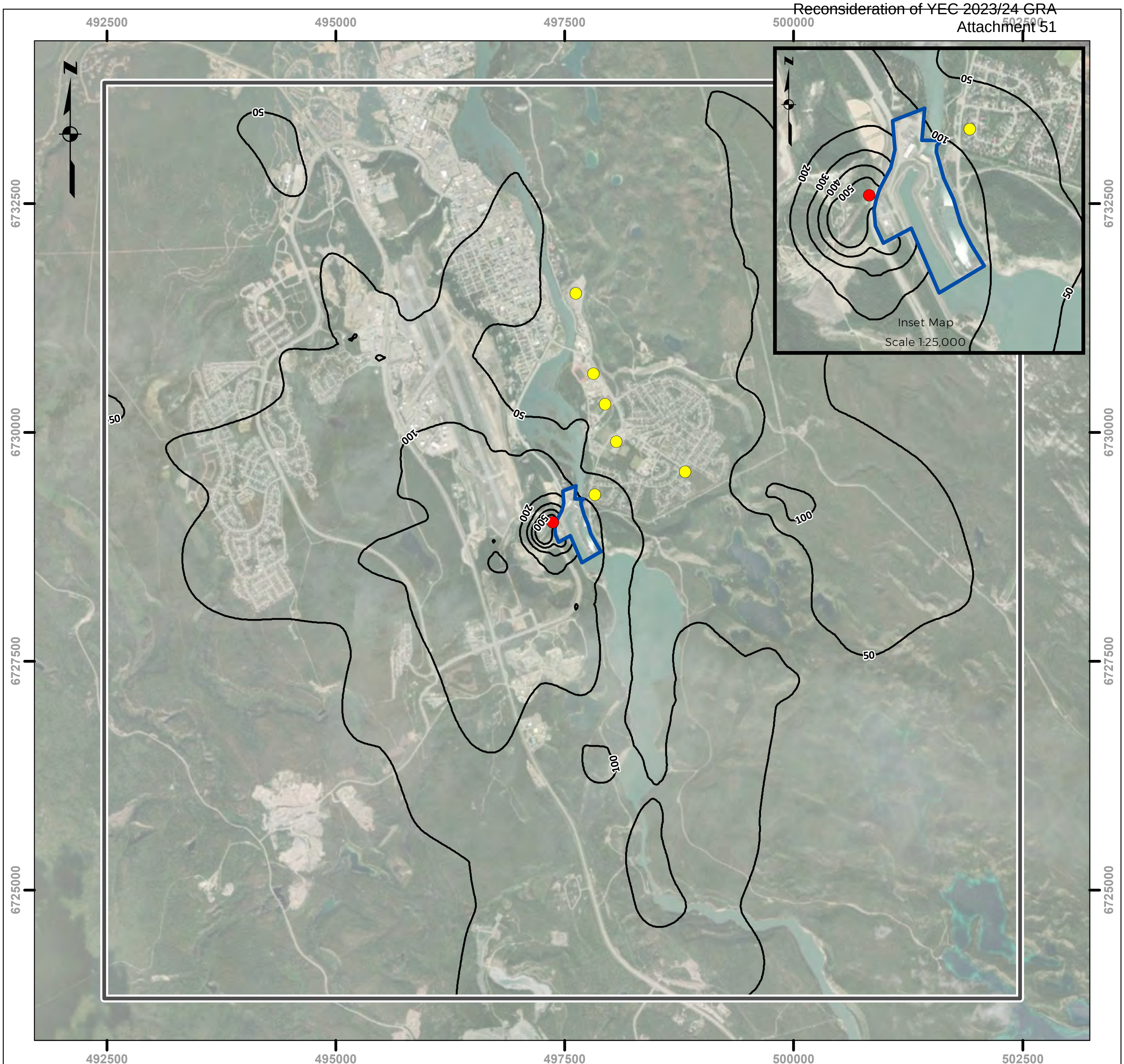
Notes
1. Ambient Background Concentration (µg/m³): -
2. Maximum Predicted Concentration (µg/m³): 2451
3. Contour levels: 100, 250, 500, 1000, 1500, 2000

References
1. BC Pollution Control Objective (used for reference purposes) (µg/m³): 14300

Maximum Predicted 1-hour CO Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-9



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): -
2. Maximum Predicted Concentration (μg/m^3): 884
3. Contour levels: 50, 100, 200, 300, 400, 500

References
1. BC Pollution Control Objective (used for reference purposes) (μg/m^3): 5500

wsp

Maximum Predicted 8-hour CO Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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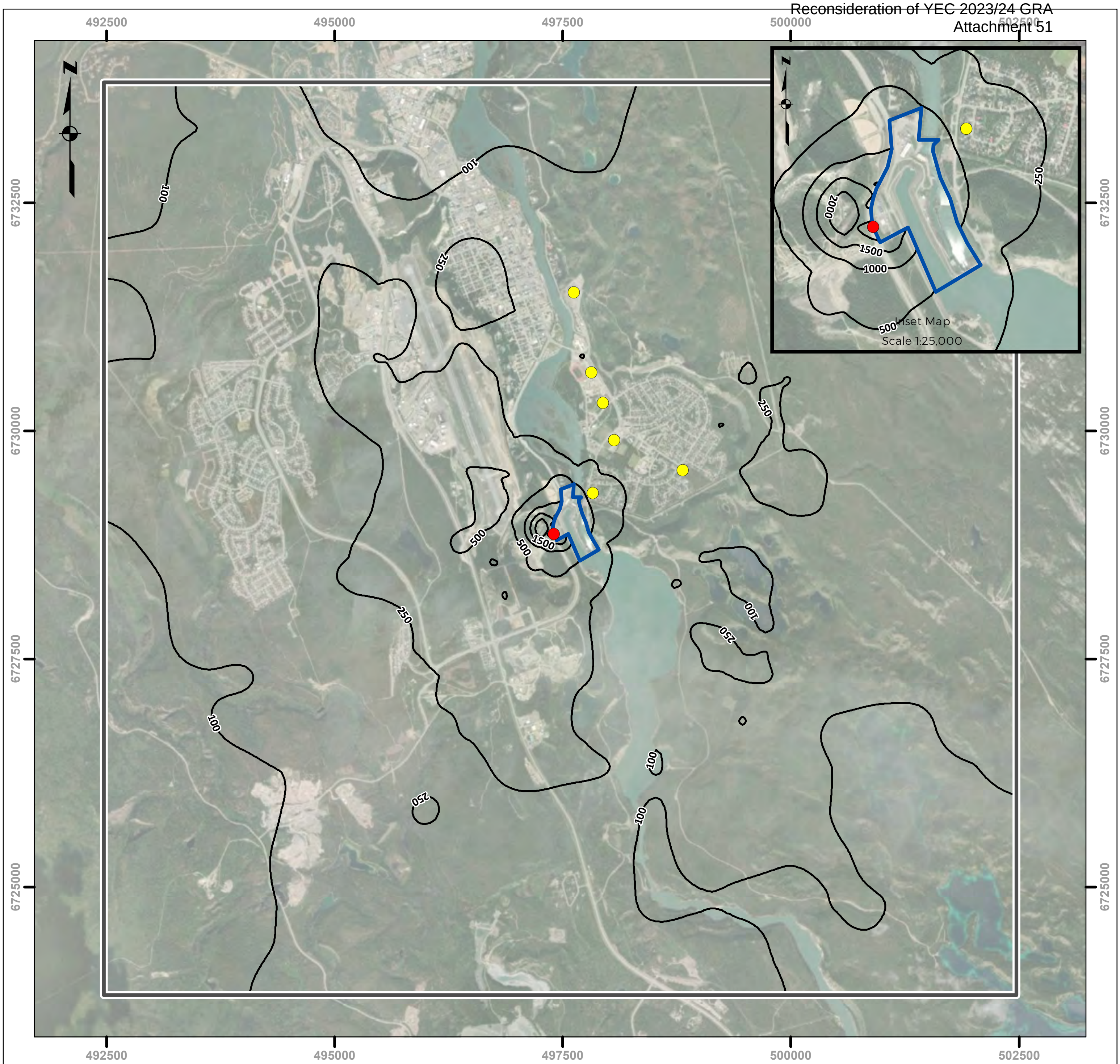
Figure E-10

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (µg/m^3): -
2. Maximum Predicted Concentration (µg/m^3): 2456
3. Contour levels: 100, 250, 500, 1000, 1500, 2000

References
1. BC Pollution Control Objective (used for reference purposes) (µg/m^3): 14300

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Maximum Predicted 1-hour CO Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

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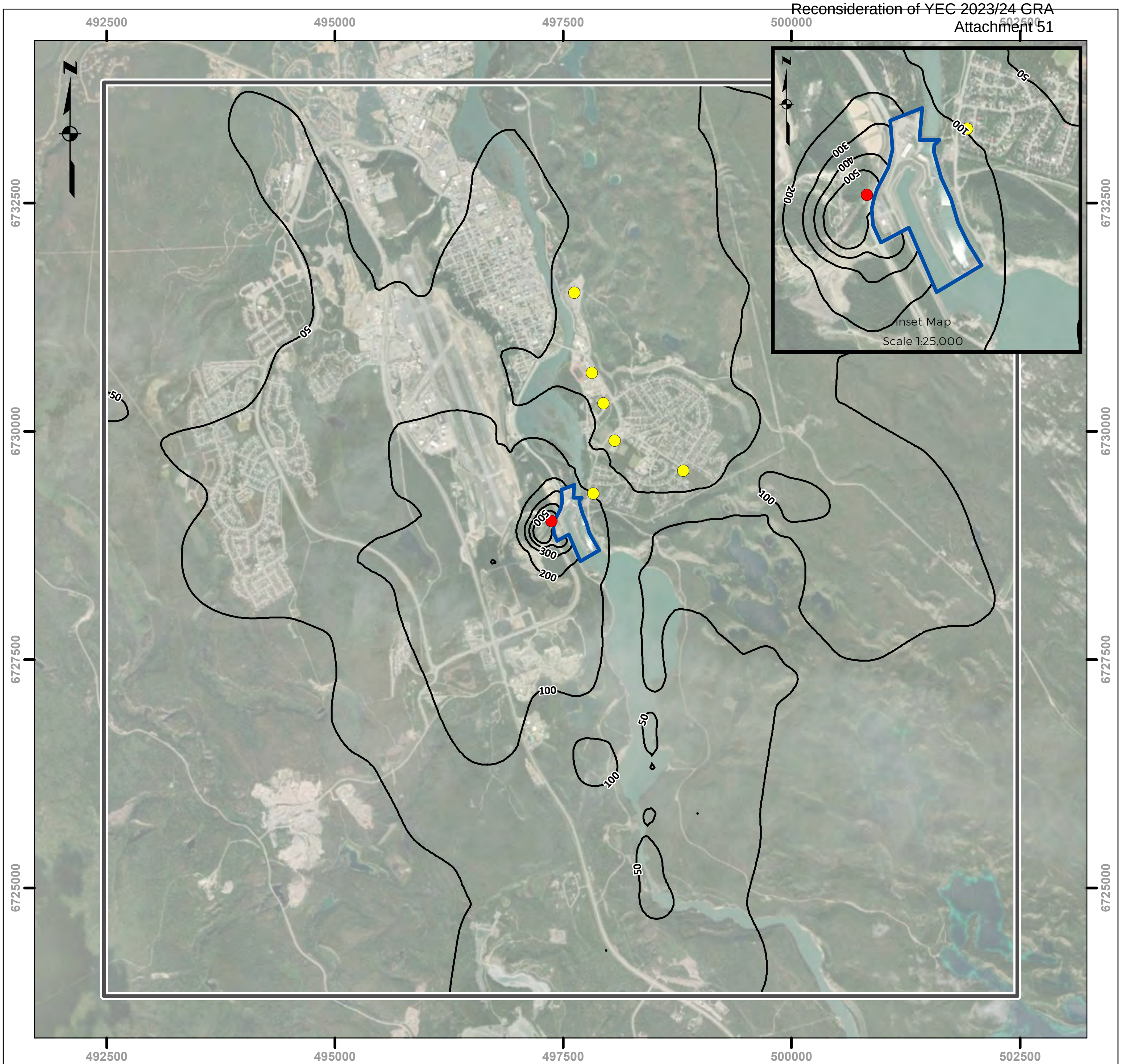
Figure E-11

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

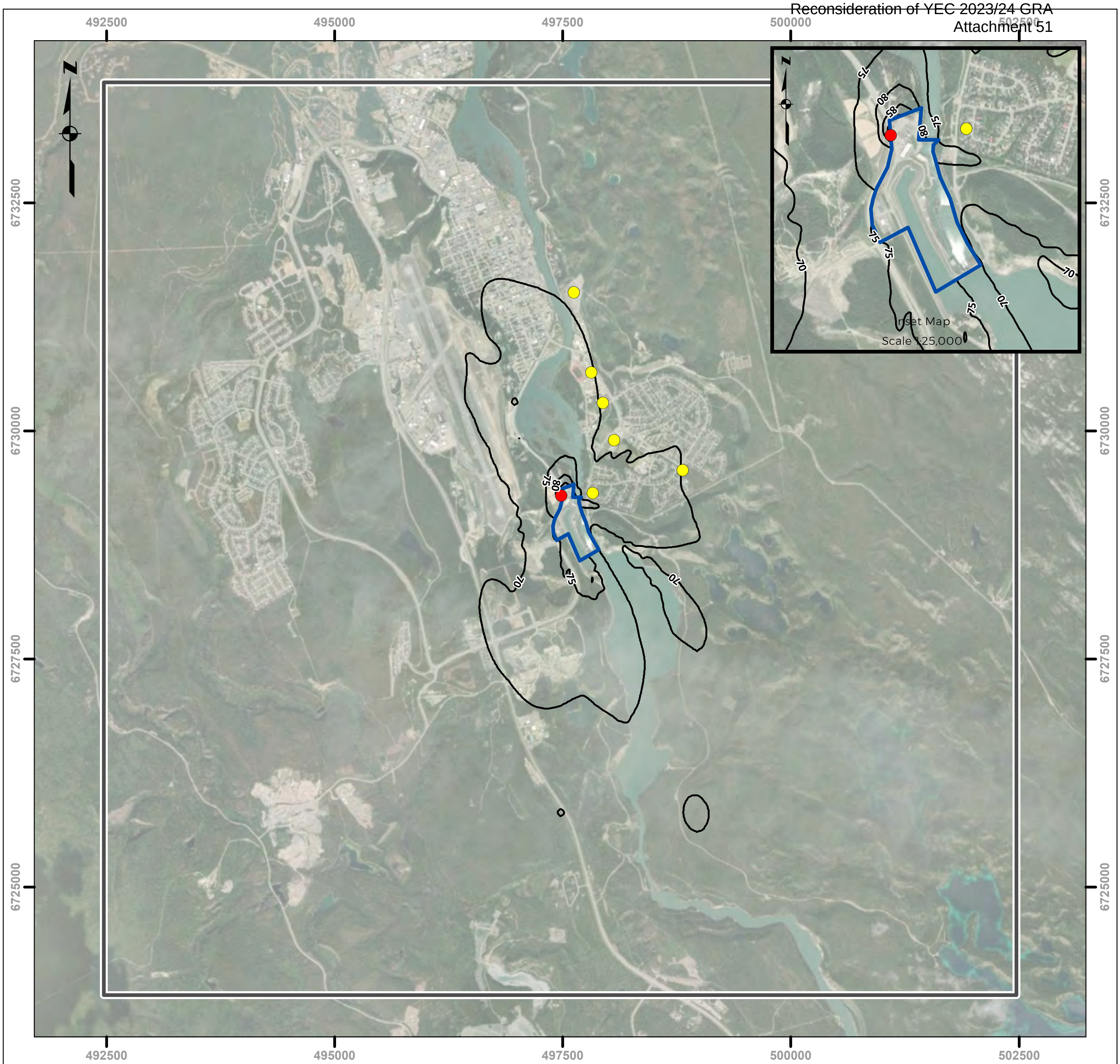
Notes
1. Ambient Background Concentration (µg/m^3): -
2. Maximum Predicted Concentration (µg/m^3): 884
3. Contour levels: 50, 100, 200, 300, 400, 500
References
1. BC Pollution Control Objective (used for reference purposes) (µg/m^3): 5500

Maximum Predicted 8-hour CO Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-12

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

Modelling Domain
Station Boundary
Contour Level
Sensitive Receptors
Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

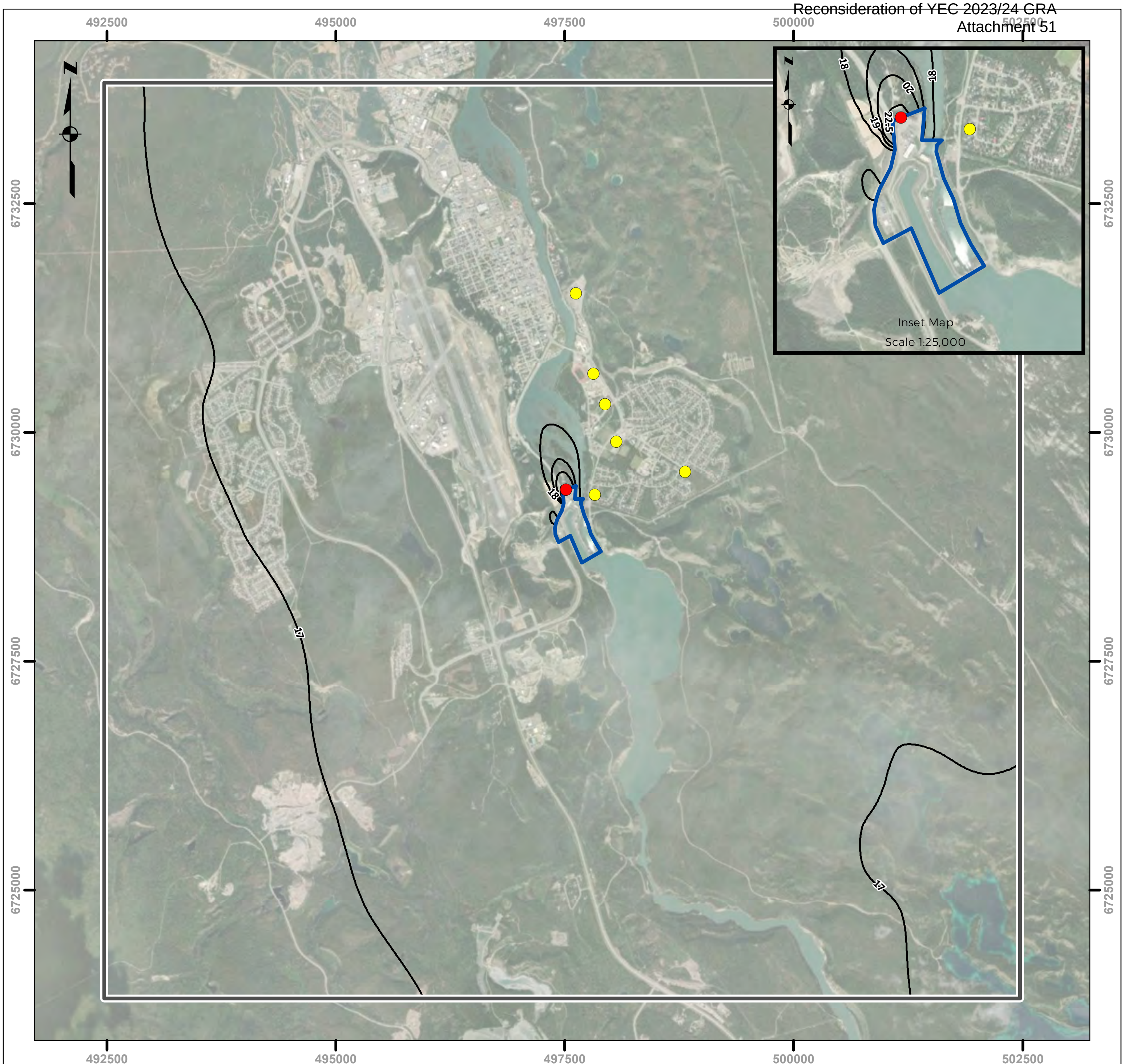
Notes
1. Ambient Background Concentration (µg/m^3): 67.3
2. Maximum Predicted Concentration (µg/m^3): 97.3
3. Contour levels: 70, 75, 80, 85, 90

References
1. YAAQS (µg/m^3): 120

Maximum Predicted 24-hour TSP Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-13



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m³): 17
2. Maximum Predicted Concentration (μg/m³): 25.3
3. Contour levels: 17, 18, 19, 20, 22.5, 25

References
1. YAAQS (μg/m³): 60

wsp

Maximum Predicted Annual TSP Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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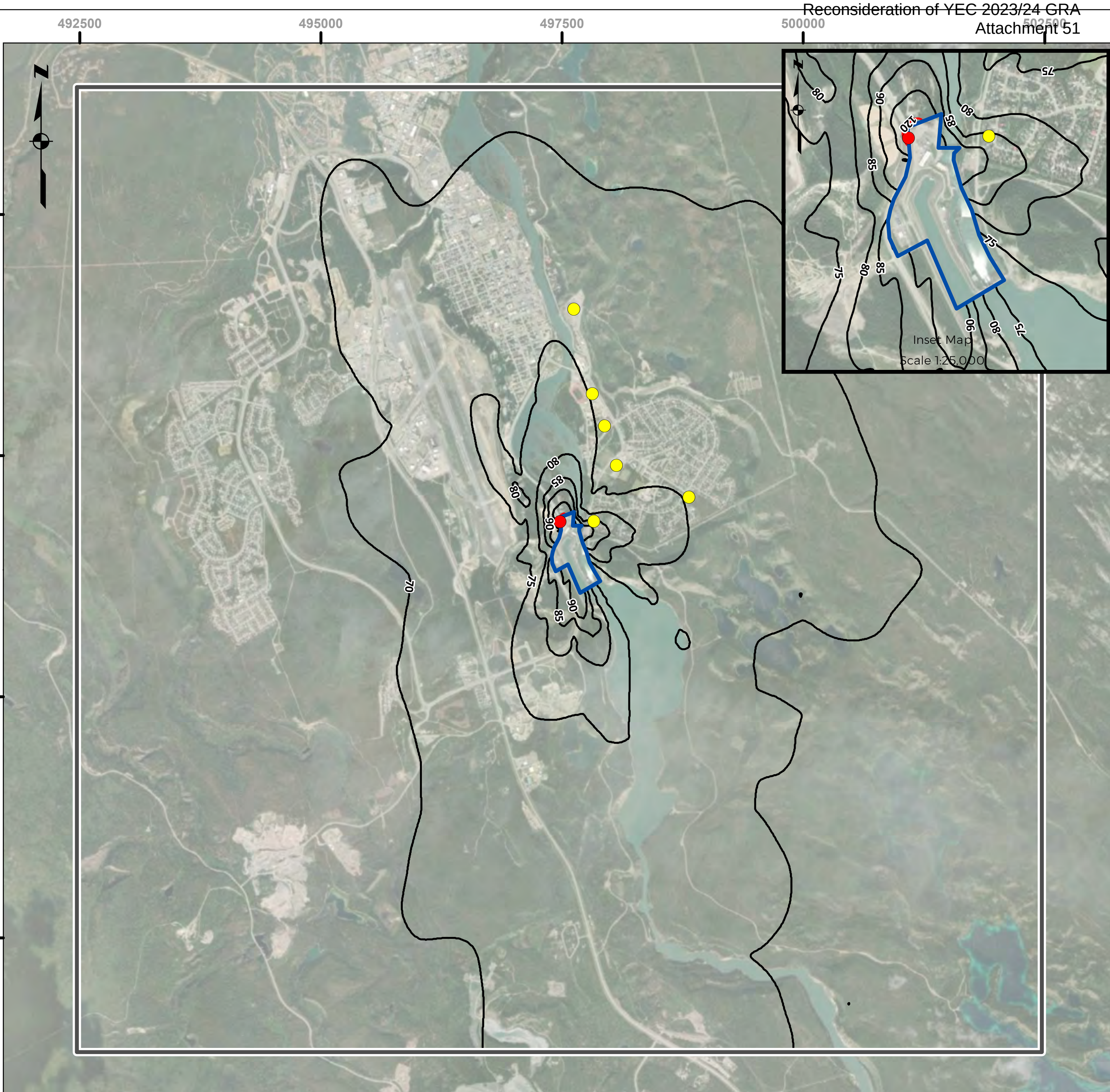
Figure E-14

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

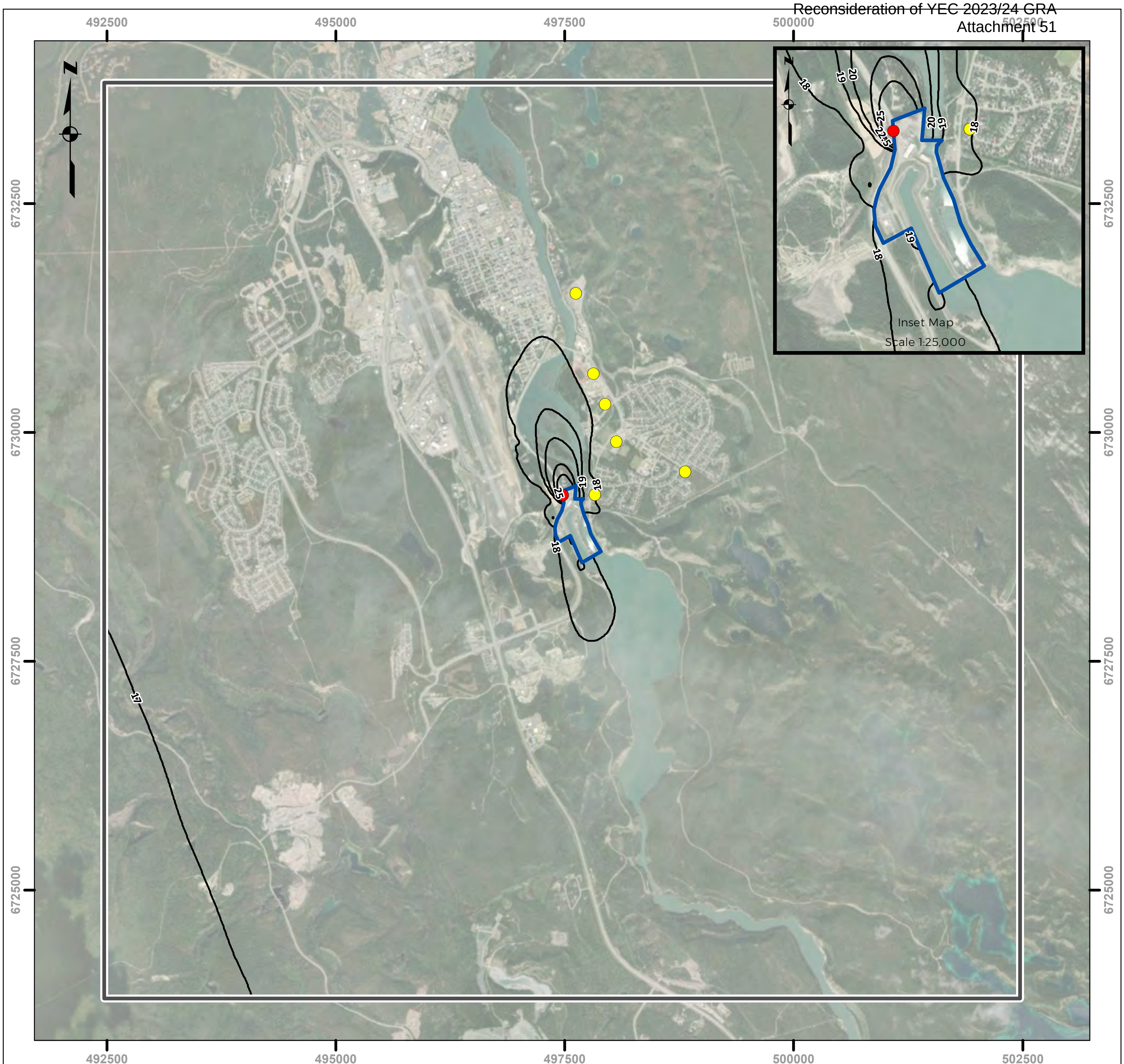
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): 67.3
2. Maximum Predicted Concentration (μg/m^3): 141
3. Contour levels: 70, 75, 80, 85, 90, 100, 120
References
1. YAAQS (μg/m^3): 120

Maximum Predicted 24-hour TSP Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-15



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m³): 17
2. Maximum Predicted Concentration (μg/m³): 38.2
3. Contour levels: 17, 18, 19, 20, 22.5, 25

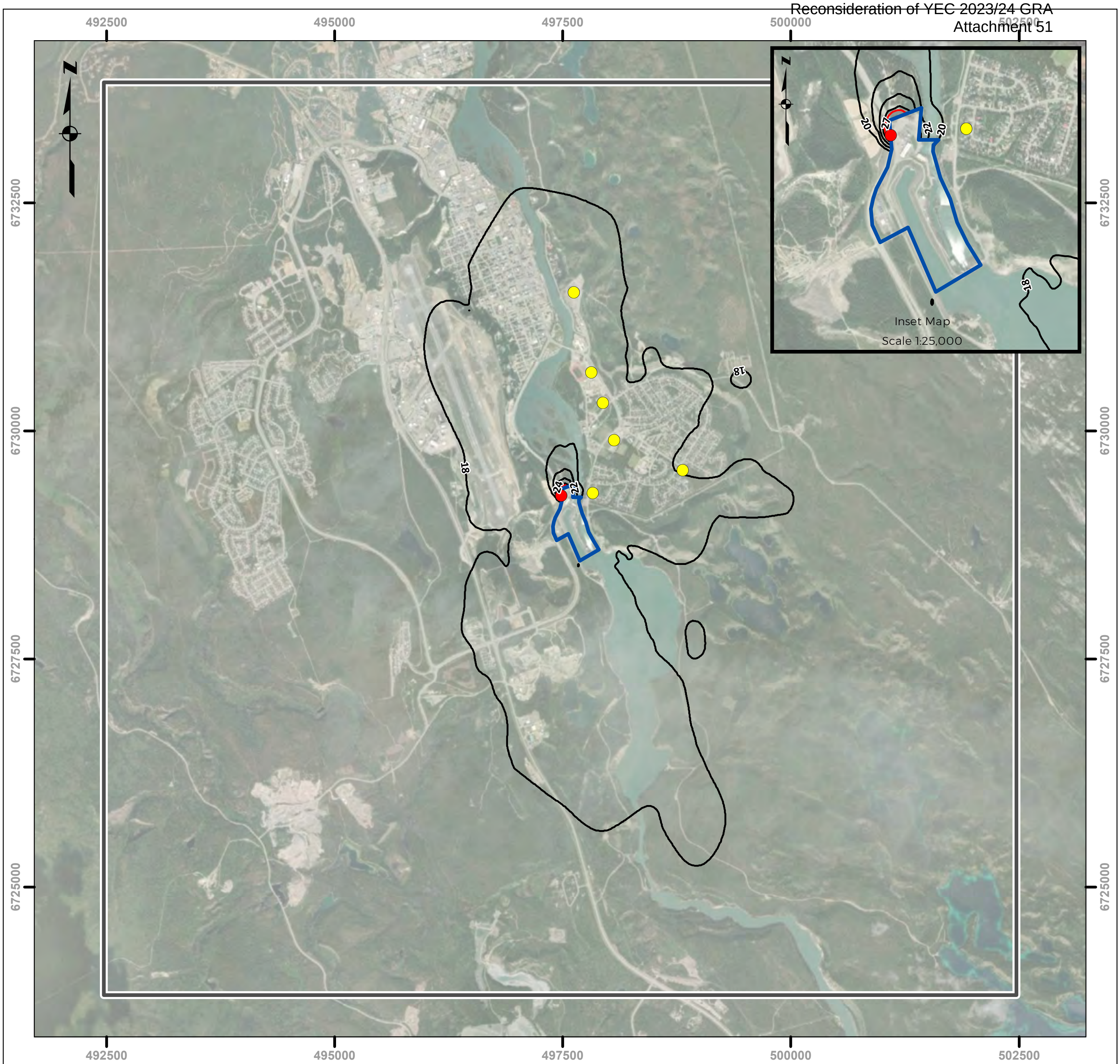
References
1. YAAQS (μg/m³): 60

Maximum Predicted Annual TSP Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-16

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (µg/m³): 17.5
2. Maximum Predicted Concentration (µg/m³): 32.2
3. Contour levels: 18, 20, 22, 24, 26, 27

References
1. YAAQS (µg/m³): 27

wsp

Maximum Predicted 24-hour $PM_{2.5}$ Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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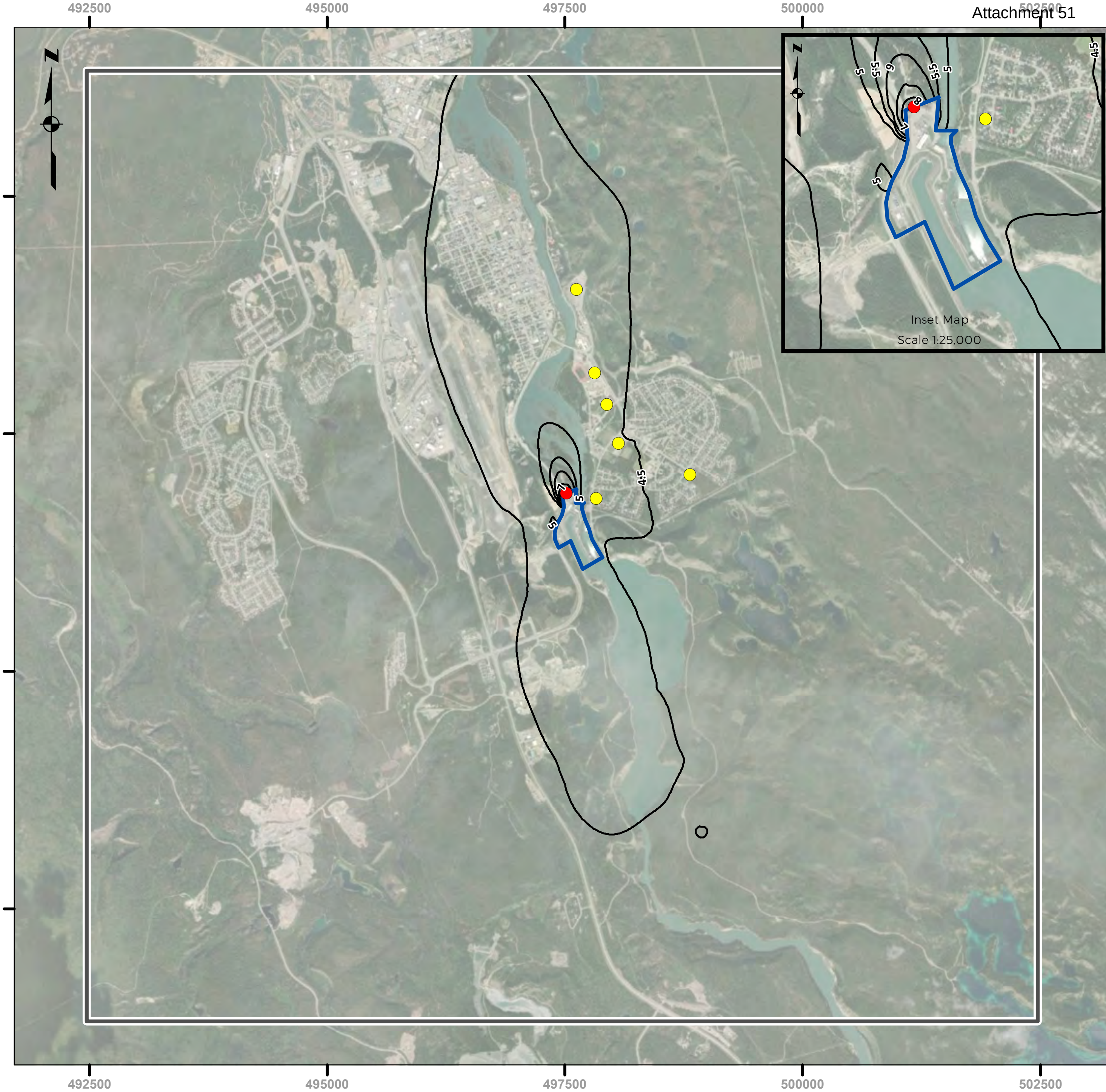
Figure E-17



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration ($\mu g/m^3$): 4.4
2. Maximum Predicted Concentration ($\mu g/m^3$): 9.3
3. Contour levels: 4.5, 5, 5.5, 6,7, 8, 8.8
References
1. YAAQS ($\mu g/m^3$): 8.8

wsp

Maximum Predicted Annual $PM_{2.5}$ Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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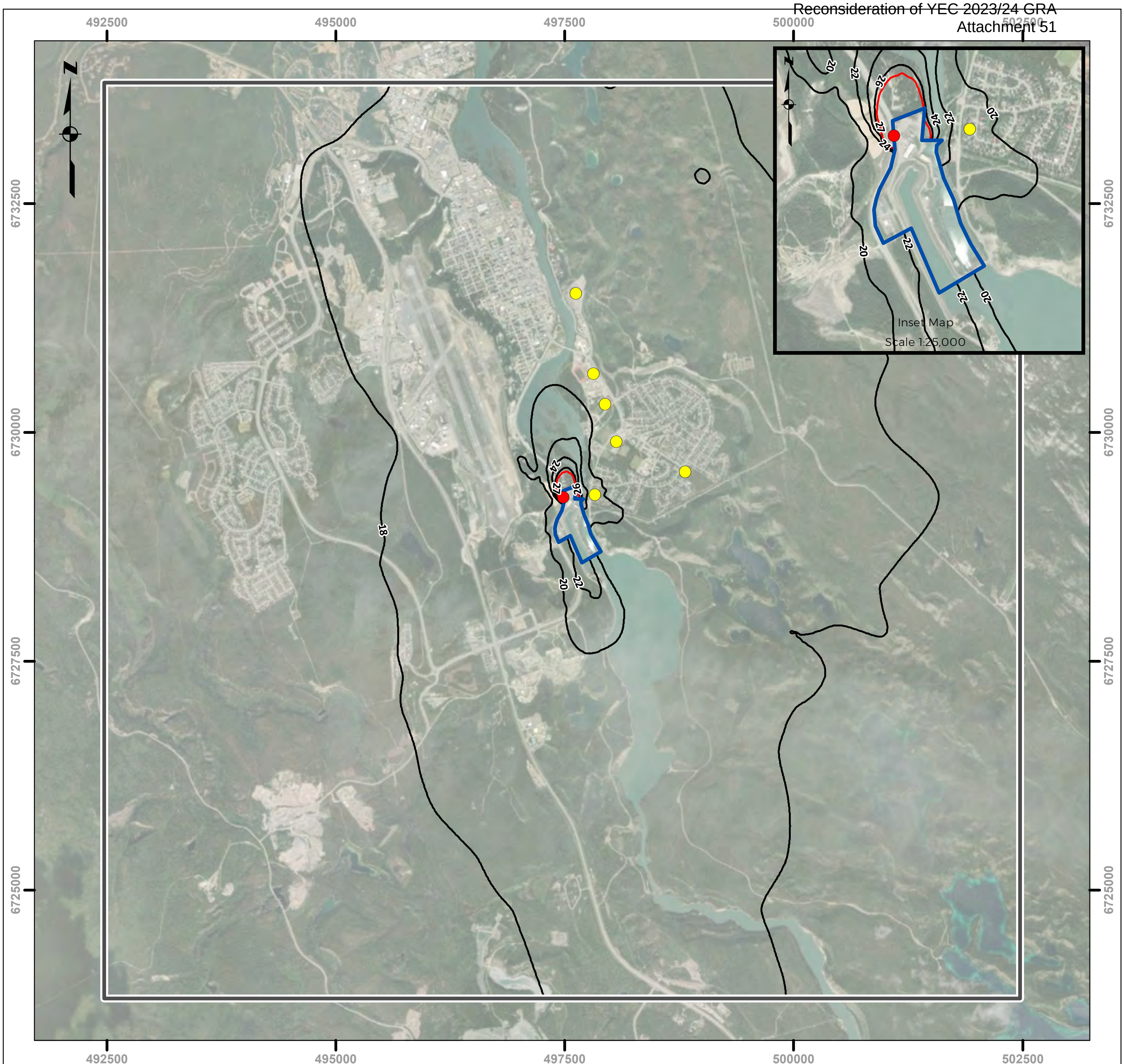
Figure E-18

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

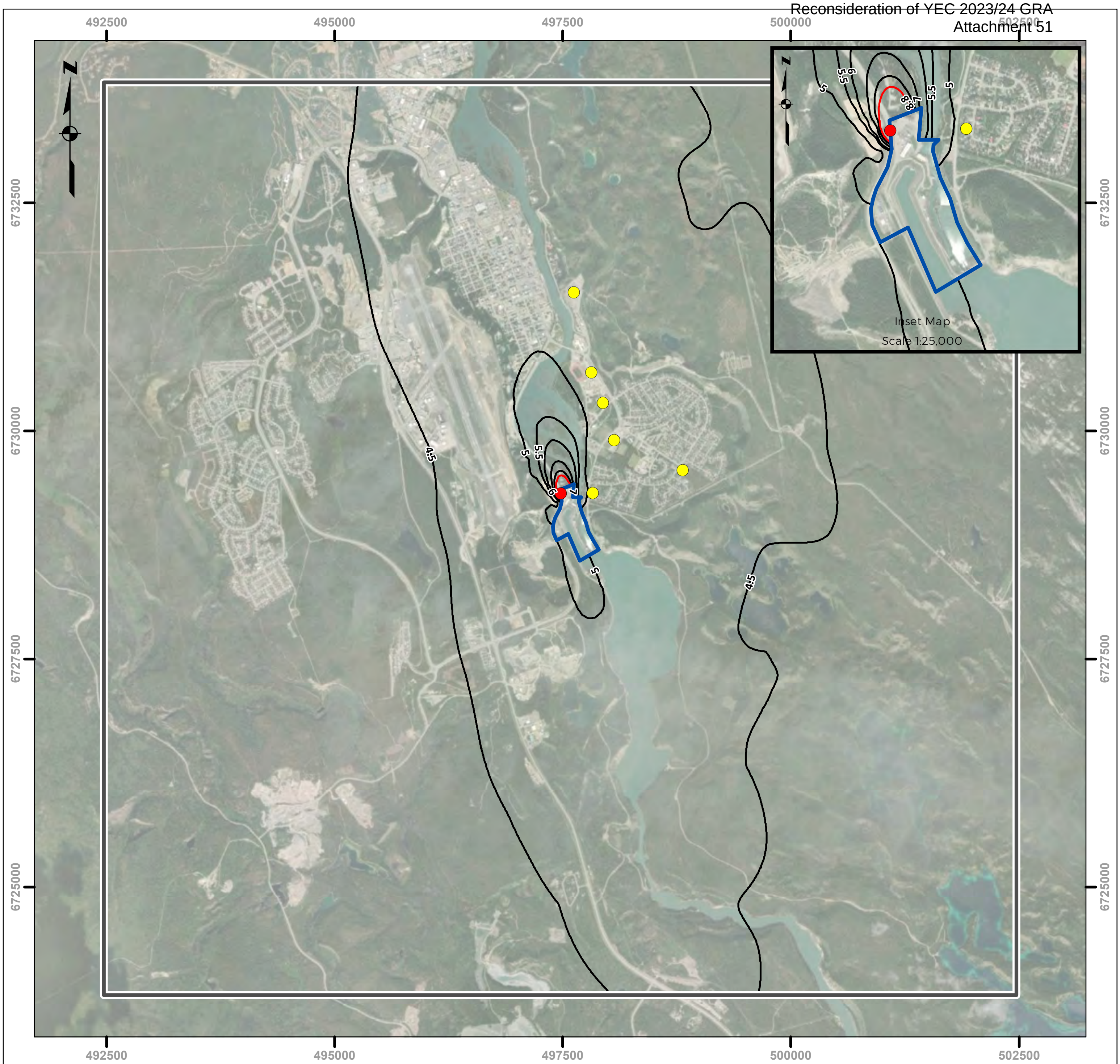
Notes
1. Ambient Background Concentration (µg/m³): 17.5
2. Maximum Predicted Concentration (µg/m³): 45.9
3. Contour levels: 18, 20, 22, 24, 26, 27
References
1. YAAQS (µg/m³): 27

Maximum Predicted 24-hour $PM_{2.5}$ Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-19

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (µg/m³): 4.4
2. Maximum Predicted Concentration (µg/m³): 14.4
3. Contour levels: 4.5, 5, 5.5, 6,7, 8, 8.8

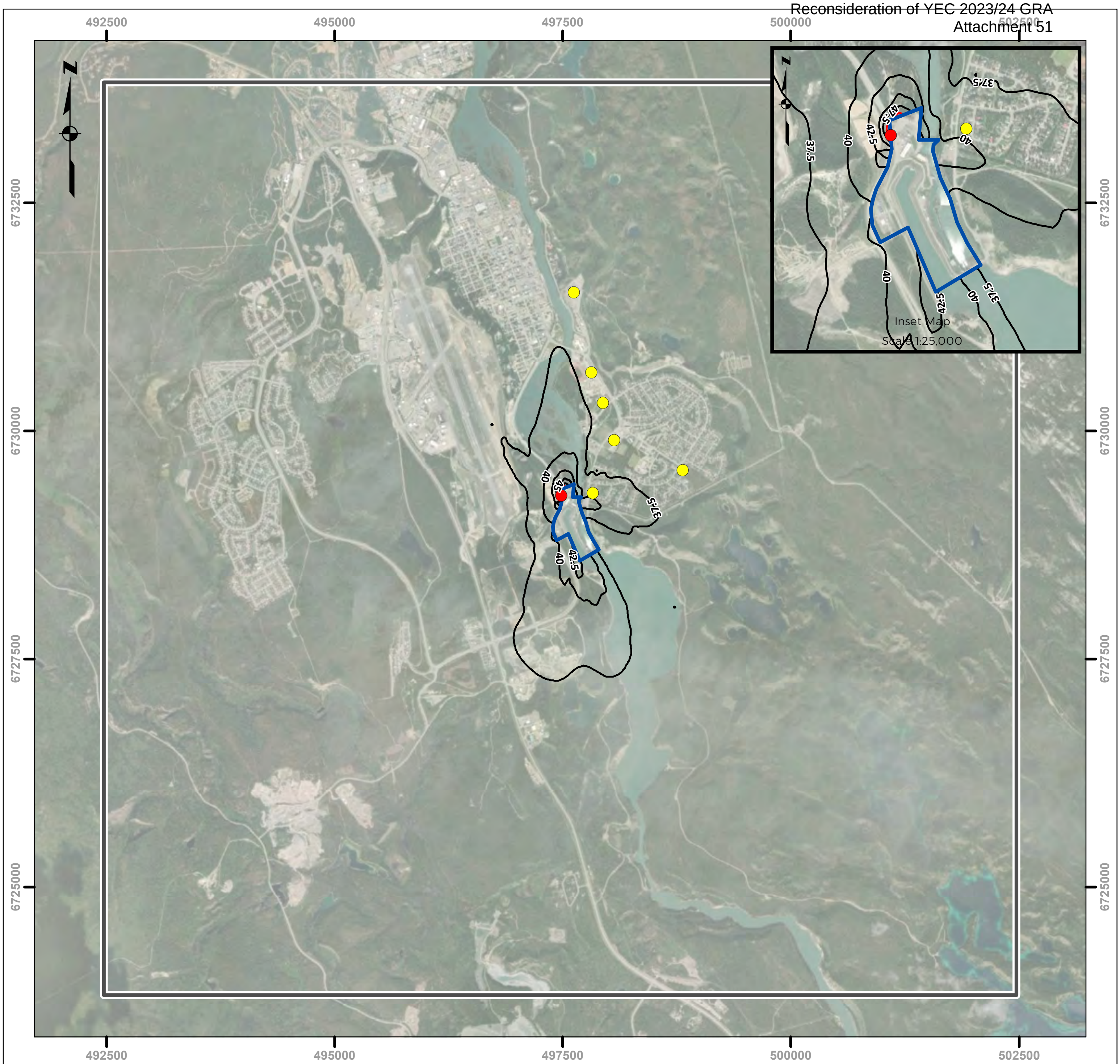
References
1. YAAQS (µg/m³): 8.8

Maximum Predicted Annual $PM_{2.5}$ Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-20

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000

0 0.25 0.5 1 1.5 2 2.5 Kilometers

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration ($\mu g/m^3$): 35
2. Maximum Predicted Concentration ($\mu g/m^3$): 55.7
3. Contour levels: 37.5, 40, 42.5, 45, 47.5, 50

References
1. YAAQS ($\mu g/m^3$): 50

wsp

Maximum Predicted 24-hour PM_{10} Concentrations - Expected Scenario

Whitehorse Rapids Generating Station
Yukon

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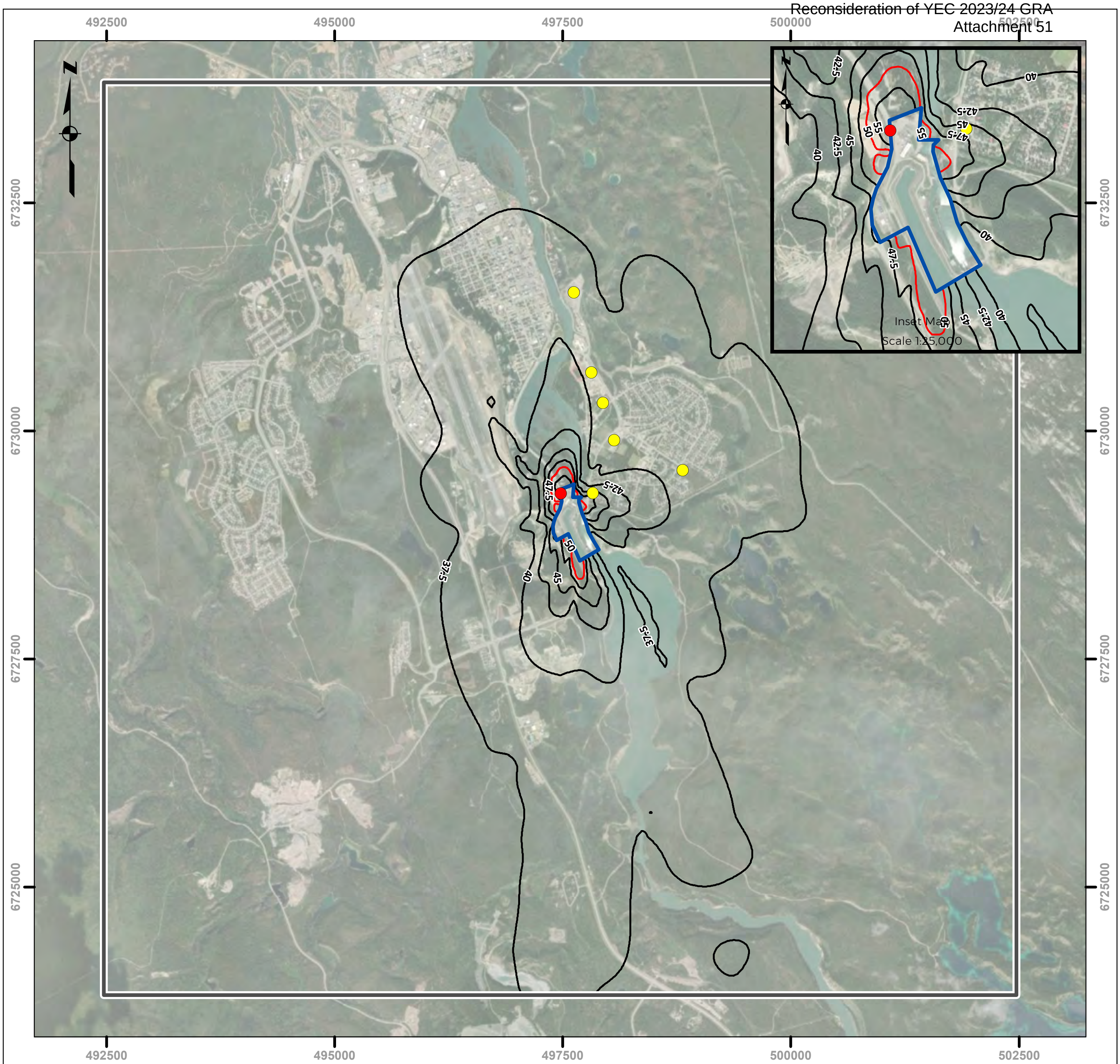
Figure E-21

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00



Legend

- Modelling Domain
- Station Boundary
- Contour Level
- Contour Level (YAAQS)
- Sensitive Receptors
- Maximum Point of Impingement

Scale: 1:95,000
0 0.25 0.5 1 1.5 2 2.5 Kilometers
Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Notes
1. Ambient Background Concentration (μg/m^3): 35
2. Maximum Predicted Concentration (μg/m^3): 76.9
3. Contour levels: 37.5, 40, 42.5, 45, 47.5, 50, 55
References
1. YAAQS (μg/m^3): 50

Maximum Predicted 24-hour PM_{10} Concentrations - Emergency (N-1 event) Scenario

Whitehorse Rapids Generating Station
Yukon

Figure E-22

Air Quality Assessment | Report By: JS | Drawn by: JH | Reviewed By: JS | WSP Job #: 221-07678-00

APPENDIX

B HUMAN HEALTH RISK ASSESSMENT

REPORT

Human Health Risk Assessment

Whitehorse Rapids Generating Station, Whitehorse, Yukon

Submitted to:

Yukon Energy Corp.

#2 Miles Canyon Road
Box 5920
Whitehorse, YK Y1A 6S7

Submitted by:

WSP Canada Inc.

840 Howe Street, Vancouver, British Columbia, V6Z 2M1, Canada

Reference No. CA-WSP-221-07678-00-001-R-Rev1

6 September 2023

Distribution List

Electronic Copy: Yukon Energy Corp.

Electronic copy: WSP Canada Inc.

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1.0 INTRODUCTION

1.1 Background

WSP Canada Inc. (WSP) was retained by Yukon Energy Corp. (Yukon Energy) to conduct a Human Health Risk Assessment (HHRA) at an existing thermal generating station, Whitehorse Rapids Generating Station (the Station), located near the City of Whitehorse, Yukon (Figure 1). The HHRA will support the renewal of Yukon Energy's existing emissions permit. The renewal of the permit considers the existing natural gas and diesel electricity generators, new Tier 4 diesel electricity generators, and the continued seasonal use of mobile generators under normal conditions as well as during an emergency (N-1) event at the Station.

The HHRA relies on air dispersion modelling results from an air quality assessment (AQA) completed by the WSP air quality team (WSP 2023). The model results represent emissions associated with the Station operation under the proposed configuration of up to 28 megawatts (MW) of diesel-fired electricity generation and 13.2 MW of natural gas-fired electricity generation, and various scenarios examining multiple sensitivities of operational changes. Based on the results of the air quality dispersion modelling, the HHRA evaluates the potential risks to human health from the Station air emissions.

1.2 Objectives and Approach

The objective of the HHRA was to assess the potential risks to human health, if any, associated with ambient concentrations of criteria air contaminants that may be influenced by emissions from the Station during expected operations and emergency (N-1) operations. Potential risks to human health were evaluated using a risk assessment framework in accordance with Health Canada's Guidance for Evaluating Human Health Impacts in Environmental Assessment: Human Health Risk Assessment (Health Canada 2019). Federal guidance was used because the Government of Yukon relies on Health Canada guidance for HHRA (Yukon Government 2020).

The study area for the HHRA is a 10-kilometre (km) by 10-km area centered on the Station, which is the same study area (receptor grid) used in the air dispersion modelling (Section 2.0). Potential acute (short-term) and chronic (long-term) health risks associated with emissions of criteria air contaminants from the Station were evaluated for six human health receptor locations identified within the study area and the maximum point of impingement (MPOI; i.e., the location with the highest predicted concentrations just outside the Station boundary).

The following two scenarios were evaluated in the HHRA:

- **Expected Emission Scenario** [21.312 MW]: 3 existing permanent natural gas units [13.125 MW] + 2 new Tier 4 diesel generators [5.2 MW] + 2 existing diesel units [3 MW] or 2 mobile diesel units [3 MW].
- **Emergency (N-1 event) Emission Scenario** [41.725 MW]: 3 existing permanent natural gas units [13.125 MW] + 4 existing permanent diesel units [10.8 MW]) + 2 new Tier 4 diesel generators [5.2 MW] + 7 of 10 mobile diesel units for use during emergencies/upset conditions to meet peak load in winter [12.6 MW].

The scenarios were evaluated assuming maximum emissions from the Station generators based upon maximum operating conditions and name-plate capacities. The modelling also conservatively assumed that all generators are emitting simultaneously and continuously at the maximum rated capacity year-round, except for the mobile units, which were assumed to be operating continuously from December through April. Thus, actual emissions are likely to be lower as the required units in the Expected Scenario will only run during the winter when needed to meet demand. Meanwhile, the Emergency scenario is a rare event that is predicted to occur once in 20 years, in which emissions would occur for a cumulative total of 1 to 5 days during a 2-week period.

2.0 AIR DISPERSION MODELLING

The WSP air quality team completed an AQA for seven constituents of potential concern (COPCs) (nitrogen oxides [NO_x], carbon monoxide [CO], sulphur dioxide [SO_2], total suspended particulates [TSP], fine particulate matter [$PM_{2.5}$], coarse particulate matter [PM_{10}] and diesel particulate matter [DPM]) in support of the HHRA (WSP 2023). Air dispersion modelling was conducted in accordance with the British Columbia Air Quality Dispersion Modelling Guideline (AQDMG; BC ENV 2022) for a 10-km by 10-km area centered on the Station (the study area). The study area is a typical air quality assessment grid size and was chosen in consideration of AQDMG guidance and the size of the grid used in previous air quality assessments completed for the Station (WSP 2020). Air quality predictions were modelled for the two scenarios (Expected Emission Scenario and Emergency N-1 Event Emission Scenario) outlined in Section 1.2 for the identified human health receptor locations (described further in Section 3.1). Both emission scenarios assumed that the generators are operating continuously at the maximum rated capacity. To reflect the worst-case predicted air quality impacts from the Station, the estimated emission rates established for each emission scenario were applied to all hours, except for the mobile generators, which were only modelled from December through April. This conservative approach is common in air dispersion modelling assessments. It allows for emission sources to be assessed at maximum air contaminant emission rates under all meteorological condition combinations to predict the potential worst-case air contaminant concentrations. Additionally, baseline air quality concentrations for the City of Whitehorse (2018-2020), collected at an air quality monitoring station, were included in the dispersion model predictions resulting in a predicted cumulative air quality concentration. Maximum concentrations were predicted for each receptor location for the applicable averaging periods (1-hour, 8-hour, 24-hour and annual) for the seven COPCs. For COPCs above air quality thresholds, 95^{th} and 75^{th} percentiles were also calculated.

The predicted air concentrations averaged over a 1-hour or 24-hour (or 8-hour for CO) period were used to evaluate potential risks from acute exposures and the predicted air concentrations averaged over an annual period were used to evaluate potential risks from chronic exposure in the HHRA. Further details on the air dispersion modelling methods, results, and discussion are provided in the AQA (WSP 2023).

3.0 PROBLEM FORMULATION

The problem formulation is the first component of a HHRA and involves developing a focused understanding of how chemical releases from a site might affect the health of people. The following are identified in the problem formulation: a representative set of receptors (i.e., people) that may be present near the site; the contaminants released from the site to which the receptors may be exposed (i.e., COPCs); and the pathways by which receptors may be exposed to chemicals released from the site (i.e., inhalation of ambient air). The information from the problem formulation is summarized in a conceptual site model which illustrates the pathways of the COPCs from their sources, through the relevant environmental media to the identified receptors.

3.1 Receptors of Concern

The receptors selected for this HHRA are consistent with those assessed in the previous 2020 air dispersion modelling completed by WSP for the Station. The following human health receptors were identified:

- Schools or Child Care Facilities – students (children and teenagers) who are attending classes on a full-time basis and toddlers and young children who attend a daycare facility on a full-time basis;
- Hospitals or Health Care Facilities – adult patients who are receiving care at hospitals whose health is already compromised, and elderly adults who reside in long-term care facilities; and
- Residences – individuals of all ages who live in the residential communities near the Station.

The human health receptors evaluated in the HHRA are summarized in Table 1 and on Figure 2. The receptors include four schools, one hospital, and the nearest residence to the Station. The acute inhalation assessment also considered that people may spend short amounts of time at the MPOI. The MPOI location has the highest predicted concentrations that occur just outside the Station boundary and may be a different geographical location for each COPC depending on where emissions are released from the Station. The MPOI locations for the chronic inhalation COPCs do not overlap with any of the receptor locations evaluated (WSP 2023), and people are not expected to spend extended amounts of time at these locations. Therefore, the MPOI was not considered relevant for long-term exposures and was not evaluated in the chronic assessment.

Table 1: Human Health Receptors Identification

Human Health Receptor	UTM Easting (m)	UTM Northing (m)	Distance from the Station[a] (km)
Nearest Residence	497827	6729321	0.34
Christ the King Elementary School	498063	6729897	0.93
Grey Mountain Primary School	498813	6729569	1.33
F.H. Collins Secondary School	497813	6730641	1.55
Selkirk Elementary School	497938	6730311	1.26
Whitehorse General Hospital	497619	6731520	2.41

Note:
(a) Distance was calculated based on a central point within the modelled boundary.

3.2 Exposure Pathways

An exposure pathway requires the following three components:

- The presence of a chemical substance;
- An exposure medium for contact (e.g., air); and
- An exposure route from the medium to the receptor (e.g., inhalation).

An exposure pathway is not complete unless all three components are present. If a pathway is incomplete, no significant exposure is anticipated to occur.

The exposure pathway of concern for this HHRA is through inhalation of ambient air. Criteria air contaminants are emitted from the Station into ambient air as vapours and may be subsequently inhaled by human health receptors within the HHRA study area. Other exposure routes such as deposition to soil and oral exposure to human are not expected to be a significant pathway for criteria air contaminants and were not evaluated in the HHRA.

3.3 Constituents of Potential Concern (COPCs)

The criteria air contaminants identified as COPCs are consistent with those assessed in the previous 2020 air dispersion modelling completed by WSP for the Station (WSP 2020). These include key criteria air contaminants from diesel and natural gas fuel combustion such as NO_x, CO, SO_2, TSP, $PM_{2.5}$, PM_{10} and DPM. COPCs were screened and retained for further evaluation in the HHRA based on the following criteria:

- Maximum predicted concentrations exceeded the selected air quality threshold at any human health receptor location.
- It is a non-threshold constituent, which means that any level of exposure to that constituent may result in potential adverse health effects. Nitrogen dioxide (NO_2), $PM_{2.5}$, and PM_{10} are considered to be non-threshold constituents (Health Canada 2016a, b), therefore they were identified as COPCs and retained for further evaluation at every human health receptor location even if predicted concentrations were below selected screening criteria.

The selection criteria of air quality thresholds used is described in Section 3.3.1. The screening of COPCs for acute and chronic inhalation are detailed in Sections 3.3.2 and 3.3.3, respectively.

3.3.1 Selection of Air Quality Thresholds

Air quality thresholds are developed based on the duration of exposure. For this HHRA, the air quality thresholds selected to evaluate acute and chronic exposures were selected based on the following definitions:

- Acute – single or intermittent exposures lasting up to 24-hours; and
- Chronic – repeated, exposures over longer term periods that are conservatively assumed to take place over a lifetime.

Where available, air quality thresholds were compiled from the Yukon Ambient Air Quality Standards (YAAQS; Yukon Government 2019) and other regulatory agencies that regularly review and update the science supporting these thresholds, provide supporting documentation, and/or engage a peer-review process in their development protocol. For the purposes of this HHRA, these other sources included:

- Canadian Council of Ministers of the Environment (CCME 1999, 2023)
- British Columbia Ministry of Environment and Climate Change Strategy (BC ENV 2021)
- Agency for Toxic Substances and Disease Registry (ATSDR 2023)
- United States Environmental Protection Agency (US EPA 2023)
- World Health Organization (WHO 2021)
- Ontario Ministry of the Environment, Conservation and Parks (MECP 2021)
- California Office of Environmental Health Hazard Assessment (Cal OEHHA 2023)
- Texas Commission on Environmental Quality (TCEQ 2023)
- Health Canada (2016c)

Each of these agencies has derived air quality thresholds based upon a prescribed level of protection. Most often, these air quality thresholds are presented as air concentrations at or below which health effects (or other effects such as odour) are not expected to occur, accounting for uncertainty and additional safety factors. Therefore, a predicted air concentration above a given threshold indicates that a health effect is possible but not certain. Further assessment is required to determine the likelihood of that health effect occurring.

The air quality thresholds have been derived by each regulatory agency to achieve a target risk level that is considered to be protective of human health. The regulatory agencies set their target risk level based on science policy decisions on what is an acceptable risk to human health. In setting target risk levels for acute exposures, regulatory agencies generally consider the non-carcinogenic and irritant health effects of chemicals, with the target risk level being defined as a hazard quotient (HQ). In setting target risk levels from chronic exposures, regulatory agencies consider both carcinogenic and non-carcinogenic effects of chemicals, with the target risk level for carcinogens being defined by an incremental lifetime cancer risk (ILCR).

The air quality thresholds applied in the HHRA for acute and chronic exposures were selected based on the following considerations:

- Availability of thresholds from the YAAQS, as per regulatory requirements;
- Protective of public health based on the current scientific understanding of the health effects known and/or suspected to be associated with exposures to criteria air contaminants;
- Protective of sensitive individuals through the use of appropriate uncertainty factors; and
- Supported by adequate documentation.

The available and selected 1-hour, 24-hour and annual air quality thresholds are presented in Tables A-C. The toxicological endpoints (e.g., respiratory effects) and a summary of the supporting technical rationale for the thresholds (if available) are also included in the table.

The Yukon government provides YAAQS for criteria air contaminants (NO_2, SO_2, TSP, $PM_{2.5}$, and PM_{10}) for 1-hour, 24-hour, and/or annual averaging periods, which were used for the identification of COPCs for further assessment (Yukon Government 2019). No supporting technical rationale for the YAAQS was available; however, it is noted that the standards for NO_2, SO_2 and $PM_{2.5}$ are consistent with the Canadian Ambient Air Quality Standards (CAAQS) from the CCME (2023).

The COPC screening consisted of comparing the maximum predicted cumulative air concentrations (i.e., incorporating background concentrations with predicted facility concentrations where available) for each COPC to the selected air quality criteria for 1-hour, 24-hour, and annual averaging periods. As updated YAAQS for NO_2 and SO_2 will be effective as of 1 January 2025, predicted concentrations were compared to both current and 2025 standards to evaluate air quality as the Station continues to operate.

Air predictions for TSP were modelled, however the available air quality criteria are not based on health-endpoints (Table B and C). No supporting technical rationale for the YAAQS was available; however, it is noted that the YAAQSs for TSP (24-hour and annual) is consistent with the CCME National Ambient Air Quality Objective (NAAQO; 1974, as cited by CCME 1999). No supporting documentation is available for the NAAQOs. For the evaluation of effects to human health from particulates, the federal government has focused on particulate matter, particularly $PM_{2.5}$, as it has been shown to be associated with a higher health risk (WHO 2021). Therefore, this assessment evaluates particulates through the assessment of $PM_{2.5}$ and PM_{10} as these are more reflective of potential health risk.

3.3.2 Screening – Acute Inhalation

Maximum predicted cumulative air concentrations of COPCs (i.e., predicted facility concentrations and background, where available) for the two scenarios (Expected and Emergency) were screened against the selected acute air quality thresholds (i.e., current and 2025 standards, if applicable) for the 1-hour and 24-hour averaging periods, shown in Tables D and E, respectively. Predicted cumulative air concentrations are based on the sum of facility concentrations and background concentrations, where available. Available background concentrations (i.e., for NO_2, $PM_{2.5}$, and PM_{10}) were shown in Table D and E for context. A COPC was retained for further assessment if its predicted maximum concentration exceeded the selected air quality criteria at any human health receptor location (including the MPOI), or if it was considered a non-threshold constituent. Screening of predicted 75th and 95th percentile concentrations was provided for context and to support the risk characterization. A summary of the magnitude of exceedance above the air quality criteria (% YAAQS or %Threshold for DPM) is provided in Tables H and I for 1-hour and Tables K and L for 24-hour and summarized below.

For predicted 1-hour concentrations, the COPCs with maximum concentrations above the air quality criteria are summarized as follows:

- **NO_2**: Maximum predicted concentrations of NO_2 exceeded both current and 2025 YAAQS for all receptor locations (including the MPOI) for both scenarios.
  - In the Expected scenario, predicted maximum NO_2 concentrations at the MPOI were over 2.5 times (254%) the current YAAQS, and over 3.5 times (363%) the 2025 YAAQS. For human health receptor locations, predicted maximum NO_2 concentrations ranged from 1.4 (141%) to 1.7 (173%) times over the current YAAQS, while predicted maximum concentrations were generally greater than 2 times (201-248%) over the 2025 YAAQS.

- In the Emergency scenario, predicted maximum NO_2 concentrations at the MPOI were nearly 5 times (491%) the current YAAQS, and about 7 times (702%) the future 2025 YAAQS. For human health receptor locations, predicted maximum NO_2 concentrations were 1.6 (163%) to 2.6 (261%) times over the current YAAQS, while predicted maximum concentrations were 2.3 (233%) to 3.7 (373%) times over the 2025 YAAQS. The magnitude of exceedance of the YAAQS was lowest at the Whitehorse General Hospital and highest at the nearest residence for both current and 2025 YAAQS.

- **DPM**: Maximum predicted concentrations of DPM for the Expected scenario exceeded the selected air threshold at the MPOI, nearest residence, Grey Mountain Primary School, and Selkirk Elementary school, while maximum predicted concentrations for the Emergency scenario exceeded the selected air quality criteria for MPOI and all human health receptor locations assessed.
  - In the Expected scenario, predicted maximum DPM concentrations at the MPOI were over 6 times (634%) the threshold, while predicted concentrations ranged from 1.1 (105%) to 2.8 (280%) times over the threshold for human health receptor locations. The magnitude of exceedance of the air quality criteria was lowest in Selkirk Elementary School and highest at the nearest residence.
  - In the Emergency scenario, predicted maximum DPM concentrations at the MPOI were nearly 16 times (1607%) the selected threshold. For human health receptor locations, predicted maximum DPM concentrations were 1.8 (183%) to 5.4 (537%) times over the threshold. The magnitude of exceedance of the air quality criteria was lowest at the Whitehorse General Hospital and highest at the nearest residence.

For predicted 24-hour concentrations, the MPOI was the only receptor with concentrations above the air quality criteria. The COPCs with maximum predicted concentrations above the air quality criteria are summarized as follows:

- **$PM_{2.5}$**: Maximum predicted concentrations of $PM_{2.5}$ exceeded the current YAAQS (does not change in 2025) at the MPOI for both scenarios.
  - In the Expected scenario, predicted maximum $PM_{2.5}$ concentrations at the MPOI were 1.2 times (119%) greater than the YAAQS, while predicted maximum concentrations were below the YAAQS (67% to 70% of the YAAQS) for human health receptor locations.
  - In the Emergency scenario, predicted maximum $PM_{2.5}$ concentrations at the MPOI were 1.7 (170%) times over the YAAQS, while predicted maximum concentrations were below the YAAQS (70% to 77% of the YAAQS) for human health receptor locations.
- **PM_{10}**: Maximum predicted concentrations of PM_{10} exceeded the current YAAQS (does not change in 2025) at the MPOI for both scenarios.
  - In the Expected scenario, predicted maximum $PM_{2.5}$ concentrations at the MPOI were 1.1 (111%) times over the YAAQS, while predicted maximum concentrations were below the YAAQS (73% to 79% of the YAAQS) for human health receptor locations.
  - In the Emergency scenario, predicted maximum PM_{10} concentrations at the MPOI were 1.5 (154%) times over the YAAQS, while predicted maximum concentrations were below the YAAQS (77% to 92% of the YAAQS) for human health receptor locations.

3.3.3 Screening – Chronic Inhalation

Predicted cumulative air concentrations of COPCs (i.e., maximum) were screened against the selected chronic air quality criteria (i.e., current and 2025 standards, if applicable) for the annual averaging period, shown in Table F. Diesel particulate matter (DPM) is associated with both non-carcinogenic and carcinogenic health effects, therefore non-carcinogenic and carcinogenic thresholds were used in the screening. Where available, background concentrations were incorporated into predicted concentrations from the facility to estimate predicted cumulative air concentration. Background concentrations for NO_2, and $PM_{2.5}$ were shown in Table F for context. A constituent was retained for further assessment if its predicted maximum concentration exceeded the selected air quality criteria at any human health receptor location (excluding the MPOI), or if it was considered a non-threshold constituent. The MPOI locations do not overlap with any of the receptor locations evaluated. Therefore, the MPOI was not considered relevant for long-term exposures and was not evaluated in the chronic assessment. Exposure to COPCs at the MPOI by human receptors may occur for short durations on an infrequent basis, therefore, the MPOI was only evaluated in the acute assessment (Section 3.3.2). The Emergency scenario is predicted to occur once in 20 years for a cumulative total of 1 to 5 days during a 2-week period. Therefore, it is not considered relevant for long-term exposures and the scenario was not retained for further chronic assessment. Predicted annual concentrations in the Emergency scenario are provided in Table F for reference.

The COPCs with maximum predicted concentrations above the annual air quality criteria are summarized as follows:

- **NO_2:** Annual predicted concentrations were above the 2025 YAAQS at the Whitehorse General Hospital for the Emergency scenario only.
- **DPM**: Annual predicted concentrations exceeded the selected carcinogenic air quality criteria at all receptor locations. There were no exceedances of the non-carcinogenic air quality criteria.

NO_2, and $PM_{2.5}$ are non-threshold constituents, which means there is a potential health risk at any level of exposure for these chemicals as health effects may occur at very low concentrations (Health Canada 2016a, b). Therefore, $PM_{2.5}$ and NO_2 were retained for all receptor locations and carried forward in the assessment even though they did not screen over the air quality criteria. Only the Expected scenario was evaluated for chronic inhalation as long-term exposure is not anticipated for the Emergency scenario.

3.3.4 Screening Summary

A summary of the COPCs retained for HHRA is presented in Table 2. For the 1-hour period, NO_2 and DPM were carried forward for the acute inhalation assessment. For the 24-hour period, $PM_{2.5}$, and PM_{10} were carried forward for the acute inhalation assessment. For the annual period, NO_2, and $PM_{2.5}$, and DPM (carcinogenic effects only) were carried forward for the chronic inhalation assessment. The Emergency scenario was not evaluated in the chronic inhalation assessment (based on annual predictions) because the Emergency scenario is anticipated to occur once in 20 years for a total of 1 to 5 days during a 2-week period.

Table 2: Summary of COPCs and Receptors Retained in the Inhalation Human Health Risk Assessment

Scenarios	Exposure Period	Averaging Period	COCs	Receptor Locations
Expected	Acute	1-hour	NO_2, DPM	NO_2: All receptors DPM: MPOI, nearest residence, Grey Mountain Primary School, Selkirk Elementary School
		24-hour	$PM_{2.5}$, PM_{10}	MPOI [(a)]
	Chronic	Annual	NO_2, $PM_{2.5}$, DPM	NO_2 and $PM_{2.5}$: N/A[(a)] DPM: All receptors
Emergency (N-1 event)	Acute	1-hour	NO_2, DPM	All receptors
		24-hour	$PM_{2.5}$, PM_{10}	MPOI [(a)]

Notes:

N/A= No receptor location screened above the selected air quality criteria.

(a) Nitrogen dioxide and particulate matter ($PM_{2.5}$ and PM_{10}) are non-threshold constituents and were assessed at each receptor location, regardless of whether the predicted concentration did not exceed the criteria.

3.4 Conceptual Site Model

A Conceptual Site Model was developed for human health to summarize the results of the problem formulation. The Conceptual Site Model includes the constituents that may be present at or originating from the site that may exceed air quality criteria for the protection of human health (i.e., COPCs; NO_2, $PM_{2.5}$, PM_{10}, and DPM), the environmental media in which the exceedances occur (i.e., air), people that may use the HHRA study area (i.e., human health receptors), and how people using the HHRA study area may come in contact with the COPCs (i.e., inhalation). The Conceptual Site Model is provided in Figure 3.

4.0 EXPOSURE ASSESSMENT

Exposure assessment involves characterizing the degree to which receptors are exposed to COPCs via the identified exposure pathways (i.e., inhalation). The exposure assessment is conducted for each COPC-pathway-receptor combination identified during the problem formulation to estimate the concentrations that human receptors are potentially exposed to. For the purposes of the exposure assessment, it was assumed that the predicted concentrations of COPCs in outdoor ambient air were equal to that in indoor air (i.e., established equilibrium).

4.1 Acute Exposure Estimation

For the acute inhalation assessment, the exposure time for each receptor at each receptor location is assumed to be the same as the averaging times of the acute air quality predictions (i.e., 1-hour and 24-hour). As such, the exposure estimates are the 1-hour and 24-hour predicted air concentrations provided in Tables D and E, respectively.

4.2 Chronic Exposure Estimation

For the chronic inhalation assessment, which relies on annual air quality predictions, exposure assessment involves estimating the amount of time that people might spend at a receptor location where they may be exposed to COPCs in air. The adult resident was evaluated at the nearest residence as well as the Whitehorse General Hospital as there are long-term residents at the hospital. Because there is no amortization of exposure, this evaluation is protective of effects of NO_2 and $PM_{2.5}$ for all life stages (not just the adult). The composite resident was evaluated at the nearest residence for carcinogenic effects of DPM. Teachers, students (non-carcinogenic exposure only), and hospital workers were evaluated the school receptor locations and the Whitehorse General Hospital. The exposure factors for the adult resident, composite residents, hospital worker, teacher and student are provided in Table 3. Exposure factors were obtained from (Health Canada 2021), unless otherwise noted.

Table 3: Receptor Exposure Factors

Receptors	Hours per Day	Days per Week	Weeks per Year	Total Years	Life Expectancy
Adult Resident	24	7	52	60	80
Composite Resident	24	7	52	Infant: 0.5 Toddler: 4.5 Child: 7 Teen: 8 Adult: 60	80
Hospital Worker/ Teacher/Student	10[(a)]	5	48	35	80

Note:

(a) Consistent with a commercial worker (Health Canada 2021).

5.0 TOXICITY ASSESSMENT

The toxicity (or hazard) assessment of an HHRA provides the basis for evaluating what is an acceptable or safe level of exposure to a COPC and what level of exposure may adversely affect the health of receptors. For an inhalation assessment, this involves estimating the concentration in air that people can be exposed to without resulting in adverse health effects. This concentration is called the toxicity reference value (TRV). The TRV is used as a benchmark for comparison with the estimated concentration of the COPC in air during risk characterization.

For non-carcinogenic chemicals, TRVs are expressed as reference concentrations (RfCs) for the inhalation pathway. A RfC is an estimate of continuous inhalation exposure to a chemical by the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects over a lifetime. RfCs are generally derived for chronic exposure periods (i.e., many years to a lifetime).

For carcinogenic chemicals, the TRVs are expressed as inhalation unit risks (IURs) for the inhalation pathway. An IUR is the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a substance at a concentration of 1 $\mu g/m^3$ in air. DPM was the only COPC that was considered to be carcinogenic (Cal OEHHA 2023), however there is some uncertainty in this classification as discussed below and in Section 7.0.

Criteria Air Contaminants

For the acute inhalation assessment, the selected screening criteria for the 1-hour and 24-hour averaging periods presented in Tables A and B were adopted as TRVs for comparison to the 1-hour and 24-hour predictions.

For the chronic inhalation assessment, the same sources described for the COPC screening (Section 3.3.1) were considered to select RfCs and IURs. In the case of non-threshold constituents (i.e., NO_2, $PM_{2.5}$, and PM_{10}), annual air quality criteria were adopted for use as TRVs as RfCs are not available for these parameters.

Diesel Particulate Matter

For DPM, the IUR of 0.0003 $(\mu g/m^3)^{-1}$ from the Cal OEHHA was selected given that a carcinogenic TRV was not available from Health Canada or US EPA. Selection of an RfC for DPM was not required for this assessment as all annual predicted concentrations were below the non-carcinogenic air quality criteria.

The Cal OEHHA inhalation unit risk is based on epidemiological studies where railroad workers had increased lung tumour incidence (Garshick et al. 1987, 1988; as cited in Cal OEHHA 2011). The lung tumour incidence data were paired with exposure concentrations from different studies (Woskie at al. 1988a, b; as cited in Cal OEHHA 2011) to estimate a range of lung cancer risk ($1.3x10^{-4}$ to $2.4x10^{-3}$ $[\mu g/m^3]^{-1}$), with a reasonable upper estimate of $3x10^{-4}$ $(\mu g/m^3)^{-1}$. One major uncertainty around the inhalation unit risk is that the exposure concentrations of DPM were not measured with the railroad worker studies and occupational exposure levels were estimated using a different study. While Cal OEHHA estimated an IUR from the epidemiological studies, they have identified the following uncertainties associated with its derivation:

- Assuming that dose-response is linear at low levels of exposure.
- Use of lung cancer mortality rates as an approximation for lung cancer incidence (use of lung cancer incidence would result in a slightly higher estimate).
- Use of the respiratory particulate fraction to represent diesel exhaust.
- Assuming occupational exposures can be extrapolated to environmental exposures.

- Shop workers were excluded from some of the analyses because many of them worked near engine sheds where exposure to DPM is very high.
- Assumption that exposure to DPM was greatest in 1959 (year corresponding to increased use of diesel locomotives) and that exposure to DPM declined in 1960 (year corresponding to use of newer and cleaner locomotives).
- Inclusion of cohorts who reported cigarette smoking.
- Mathematical modelling uncertainties.
- Sensitive individuals were not considered (e.g., women and children).
- Accounting for potential “healthy worker effect”, which is the phenomenon where workers typically have lower rates of morbidity and mortality than the general population.

Studies conducted since the Cal OEHHA’s evaluation in 1998 indicated that there are too many uncertainties with the available studies to confidently derive inhalation risk levels for DPM. The US EPA (2003) has not derived a carcinogenic risk level for DPM, citing inadequate epidemiological data to derive a dose-response relationship. The US EPA also indicated that animal carcinogenicity data were not suitable for extrapolation to humans to derive a carcinogenic risk level for DPM. Health Canada (2016c) conducted a detailed review of studies published since the Cal OEHHA (1998) and US EPA (2003) evaluation and concluded that there is sufficient evidence linking diesel exhaust exposure to lung cancer and suggestive evidence linking diesel exhaust exposure to bladder cancer. However, Health Canada (2016c) also indicated that there are uncertainties with quantifying unit risks based on rat bioassays of lung tumour induction and has not derived a carcinogenic risk level or an air quality criterion for DPM based on animal studies.

6.0 RISK CHARACTERIZATION

Risk characterization, the final component of a HHRA, integrates the previous stages (exposure and toxicity assessments) to evaluate whether COPC exposure has the potential for adverse health effects to occur (i.e., risk). This is determined by calculating risk estimates in which the estimated exposures of the receptors (i.e., estimated concentrations of COPCs in air) is compared with the level of exposure that is considered to be acceptable or safe (i.e., air quality criteria or TRVs). Additionally, uncertainties and conservatism in each HHRA component are taken into consideration in evaluating the potential adverse health effects and associated risk.

6.1 Acute Inhalation Assessment

For the assessment of acute exposures, only non-carcinogenic effects were evaluated as the COPCs that were carried forward from screening (Section 3.3.2) are not considered to be carcinogenic. Regulatory agencies assume that for non-carcinogens, there is a dose or concentration below which no harmful health effects will occur. As such for non-carcinogens, health risk is estimated through the calculation of a hazard quotient (HQ), defined as the ratio between the estimated exposure and selected air quality criteria (e.g., TRV). HQs were calculated for COPCs retained for evaluation of 1-hour and 24-hour acute inhalation, as follows:

$$Hazard\ Quotient = \frac{COPC\ Concentration\ in\ Air\ (\mathrm{\mu g/m^3})}{Acute\ inhalation\ threshold\ (\mathrm{\mu g/m^3})}$$

The HQ provides an indication of whether there is a potential health concern with the estimated exposures. The acceptable risk threshold for inhalation exposure for this assessment is 0.2. Predicted air concentrations do not account for background indoor air exposure for the COPCs, therefore the target HQ of 0.2 was selected as a conservative approach. Given the conservative assumptions are used in our calculations and by regulatory agencies in the development of air quality criteria/TRVs, HQs greater than 0.2 do not necessarily mean that adverse human health effects will occur. It does, however, indicate that further assessment may be required.

Conservative assumptions were applied in the HHRA to avoid underestimating risks. A negligible level of risk means risk estimates were below the level of concern (i.e., HQ less than 0.2).

Nitrogen dioxide, $PM_{2.5}$, and PM_{10} are non-threshold substances, which means a threshold concentration below which no adverse effects (i.e., any level of increased exposure may result in negative health effects) are expected is not likely to exist for these constituents (Health Canada 2016a, b). As there is no prescribed method for assessing health risks of non-threshold constituents; NO_2, $PM_{2.5}$, and PM_{10} were assessed using the same approach as the other threshold COPCs (i.e., following a HQ approach) with the consideration in the risk characterization that there is no threshold concentration below which adverse effects are unlikely to exist.

6.1.1 1-Hour Averaging Time

Hazard quotients (HQs) for the two scenarios were calculated at receptor locations where the predicted maximum air concentration exceeded the screening threshold, or at all locations for non-threshold constituents. NO_2 and DPM were identified as COPCs for the 1-hour averaging time. The 1-hour HQs for NO_2 and DPM are provided in Table G and are discussed below.

6.1.1.1 Nitrogen Dioxide (NO_2)

Maximum predicted NO_2 concentrations exceeded the acute 1-hour screening value for both current and future guidelines at all locations in both scenarios. HQs were calculated from the maximum predicted concentrations, as well as for other statistics representing upper estimates of exposure (95th and 75th percentiles) which are shown for context.

Hazard quotients, magnitudes, and contingent frequencies of exceedance for NO_2 are presented in Table G and Table H, respectively. The findings for the two scenarios are discussed below:

- **Expected scenario**:
  - The calculated 1-hour HQs for NO_2 were above the target HQ of 0.2 for both current and future standards. HQs (based on maximum predicted concentration) were highest at the MPOI (Current HQ = 2.5; 2025 HQ = 3.6), followed by the nearest residence (Current HQ = 1.7; 2025 HQ = 2.5). Hazard quotients (HQs) for other statistics (95th and 75th percentiles) were lower than those based on maximum predicted concentrations but were still above 0.2 for the MPOI and receptor locations evaluated.
  - The predicted contingent frequency of exceedance (calculated based on maximum predicted concentrations) over the current standard at the MPOI was 52%, whereas the predicted contingent frequency of exceedance over the 2025 standard was 60%. This means that for over half of the year, the combination of worst-case maximum emissions and prevailing meteorology could result in exceedance of the hourly standard. However, maximum Station emissions are only expected to occur for approximately 6 hours in any given two-week winter period, therefore the actual number of hours where exceedances occur would likely be considerably lower.
  - For human health receptor locations, the predicted contingent frequency of exceedance of the current standard was generally low (2.7-5.4%), where the frequency of exceedance was lowest at the Grey Mountain Primary School and highest at the F.H. Collins Secondary School. The predicted contingent frequencies of exceedance were higher for the 2025 standard (10-25%), where contingent frequency of exceedance was lowest at the Grey Mountain Primary School and highest at the Whitehorse General Hospital. The predicted contingent frequency of exceedance calculated based on the 95th (Current: 47%, MPOI only; 2025: 55% for MPOI, 5-20% for human health receptor locations) and 75th (Current: 27%, MPOI only; 2025: 35%) percentiles were comparatively lower for the MPOI and all human health receptor locations. For instance, the predicted contingent frequencies of exceedance at the MPOI were reduced by nearly half at the 75th percentile (e.g., 52 to 27% for current standard; 60 to 35% for 2025 standard).
  - For both current and future standards, the HQs were above 0.2 at the human health receptor locations evaluated. As the YAAQS will be reduced in 2025 (Current: 113 µg/m^3; 2025: 79 µg/m^3), the calculated HQ and predicted contingent frequency of exceedance based on the 2025 standard are higher.
- **Emergency scenario**:
  - The calculated 1-hour HQs for NO_2 were above the target HQ of 0.2 for both current and future standards. HQs (based on maximum predicted concentration) were highest at the MPOI (Current HQ = 4.9; 2025 HQ = 7.0), followed by the nearest residence (Current HQ = 2.6; 2025 HQ = 3.7). Hazard quotients (HQs) for other statistics (predicted 95th and 75th percentiles) were lower than those based on maximum predicted concentrations but were still above 0.2 for the MPOI and the receptor locations evaluated.

- The predicted contingent frequency of exceedance (based on maximum predicted concentrations) at the MPOI was 56% and 68% for the current and 2025 standards, respectively. This means that, for over half of the year, the combination of worst-case maximum emissions and prevailing meteorology could result in exceedance of the hourly standard. However, as an Emergency event is only expected to occur for a 1-to-5-day period every 20 years, the actual number of hours exceeding the standard is not expected to be more than 120 (1.4% of year).
- For human health receptor locations, the predicted contingent frequency of exceedance was generally low for the current standard (2.9-12%) and higher for the 2025 standard (11-34%), where contingent frequency of exceedance was lowest at the Grey Mountain Primary School and highest at the Whitehorse General Hospital for both standards. The predicted contingent frequency of exceedance calculated based on the 95th (Current: 51% [MPOI], 0.64-7% [human health receptor locations]; 2025: 63% [MPOI], 6.1-29% [human health receptor locations]) and 75th (Current: 31%, MPOI only; 2025: 23% [MPOI], 2.1-9.1% [human health receptor locations]) percentiles decrease and are comparatively lower than predicted frequencies of exceedance based on maximum predicted concentrations for all human health receptor locations evaluated.
- For both current and future standards, the HQs were above 0.2 at all human health receptor locations evaluated. As the YAAQS will be reduced in 2025 (Current: 113 µg/m^3; 2025: 79 µg/m^3), the calculated HQ and predicted contingent frequency of exceedance based on the 2025 standard are higher.

- **Comparison between scenarios**: The calculated 1-hour HQs for NO_2 were above 0.2 for both current and future standards at all human health receptor locations evaluated in both scenarios. In both scenarios, HQs were highest at the MPOI, followed by the nearest residence. Overall, HQs and the predicted contingent frequency of exceedance for the Emergency scenario were generally higher than results from the Expected scenario.

It should be noted that a target HQ of 0.2 is a conservative approach and was chosen to account for the uncertainty associated with background concentrations of NO_2 in indoor air. In addition, contingent frequencies of exceedance were calculated based on worst-case maximum emission rates and prevailing meteorology and may be overestimated.

Nitrogen dioxide predictions were also calculated conservatively assuming 100% conversion of modelled NOx to NO_2 (total conversion method). If the total conversion method resulted in a cumulative (modelled plus ambient baseline conditions) air prediction above the air criteria, the ozone limiting method (OLM) was applied to estimate NO_2 concentrations using an algorithm to provide more realistic estimates. Therefore, emphasis was placed on the HQs estimated using the OLM. However, the following should be noted when interpreting the NO_2 results:

- In the atmosphere, there will be a certain amount of NO_2 in NOx, this is the ambient equilibrium ratio. For this assessment an equilibrium ratio of 1.0 was selected for conservatism, rather than the default value of 0.9 which is provided in the BC ENV (2022) guidance document.
- The ambient baseline of NO_2 is conservative as it is based on the statistical form of 98th percentile of the daily maximum 1-hour concentrations.
- The predicted NO_2 concentrations emitted from the Station are conservative as the permanent units were modelled at full capacity for all hours of the year and the mobile diesel generators were conservatively modelled each hour from December 1 to April 30 instead of typical operations where only the required units are run in winter to meet demand.

6.1.1.2 Diesel Particulate Matter (DPM)

Hazard quotients (Table G), magnitude and contingent frequency of exceedance information (Table I) are presented for DPM at receptor locations where the predicted maximum concentration exceeded the air quality criteria. HQs were calculated from the maximum predicted concentrations, as well as other statistics representing upper estimates of exposure (95th and 75th percentiles) which are provided for context. Baseline air concentrations were not available, therefore DPM air predictions are for emissions from the facility only. For the Expected scenario, predicted maximum DPM concentrations at Christ the King Elementary School, F.H Collins Secondary School and the Whitehorse General Hospital were below the air quality threshold, therefore these receptor locations were not retained and are not assessed further. The HQs (based on maximum predicted concentrations), magnitude, and contingent frequency of exceedance are discussed below.

- **Expected scenario**:
  - The calculated 1-hour HQs (based on maximum predicted concentrations) for DPM were above the target HQ of 0.2 for the MPOI and the human health receptor locations evaluated. HQs were highest at the MPOI (HQ= 6.3), followed by the nearest residence (HQ= 2.8). For statistics representing the upper estimates of exposure (predicted 95th and 75th percentiles), the HQs were below 0.2, with the exception of the MPOI for which the HQs were reduced, but still above 0.2.
  - The predicted contingent frequency of exceedance (based on maximum predicted concentrations) at the MPOI was 27%. This means that for approximately a quarter of the year, the combination of worst-case maximum emissions and prevailing meteorology could result in exceedances of the hourly TRV. However, maximum Station emissions are only expected to occur for approximately 6 hours in any given two-week winter period, therefore the actual number of hours where emissions are expected to exceed hourly TRV exceedances are likely to be considerably lower.
  - For human health receptor locations, the predicted contingent frequencies of exceedance based on maximum concentrations were very low (0.011-0.38% of the year). The predicted contingent frequency of exceedance based on the 95th (22%) and 75th (2.5%) percentile at the MPOI were comparatively lower than the contingent frequency of exceedance based on the maximum (27%). Predicted contingent frequencies of exceedance were not calculated for the 95th and 75th percentiles for the human health receptor location as predicted concentrations did not exceed the air quality criteria.
- **Emergency scenario**:
  - The calculated 1-hour HQs (based on maximum predicted concentrations) for DPM were above the target HQ of 0.2 for the MPOI and all human health receptor locations. HQs were highest at the MPOI (HQ= 16), followed by the nearest residence (HQ= 5.4). For other statistics (predicted 95th and 75th percentiles), the HQs remained above 0.2 for the MPOI, but were below 0.2 at all human health receptor locations except for the nearest residence and F.H. Collins Secondary School at the 95th percentile.
  - The predicted contingent frequency of exceedance (based on maximum predicted concentrations) at the MPOI was 44% over the TRV. This means that for nearly half the time during the year, the combination of an Emergency scenario event and prevailing meteorology could result in exceedances of the hourly TRV. However, an Emergency event is only expected to occur for 1-5 days once every 20 years, therefore actual number of hours of TRV exceedance should not be more than 120 (1.4% of year).

  - For human health receptor locations, the predicted contingent frequencies of exceedance based on the maximum concentration were low (0.046-1.7%). The predicted contingent frequencies of exceedance based on the 95th (39%) and 75th (19%) percentile at the MPOI were comparatively lower than the contingent frequency of exceedance based on the maximum (44%). No contingent frequencies of exceedance were calculated based on 95th and 75th percentiles for the human health receptor locations as predicted concentrations did not exceed the air quality criteria.

- **Comparison between scenarios:** The calculated 1-hour HQs for DPM were above the target HQ of 0.2 at all locations evaluated for both scenarios. In both scenarios, HQs were highest at the MPOI, with HQs (based on maximum predicted concentrations) of 6.3 for the expected scenario and 16 for the emergency scenario. For human health receptor locations, HQs were highest for the nearest residence, with HQs (based on maximum concentration) of 2.8 for the Expected scenario and 5.4 for the Emergency scenario. However, it should be noted that the predicted contingent frequencies of exceedance at the nearest residence were low (e.g., 0.38% Expected scenario, 1.7% Emergency scenario). Overall, HQs and the predicted contingent frequency of exceedance for the Emergency scenario were generally higher than results from the Expected scenario.

It should be noted that using a target HQ of 0.2 is a conservative approach which was selected because predicted air concentrations do not account for background air concentrations for DPM. In addition, contingent frequencies of exceedance were calculated based on worst-case maximum emission rates and prevailing meteorology.

6.1.2 24-Hour Averaging Time

Hazard quotients (HQs) for the two scenarios were calculated at receptor locations where the predicted maximum air concentration exceeded the screening threshold, or at all locations evaluated for non-threshold constituents. $PM_{2.5}$ and PM_{10} were identified for the 24-hour averaging time as these COPCs exceeded their respective criteria for at least one of the locations evaluated and all receptor locations were retained as these COPCs are non-threshold substances. The 24-hour HQs for $PM_{2.5}$ and PM_{10} are provided in Table J and are summarized below.

6.1.2.1 $PM_{2.5}$

Hazard quotients (Table J), and magnitudes and contingent frequencies of exceedance (Table K) are presented for $PM_{2.5}$ for all receptor locations evaluated. Hazard quotients (HQs) were calculated from the maximum predicted concentrations, as well as other statistics representing upper estimates of exposure (predicted 95th and 75th percentiles) which are shown for reference.

- **Expected scenario**:

  - The calculated 24-hour HQs for $PM_{2.5}$ were above the target HQ of 0.2 for the MPOI and the human health receptor locations evaluated. Hazard quotients (HQs) based on maximum and 95th percentile predicted concentrations were similar and were highest at the MPOI (HQ = 1.2), followed by the nearest residence (HQ = 0.7). For the predicted 75th percentile, the HQ at the MPOI was lower (HQ = 1.0), but HQs at the human health receptor locations (HQ=0.7) remained similar to those based on maximum (HQ = 0.7) and 95th percentiles (HQ=0.7). The HQs remained above 0.2 for all receptor locations and statistics assessed.

  - The predicted contingent frequency of exceedance (based on maximum predicted concentrations) at the MPOI was 22% This means that for approximately a quarter of the year, the combination of worst-case maximum emissions and prevailing meteorology could result in exceedances of the daily standard. However, as maximum station emissions are only expected for approximately 6 hours in any given two-week winter period, the actual number of full days where the daily standard is exceeded would likely be considerably lower. The predicted contingent frequency of exceedance was comparatively lower for the 95th percentile (17%) but was similar for the 75th percentile (26%). The contingent frequencies of exceedances were not calculated for human health receptor locations as maximum concentrations did not screen above air quality criteria.

- **Emergency scenario**:

  - The calculated 24-hour HQs for $PM_{2.5}$ were above the target HQ of 0.2 for the MPOI and the human health receptor locations evaluated. Hazard quotients (HQs) based on maximum and 95th percentile predicted concentrations were similar and were highest at the MPOI (HQ= 1.7), followed by the nearest residence (HQ= 0.8 and 0.7). For the predicted 75th percentile, the HQ at the MPOI was lower (HQ = 1.3), but HQs at the human health receptor locations (HQ=0.7) remained similar to those based on maximum (HQ = 0.7) and 95th (HQ = 0.7) percentiles. The HQs remained above 0.2 for all receptor locations and all statistics assessed.

  - The predicted contingent frequency of exceedance at the MPOI was 54%. This means that for approximately half the year, the combination of an Emergency scenario event and prevailing meteorology could result in exceedances of the daily standard. However, an Emergency event is only expected to occur for 1-5 days once every 20 years, therefore actual number of days exceeding the daily standard should not be more than 5 (1.4% of year). The predicted contingent frequency of exceedance calculated based on the 95th (49%) and 75th (29%) percentiles at the MPOI were comparatively lower than the contingent frequency of exceedance based on maximum predicted concentrations. The contingent frequencies of exceedances were not calculated for human health receptor locations as maximum concentrations did not screen above air quality criteria.

  - **Comparison between scenarios:** The calculated 24-hour HQs for $PM_{2.5}$ were above the target HQ of 0.2 at all locations assessed for both scenarios. In both scenarios, HQs were highest at the MPOI, with HQs (based on predicted maximum and 95th percentile concentrations) of 1.2 for the expected scenario and 1.7 for the emergency scenario. For human health receptor locations, HQs were highest for the nearest residence, with HQs (based on maximum predicted concentration) of 0.7 for the expected scenario and 0.8 for the emergency scenario. Overall, the HQs and predicted contingent frequency of exceedance were generally similar between scenarios, though results at the MPOI were generally higher in the Emergency scenario.

It should be noted that using a target HQ of 0.2 is a conservative approach which was chosen to account for the uncertainty associated with background $PM_{2.5}$ exposure from indoor air. In addition, contingent frequencies of exceedance were calculated based on worst-case maximum emission rates and prevailing meteorology.

6.1.2.2 PM_{10}

Hazard quotients (Table J), magnitudes and contingent frequencies of exceedances (Table L) are presented for PM_{10} for all receptor locations evaluated. Hazard quotients (HQs) were calculated from the maximum predicted concentrations, as well as other statistics representing upper estimates of exposure (predicted 95th and 75th percentiles) which are provided for context.

- **Expected scenario:**
  - The calculated 24-hour HQs for PM_{10} were above 0.2 for the MPOI and the human health receptor locations assessed. Hazard quotients (HQs) (based on maximum predicted concentration) were highest at the MPOI (HQ= 1.1), followed by the nearest residence (HQ= 0.8). When considering the upper estimates of estimates 95th (HQ = 0.7-1.0) and 75th percentiles (HQ = 0.7-0.9), the HQs were slightly reduced but remained above 0.2 for all human health receptor locations.
  - The predicted contingent frequency of exceedance (based on maximum predicted concentrations) at the MPOI was relatively low at 6% and comparatively lower when based on 95th percentile which was 0.82%. The contingent frequency of exceedance values was not calculated based on the 75th percentile for the MPOI as the concentration did not exceed the air quality criteria. The contingent frequency of exceedance was not calculated for human health receptor locations as maximum concentrations did not screen above air quality criteria.
- **Emergency scenario**:
  - The calculated 24-hour HQs for PM_{10} were above the target HQ of 0.2 for the MPOI and the human health receptor locations evaluated. Hazard quotients (HQs) (based on maximum predicted concentration) were highest at the MPOI (HQ= 1.5), followed by the nearest residence (HQ= 0.9). When considering the upper estimates of estimates predicted 95th and 75th percentiles, the HQs (95th: 0.7-1.3; 75th: 0.7-1.1) were slightly reduced but remained above 0.2 for all receptor locations.
  - The predicted contingent frequency of exceedance (based on maximum concentrations) at the MPOI was 40% over the selected standard. This means that for almost half the year, the combination of worst-case maximum station emissions and prevailing meteorology could result in exceedances of the daily standard. However, as emergency conditions are only expected to occur for 1-5 days once every 20 years, the actual number of days of exceedance is not expected to exceed 5 (1.4% of year).
  - The contingent frequency of exceedance calculated based on the 95th and 75th percentiles were reduced to 36% and 16%, respectively. The contingent frequency of exceedance was not calculated for human health receptor locations as maximum concentrations did not screen above air quality thresholds.
- **Comparison between scenarios:** The calculated 1-hour HQs for PM_{10} were above the target HQ of 0.2 at all locations assessed for both scenarios. In both scenarios, HQs were highest at the MPOI, with HQs (based on maximum predicted concentrations) of 1.1 for the expected scenario and 1.5 for the emergency scenario. For human health receptor locations, HQs were highest for the nearest residence, with HQs (based on maximum predicted concentration) of 0.8 for the expected scenario and 0.9 for the emergency scenario. Overall, the HQs and predicted contingent frequency of exceedance were generally higher in the Emergency scenario.
  It should be noted that the Emergency scenario is a worst-case scenario that is unlikely to occur.

It should be noted that using a target HQ of 0.2 is a conservative approach which was chosen to account for the uncertainty associated with background exposure to $PM_{2.5}$ from indoor air. In addition, contingent frequencies of exceedance were calculated based on worst-case maximum emission rates and prevailing meteorology.

6.2 Chronic Inhalation Assessment

6.2.1 Non-Carcinogenic Endpoints

To assess risk of non-carcinogenic health effects, hazard quotients for the Expected scenario were calculated for parameters identified as COPCs in the chronic inhalation assessment. The Emergency Scenario was not evaluated in the chronic inhalation assessment as the scenario is not expected to occur at a duration that is considered to be a chronic exposure. The HQ calculation for chronic inhalation is as follows:

$$HQ = \frac{C_{Air} \times D_1 \times D_2 \times D_3}{RfC}$$

Where:
HQ = hazard quotient (unitless)
C_{Air} = predicted COPC concentration in air ($\mu g/m^3$)
D_1 = exposure time out of 24 hours (hours)
D_2 = exposure frequency out of 7 days (days)
D_3 = exposure duration out of 52 weeks (weeks)
RfC = reference concentration ($\mu g/m^3$)

For chronic exposures, HQs consider exposure estimates of human receptors for locations retained in the screening assessment (Section 3.3.3). Exposure factors for the adult resident, and hospital worker/ teacher/ student were considered (Table 3). As discussed in Section 6.1, the acceptable risk threshold (e.g., target HQ) for inhalation is 0.2, which is a conservative threshold that was chosen to account for the uncertainty associated with background exposure to NO_2 and $PM_{2.5}$ from indoor air.

Nitrogen dioxide predictions were first carried out conservatively assuming 100% conversion of modelled NO_x to NO_2 (total conversion method). If the total conversion method resulted in a cumulative (modelled plus ambient baseline conditions) air prediction above the air criteria, then OLM was applied to estimate NO_2 concentrations using an algorithm to provide more realistic estimates.

It should be noted that the annual concentrations were modelled by assuming the maximum emission rate occurs throughout the year. However, maximum emissions are only likely to occur for 6 hours in every two-week winter period, and no emissions are expected occur during the summer period. As such, annual exposure estimates are likely to be conservative.

No COPCs screened above the selected air quality criteria based on non-carcinogenic endpoints. However, NO_2 and $PM_{2.5}$ are non-threshold constituents, therefore they were retained for the risk characterization. For non-threshold constituents, a threshold concentration below which no adverse effects are expected is not likely to exist (Health Canada 2016a, b). There is no prescribed method for assessing health risks of non-threshold constituents; therefore, NO_2, and $PM_{2.5}$ were assessed using the same approach as the other threshold COPCs (i.e., following a HQ approach and uncertainty analysis).

6.2.1.1 NO_2

Hazard quotients (Table M) are presented for NO_2 at all human health receptor locations assessed. The contingent frequency of exceedance was not calculated as maximum predicted concentrations did not screen above air quality thresholds. The HQs (based on maximum predicted concentrations) for the Expected scenario are discussed below:

- ***Adult Resident***—The calculated annual HQs were above 0.2 at the nearest residence and the Whitehorse General Hospital for both current (HQ = 0.5 and 0.6, respectively) and 2025 standards (HQ = 0.7 and 0.8, respectively). Hazard quotients (HQs) were highest at the Whitehorse General.
- ***Hospital Worker/Teacher/Student***—The calculated annual HQs were below or equal to 0.2 at all human health receptor locations evaluated for both scenarios (HQ = 0.1 to 0.2). Although, the HQs are below the target threshold of 0.2, NO_2 is considered a non-threshold substance so risks have been classified as low rather than low rather than negligible which would typically be the case if risks were predicted below the threshold.

6.2.1.2 $PM_{2.5}$

Hazard quotients (Table M) are presented for $PM_{2.5}$ for all human health receptor locations assessed. The contingent frequency of exceedance was not calculated as maximum predicted concentrations did not screen above air quality thresholds. The HQs (based on maximum predicted concentrations) for the Expected scenario are discussed below:

- ***Adult Resident***—The calculated annual HQs were above 0.2 for the nearest residence and the Whitehorse General Hospital. The HQs for both locations assessed were similar (HQ = 0.5).
- ***Hospital worker/Teacher/Student***—The calculated annual HQs were below or equal to 0.2 at all human health receptor locations evaluated (HQ = 0.1). Although, the HQs are below the target threshold of 0.2, $PM_{2.5}$ is considered a non-threshold substance so risks have been classified as low rather than low rather than negligible which would typically be the case if risks were predicted below the threshold.

6.2.2 Carcinogenic Endpoints

Incremental lifetime cancer risks (ILCR) for the Expected scenario were calculated for parameters identified as carcinogenic COPCs in the chronic inhalation assessment by comparing the maximum predicted annual concentrations with the TRVs, as follows:

$$ILCR = \frac{CAir \times D1 \times D2 \times D3 \times D4 \times IUR}{LE}$$

Where:
ILCR = incremental lifetime cancer risk (unitless)
C_{Air} = predicted COPC concentration in air (µg/m^3)
D1 = exposure time out of 24 hours (hours)
D2 = exposure frequency out of 7 days (days)
D3 = exposure duration out of 52 weeks (weeks)
D4 = total years exposed (years)
LE = life expectancy (years)
IUR = inhalation unit risk ([µg/m^3]$^{-1}$) = 0.0003 per µg/m^3 (CAL OEHHA 2022)

The acceptable risk threshold for inhalation exposure is 1×10^{-5} for carcinogens and cancer risks below this threshold are considered to be essentially negligible (Health Canada 2017). An ILCR of 1×10^{-5} means that there is one in 100,000 chance that an individual may develop cancer during their lifetime from exposure of the COPC. For carcinogens, Health Canada (2010) indicates the risks associated with on-site exposure (e.g., the facility only case), and not background risks, should be compared to the acceptable risk threshold (1×10^{-5}) because the acceptable risk threshold has been determined to address cancer risks above background cancer incidence. The ILCRs for the Expected scenario were calculated at receptor locations where the predicted maximum annual air concentration exceeded the chronic screening criteria. For carcinogenic-based thresholds, DPM was identified as a COPC for the annual averaging time. Baseline air concentrations were not available, therefore DPM air predictions are for emissions from the facility only.

It should be noted that that annual concentrations were modelled based on the assumption that maximum emissions will occur throughout the year. However, maximum emissions are only likely to occur for 6 hours in every two-week winter period, and no emissions are expected occur during the summer period. As such, annual exposure estimates are likely to be conservative. Furthermore, the assumption of lifetime exposure is also conservative, given that the Station will likely have a lifetime of 10-15 years as Yukon Energy is working to build alternative capacity for peaking (battery/ pumped storage). Hence, calculated ILCRs may be overestimated as a result.

6.2.2.1 DPM

The ILCRs for DPM are presented in in Table N. The ILCRs (based on maximum predicted concentrations) are discussed below:

- **Expected scenario**:
  - ***Composite Resident***—The calculated ILCR at the nearest residence (6.4x10-5) exceeded the acceptable risk threshold of 1×10^{-5}. However, the ILCR may be overestimated for reasons described above.
  - ***Adult Resident***—The calculated ILCRs at the nearest residence (4.8×10^{-5}) and hospital (3.7×10^{-5}), exceeded the acceptable risk threshold of 1×10^{-5}. However, the ILCR at the hospital likely overestimates potential risk as residents are unlikely to be present for the entirety of their adult years (e.g., 60 years).
  - ***Hospital Worker/ Teacher***—The calculated ILCRs at the schools (2.2×10^{-6} to 5.8×10^{-6}) and the hospital (5.9×10^{-6}) were below the acceptable risk threshold of 1×10^{-5}. Therefore, risks to these receptors from DPM are considered negligible.

7.0 UNCERTAINTY ANALYSIS

This HHRA was conducted using reasonably conservative assumptions. Most assumptions made in the HHRA are more likely to overestimate rather than underestimate potential health risks. This section outlines the possible sources of uncertainty potentially leading to an underestimate, neutral, or overestimate of risk.

Table 4: Uncertainty Analysis for the Human Health Risk Assessment

Source of Uncertainty	Likelihood to over/underestimate
The air predictions were generated considering a series of assumptions, the majority of which have provided an overall conservative assessment. ▪ The modelling results represent the worst-case predicted air quality impacts based upon the Stations maximum operating conditions. The model predicted air contaminant concentrations are likely conservative. The modelled scenarios were very conservative compared to the actual operation. The Expected scenario was modelled at full capacity for all hours instead of a typical operation where only the required units are run in winter to meet demand. The actual station emissions are expected to be much lower. For the Emergency scenario, the permanent generators were conservatively modelled at full capacity for all hours, and the mobile diesel generators were conservatively modelled each hour from December 1 to April 30. However, Yukon Energy estimates that the Emergency (N-1 event) scenario would only occur when the ambient temperature is colder than -30°C for a cumulative total of 1 to 5 days during a 2-week period, and based on historic data, only occurring once in approximately 20 years. ▪ While the OLM was applied to estimate NO_2 concentrations using an algorithm to provide more realistic estimates, this involved conservative assumptions: an equilibrium ratio of 1.0 was selected for conservatism (rather than 0.9 default provided in BC ENV (2022), the ambient baseline of NO_2 is conservative as it is based on the statistical form of 98th percentile of the daily maximum 1-hour concentrations, and the predicted NO_2 concentrations from the Station are conservative as the permanent units were modelled at full capacity for all hours of the year and the mobile diesel generators were conservatively modelled each hour from December 1 to April 30 instead of typical operation where only the required units are run in winter to meet demand.	Overestimate
Composite residents were assumed to be exposed to ambient air for 24 hours per day, 7 days per week for 52 weeks per year. While the assumption that a resident spends 24 hours per day outside at their residence every day of the year for their lifetime is conservative, there is also a potential for low-level background concentrations of NO_2, $PM_{2.5}$, and acrolein to be present in indoor air within in these residences.	Overestimate
The carcinogenic screening value/TRV for DPM was developed by Cal OEHHA (1998). Based on a more current evaluation from Health Canada (2016), there are uncertainties with quantifying unit risks based on rat bioassays of lung tumour induction, thus Health Canada has not derived guidance value based on cancer effects. Therefore, there is uncertainty in the calculated ILCRs for DPM.	Overestimate
For the calculation of ILCR, a lifetime exposure was assumed. The Station will likely have a lifetime of 10-15 years as Yukon Energy is working to build alternative capacity for peaking (battery/ pumped storage).	Overestimate
As per Health Canada (2017) guidance, the acceptable risk threshold for inhalation exposure for COPCs that do not incorporate background is 0.2. Because the predictions do not account for indoor background air for all COPCs (e.g., DPM), the target HQ of 0.2 was used for all COPCs for consistency.	Overestimate

8.0 SUMMARY AND CONCLUSIONS

The HHRA evaluated the potential acute (short-term) and chronic (long-term) risks to human health associated with criteria air contaminants emissions from the operation of the Whitehorse Rapids Generating Station, located near the City of Whitehorse, Yukon. The HHRA will support the renewal of Yukon Energy's existing emissions permit. The renewal of the permit considers the existing natural gas and diesel electricity generators, new Tier 4 diesel electricity generators, and the continued seasonal use of mobile generators under normal conditions as well as during an emergency (N-1) event at the Station. The HHRA was conducted in accordance with federal guidance and included the four key components of the risk assessment framework, including problem formulation, exposure assessment, toxicity assessment and risk characterization.

Two scenarios were evaluated in the HHRA. The Expected emissions scenario evaluated the potential risks to human health from criteria air contaminants associated with the Station operations as it is expected to operate, including background concentrations, where as the Emergency emissions scenario evaluated the potential risks to human health under emergency/upset conditions to meet peak load in winter. For both emission scenarios, the modelling conservatively assumed maximum emission from the Station generators operating under maximum conditions and maximum rated capacities. It was also assumed that all generators are emitting simultaneously and continuously at the name-plate capacity year-round, except for the mobile units, which were assumed to be operating continuously from December through April. In reality, the Expected Scenario will only run during the winter when needed to meet demand, and peak emissions rates are expected to occur for a small number of hours. The emergency scenario is predicted to occur once in 20 years for a cumulative total of 1 to 5 days during a 2-week period. The human health receptors evaluated in the HHRA were identified based on land use within a 10-km by 10-km area centered on the Station and are consistent with those assessed in the previous 2020 air dispersion modelling completed by WSP for the Station. Six human health receptor locations were identified and evaluated, including four schools, one hospital and the nearest residence. The acute inhalation assessment also considered that people may spend short amounts of time at the MPOI, however the MPOI was not considered relevant for long-term exposures and was not evaluated in the chronic assessment. Inhalation of criteria air contaminants in ambient air by the identified human health receptor locations was evaluated in the HHRA.

As per regulatory requirements, the YAAQS were selected as the air quality criteria/TRVs for NO_2, $PM_{2.5}$ and PM_{10}. As updated YAAQS for NO_2 and SO_2 will be effective as of 1 January 2025, potential risks to human health were evaluated considering both current and 2025 standards to evaluate air quality as the Station continues to operate. For DMP, the Health Canada air quality thresholds/TRVs for the 24-hour and annual (non-carcinogenic) averaging periods were selected. For the annual averaging period evaluation of carcinogenic effects, the Cal OEHHA IUR was selected given that a carcinogenic TRV was not available from Health Canada or US EPA.

Acute Health Risks

Based on comparison of predicted 1-hour and 24-hour concentrations to acute air quality criteria, NO_2 and DPM were retained for further evaluation for the 1-hour averaging time and $PM_{2.5}$ and PM_{10} were retained for further evaluation for the 24-hour averaging time.

Non-negligible risks were identified for all acute COPCs (e.g., NO_2, DPM, $PM_{2.5}$, PM_{10}) for current and future standards, where applicable, at all locations evaluated in both scenarios (Expected and Emergency). In both scenarios and for all acute COPCs, risks were highest at the MPOI, followed by the nearest residence. It should be noted that emissions were modelled conservatively assuming that the generators are operating continuously at the maximum rated capacity at all hours, except for the mobile generators, which were only modelled from December through April. Furthermore, an HQ of 0.2 was used in risk characterization as a threshold in this HHRA to account for uncertainty associated with background indoor air exposure. Predicted air concentrations also do not account for outdoor background air for all COPCs (e.g., DPM), therefore the target HQ of 0.2 was selected as a conservative approach. Overall, the magnitude (i.e., HQ) and predicted contingent frequency of exceedance for the Emergency scenario were generally higher than results from the Expected scenario. However, actual frequencies of exceedance are likely to be lower as the Expected Scenario will only run during the winter when needed to meet demand, and peak emissions rates are expected to occur for a small number of hours. The Emergency scenario is a rare event, that is predicted to occur once every 20 years where emissions will occur for a cumulative total of 1 to 5 days during a 2-week period. Thus, predicted emission rates, contingent frequencies of exceedance and subsequent calculated risks are likely overestimated.

Chronic Health Risks

Based on comparison of predicted annual concentrations to chronic air quality thresholds, NO_2 and $PM_{2.5}$ were retained for further evaluation for the non-carcinogenic effects and DPM was retained for further evaluation of carcinogenic effects. The resident (adult and composite) and the hospital worker/teacher/student receptors were evaluated. The main conclusions are summarized below:

- **NO_2 (annual, non-carcinogenic):** Non-negligible risks were identified for residents at the nearest residence and the Whitehorse General Hospital for both current and 2025 standards. As the YAAQS will be reduced in 2025, the calculated risks based on the 2025 standard were higher, though risks based on both standards are non-negligible. There were negligible risks for the hospital/teacher/student receptor at all human health receptor locations assessed for both current and 2025 standards.
- **$PM_{2.5}$ (annual, non-carcinogenic):** Non-negligible risks were identified for the resident at the nearest residence and the Whitehorse General Hospital, with similar magnitude of risks.
- **DPM (annual, carcinogenic):** Non-negligible risks were identified for the residents (composite and adult) at all receptor locations assessed. For the hospital worker/teacher receptor, risks were acceptable at all receptor locations assessed.

Annual concentrations were modelled conservatively where it was assumed that maximum concentrations will occur throughout the year. Emissions are only likely to occur 6 hours during a two-week period every winter. Therefore, annual exposure estimates are likely to be overestimated. Additionally, lifetime exposure is also a conservative estimate, given that the Station will likely operate for 10-15 years as Yukon Energy is working to build alternative capacity for peak capacity (battery/ pumped storage).Calculated ILCRs may therefore be overestimated as a result.

In conclusion based on the findings of the HHRA, there are potential acute and chronic risks to human health associated with ambient air concentrations of NO_2, $PM_{2.5}$, PM_{10} and DPM that may be influenced by emissions from the Station during both the Expected and Emergency scenarios. These risk estimates are likely conservative, and a detailed discussion of the uncertainty associated with these risk estimates is provided in Section 7.0.

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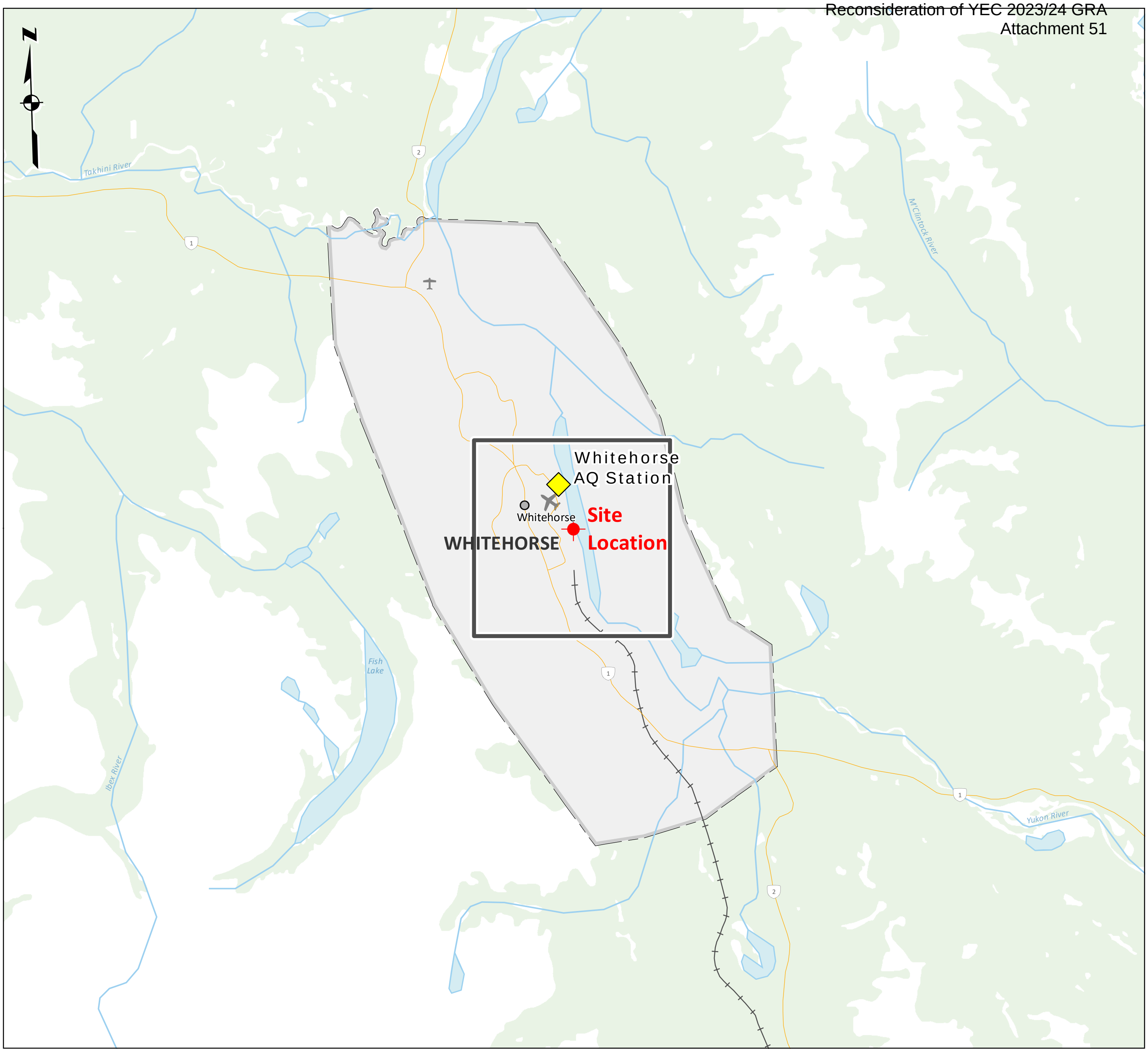


Legend

Activity
- Site Location
- Whitehorse AQ Station
- Modelling Domain (10 km x 10 km)

Water Features
- Major Lake/River
- Perennial Creeks/Streams

Municipal
- Major Urban Centre

Transportation
- Paved Roads
- Railways
- Airport
- Airfield

Environmental
- Vegetation

Scale: 1:300,000

0 3 6 9 12 15 Km

Universal Transverse Mercator (Zone 8)
North American Datum (1983)

Site Location Map

Whitehorse Rapids Generating Station

Yukon

Figure 1

Legend

Human Health Receptors

Site Boundary

Scale: 1:25,000

0 200 400 600 800 1,000 Meters

Universal Transverse Mercator (Zone 8)

North American Datum (1983)

Human Health Receptors

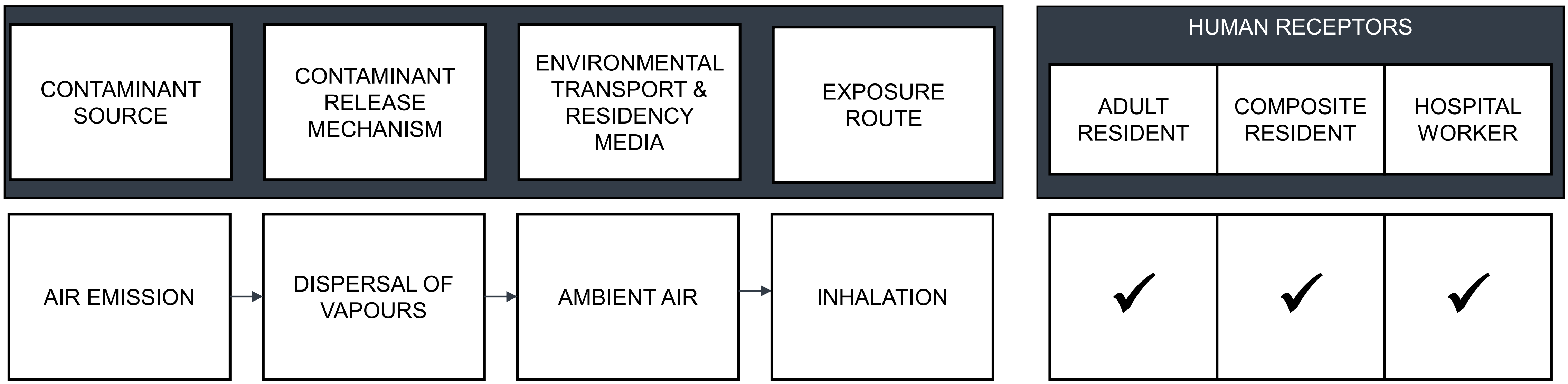
Whitehorse Rapids Generating Station

Yukon

Figure 2

Conceptual Site Model for Human Receptors

FIGURE 3



Date: September 2023

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CAD: JC

CKD: SG

Table A: 1-Hour (Acute) Air Quality Thresholds

Parameter	CAS	YAAQS (2019)	BC ENV (2021) AAQO	CCME (1999, 2023) CAAQS and NAAQO	ATSDR (2023) MRL	US EPA (2023) NAAQS	WHO (2021) AQG	MECP (2020) AAQC	Cal OEHHA (2022) REL	TCEQ (2023) ESL	Toxicological Endpoints and Derivations
Criteria Air Contaminants											
Carbon monoxide (CO)	630-08-0	-	14,300	**Desirable NAAQO = 15,000** Acceptable NAAQO = 35,000	-	40,100 (35 ppm)	35,000	34,400 (30 ppm)	23,000	-	BC ENV: Pollution control objectives for all discharges to the environment for food-processing, agriculturally orientated, and other industries developed in the 1970s. This criteria has since been rescinded in 2006 but is used for reference purposes (supporting documentation not available). CCME NAAQO: Screening value is based on cardiorespiratory effects in people with exercise-induced myocardial ischemia, which was evaluated and derived by the NAAQO in 1994 (NAAQO 1994). The NAAQO derived a 1-hour average maximum acceptable level (35,000 µg/m3) which is based on the maintenance of blood carboxyhemoglobin concentrations below the LOEL of 2% (Allred et al. 1989; as cited in NAAQO 1994). The PBPK model developed by Coburn, Foster, and Kane was used to extrapolate a 2% blood carboxyhemoglobin concentration to an ambient carbon monoxide concentration in the air. The maximum desirable level was based on 1% blood carboxyhemoglobin concentration US EPA NAAQS: Screening value based on clinical evidence relating carboxyhemoglobin (carbon monoxide bound to blood hemoglobin) levels to various adverse health endpoints. The NAAQS of 35 ppm was converted to µg/m3 using a molecular weight of 28.01 g/mol. Not to be exceeded more than once per year. WHO: Screening value based on a maximum concentration of 2.5% carboxyhemoglobin in blood which is intended to be protective of non smoking, middle-aged and elderly population groups with coronary artery disease, and fetuses of non smoking pregnant women. The guideline is calculated using an equation that takes into account the known physiological variables that have an impact on the uptake of carbon monoxide and determines the guideline that will keep carboxyhemoglobin levels below 2.5%. MECP: Screening value based on a health endpoint (supporting documentation not available). Cal OEHHA: Screening value based on an inhalation study in humans examining the aggravation of existing angina and other cardiovascular diseases when subjects are exercising heavily (Allred et al. 1989 and Kleinman et al., 1989; as cited in Cal OEHHA 2008b). The screening values is based on a NOAEL of 1.1 to 1.3 % carboxyhemoglobin level in blood which corresponds to 23,000 µg/m3.
Nitrogen dioxide (NO2)	10102-44-0	**CAAQS (Current) = 113 (60 ppb)** **CAAQS (2025) = 79 (42 ppb)**	**CAAQS (Current) = 113 (60 ppb)** **CAAQS (2025) = 79 (42 ppb)**	**CAAQS (Current) = 113 (60 ppb)** **CAAQS (2025) = 79 (42 ppb)**	-	188 (100 ppb)	200	400	470	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: Supporting documentation not available for screening value. BC adopted the 2020 CAAQS of 113 µg/m3 as the new Provinical Air Quality Objective took effect on 1 January 2020. A value of 42 ppb (79 µg/m3) is proposed for the year 2025 and it was selected as the screening value as it is more conservative than the 2020 CAAQS of 113 µg/m3. The CAAQS is a three-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations. The CAAQS of 42 ppb was converted to µg/m3 using a molecular weight of 46.01. CCME CAAQS: Proposed screening value for the year 2025 was selected as it is more conservative than the 2020 CAAQS of 113 µg/m3. The metric is the 3-year average of the 98th percentile of the nitrogen dioxide daily maximum 1-hour average concentration. The CAAQS of 60 and 42 ppb were converted to µg/m3 using a molecular weight of 46.01. US EPA NAAQS: Screening value based on the 98th percentile of maximum 1-hour daily concentrations, averaged over a three-year period. The NAAQS is protective of a broad range of respiratory effects in sensitive populations, such as those with asthma and those who spend time near major roadways. The NAAQS of 100 ppb was converted to µg/m3 using a molecular weight of 46.01 g/mol. WHO: Screening value based on studies of bronchial responsiveness among asthmatics. MECP: For monitored ambient air levels. The 1-hour screening value is based on health effects of nitrogen dioxide at the time of derivation; however, the specific health endpoint was not specified. The MECP selected this screening value as it was considered below any adverse effect level. Cal OEHHA: Screening value is based on a study where sensitive humans (asthmatics) were exposed to 0.25 ppm of NO2 for 1 hour (Mohsenin 1987; as cited in Cal OEHHA 2008b). The critical effect was an increase in airway reactivity. No uncertainty factors were applied to the NOAEL of 0.25 ppm (470 µg/m3), which was adopted as the reference exposure level (REL) and California ambient air quality standard to protect against mild adverse effects.
Sulphur dioxide (SO2)	7446-09-5	**CAAQS = 183 (70 ppb)** **CAAQS = 170 (65 ppb) (effective in 2025)**	**CAAQS = 183 (70 ppb)** **CAAQS = 170 (65 ppb) (effective in 2025)**	**CAAQS = 183 (70 ppb)** **CAAQS = 170 (65 ppb) (effective in 2025)**	-	196 (75 ppb)	-	105 (40 ppb)	660	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: The CAAQS of 183 µg/m3 took effect on 1 January 2020 and a value of 170 µg/m3 is proposed for the year 2025. The CAAQS is a based on the annual 99th percentile of D1HM, averaged over three consecutive years and is described below. The CAAQS of 65 ppb was converted to µg/m3 using a molecular weight of 64.07. CCME CAAQS: Screening value was developed based on respiratory health problems, focused on susceptible populations (e.g. asthmatic children and adults), and environmental impacts such as acid rain and smog (CCME 2017). A value of 170 µg/m3 is proposed for the year 2025. It was selected as the screening value as it is more conservative than the 2020 CAAQS of 183 µg/m3. The metric is the 3-year average of the 99th percentile of the sulphur dioxide daily maximum 1-hour average concentration. The CAAQS of 70 and 65 ppb were converted to µg/m3 using a molecular weight of 64.07. US EPA NAAQS: Screening value based on epidemiological evidence of increased emergency department visits and hospitalizations associated with sulphur dioxide concentrations in the range of 75 to 150 ppb. The NAAQS of 75 ppb was converted to µg/m3 using a molecular weight of 64.07 g/mol. MECP: MECP derived the 1-hour screening value from the AAQC for the 10-minute averaging time, where 1 ppb of sulphur dioxide is equal to 2.66 µg/m3 (at 20.0°C and 1 atmosphere), rounded. Cal OEHHA: Screening value based on impairment of airway function (bronchoconstriction) especially in asthmatics (Linn et al. 1987; as cited in Cal OEHHA 2008b). After reviewing human several studies on acute exposures of normal, asthmatic, and atopic (susceptible to hypersensitive allergic reactions) individuals to low concentrations of SO2 (0.25 to 2.0 ppm), Cal OEHHA staff concluded that exposure to 0.25 ppm, the California Ambient Air Quality Standard (Cal AAQS) for SO2, would not result in respiratory effects causing discomfort in sensitive individuals exposed for one hour. The Cal AAQS for SO2 is intended to protect sensitive individuals (i.e., exercising asthmatics) from lower respiratory effects of acute exposure. Cal OEHHA concluded that an exposure concentration of 0.25 ppm SO2 for 1-hour is comparable to a NOAEL in sensitive individuals. It was determined by Cal OEHHA that the NOAEL would be protective of asthmatic individuals because adverse effects are consistently observed only at higher concentrations with participants undertaking moderate exercise and there is also an inconsistency in response to SO2 exposure at lower concentrations.
Diesel particulate matter (DPM)	N/A	-	-	**10 (Health Canada, 2016)**	-	-	-	-	-	19	Health Canada: Screening value based on a LOAEL of 100 µg/m3 for respiratory effects (increased airway resistance and inflammation) in healthy subjects exposed to DPM for 2 hours (Health Canada 2016). An uncertainty factor of 10 was applied (√10 for intraspecies variability and √10 for use of a LOAEL). TCEQ: Screening value based on a health endpoint (interim, supporting documentation not available), as diesel engine exhaust in PM.

AAQC= Ambient Air Quality Criteria; AAQO= Ambient Air Quality Objectives; AQG = Air Quality Guideline; ATSDR = Agency for Toxic Substances and Disease Registry; BC ENV = British Columbia Ministry of Environment and Climate Change Strategy; CAAQS= Canadian Air Quality Standards; Cal OEHHA = California Office of Environmental Health Hazard Assessment; CCME = Canadian Council of Ministers of the Environment; ESL = Effects Screening Level; LOAEL= Lowest Adverse Effect Level; MECP = Ontario Ministry of the Environment, Conservation and Parks; µg/m^3= microgram per cubic meter; MRL = Minimal Risk Level; NAAQO = National Ambient Air Quality Objectives; NAAQS = National Ambient Air Quality Standard; PM= Particulate Matter; REL = Reference Exposure Level; RSL = Regional Screening Level; TCEQ = Texas Commission on Environmental Quality; US EPA = United States Environmental Protection Agency; US EPA= U.S. Environmental Protection Agency; WHO = World Health Organization; YAAQS= Yukon Ambient Air Quality Standards
Concentrations are in microgram per cubic metre (µg/m3), unless otherwise noted.
Concentrations in parts per million (ppm) were converted to mg/m3 by applying the formula: molecular weight (grams per mol) x ppm / 24.45.
Grey and bolded cells indicated selected screening value.
- = Guideline not available

Table B: 24-Hour (Acute) Air Quality Thresholds

Parameter	CAS	YAAQS (2019)	BC ENV (2021) AAQO	CCME (1999, 2023) CAAQS and NAAQO	ATSDR (2023) MRL	US EPA (2023) NAAQS	WHO (2021) AQG	MECP (2020) AAQC	TCEQ (2023) ESL	Toxicological Endpoints and Derivations
Criteria Air Contaminants										
Carbon monoxide (CO) [a]	630-08-0	-	5,500	**Desirable NAAQO = 6,000** Acceptable NAAQO = 15,000 Tolerable NAAQO = 20,000	-	10,300 (9 ppm)	**10,000 (8-Hour)** 4,000 (24-Hour)	14,900 (13 ppm)	-	BC ENV: Pollution control objectives for food-processing, agriculturally orientated, and other industries; additional supporting documentation not available. This criteria has since been rescinded in 2006 but is used for reference purposes. CCME NAAQO: CCME: Screning value is based on cardiorespiratory effects in people with exercise-induced myocardial ischemia, which was evaluated and derived by the NAAQO in 1994 (NAAQO 1994). The NAAQO derived an 8-hour rolling average maximum acceptable level (15,000 µg/m3) which is based on the maintenance of blood carboxyhemoglobin concentrations below the LOEL of 2% (Allred et al. 1989; as cited in NAAQO 1994). The PBPK model developed by Coburn, Foster, and Kane was used to extrapolate a 2% blood carboxyhemoglobin concentration to an ambient carbon monoxide concentration in the air. The maximum desirable level was based on 1% blood carboxyhemoglobin concentration and the maximum tolerable level was based on a LOAEL of 2.9% carboxyhemoglobin. US EPA NAAQS: Screening value based on clinical evidence relating carboxyhemoglobin (carbon monoxide bound to blood hemoglobin) levels to various adverse health endpoints including hypoxia, cardiovascular effects, reproductive effects, central nervous system effects, respiratory effects and impairment of prenatal development. The NAAQS of 9 ppm was converted to µg/m3 using a molecular weight of 28.01 g/mol. Not to be exceeded more than once per year. WHO: Guideline available for both 8-hour and 24-hour. Based on a systemic review of CO exposure and hospital admissions for myocardial infarction. The 99th percentile daily mean concentrations in a year was calculated with the assumption that the 99th percentile is three times greater than the annual mean observed in the MCC Collaborative Research Network database. Although the risk of myocardial infarction hospital admissions and emergency room visits is expected to be elevated by about 5% on day where CO is equal to the air quality guideline, the overall health burden related to a few days with higher concentrations corresponds to a very small fraction of the total air pollution related burden. MECP: Screening value based on a health endpoint (supporting documentation not available).
PM10	N/A	**50**	**50**	**-**	-	150	45	**50**	-	YAAQS: Supporting documentation not available. Consistent with BC ENV and MECP. BC ENV: Provincial AQO. Supporting documentation not available. US EPA NAAQS: Air screening level to protect against adverse health effects of inhalable airborne particles that can be deposited in the lower (thoracic) regions of the human respiratory tract. The standard is met when a 24-hr average PM10 concentration of 150 mg/m3 is not exceeded more than one day per year, on average over a three-year period. WHO: Based on non-accidental and cause-specific mortality (e.g., cardiovascular, non-malignant respiratory and cerebrovascular mortality). The guideline is derived from the 99th percentile of common distributions of daily air pollution concentrations corresponding to an average long-term concentration equivalent to the annual AQG level. MECP: Screening value based on a health endpoint (supporting documentation not available). Interim AAQC for decision making; no conversion to other averaging times.
PM2.5	N/A	**CAAQS = 27**	**CAAQS = 27**	**CAAQS = 27**	-	35	15	27	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: Supporting documentation not available. Based on the CAAQS, which superseded the provicinial air quality objective (of 25 µg/m3) on 1 January 2020. The CAAQS is based on the annual 98th percentile of daily average, averaged over three consecutive years. CCME CAAQS: Air screening levels based on Canada Wide Standards, intended for the protection of respiratory effects. CCME has proposed a Canadian ambient air quality standard (CAAQS) for PM2.5 of 27 µg/m3 for the year 2020, which is intended to be protective of human health and the environment. The metric is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations. US EPA NAAQS: Standard based on the 98th percentile of daily 24-hour concentrations averaged over 3 years and is protective of increased health effects associated with short-term PM2.5 exposure, including premature mortality and increased hospital admissions and emergency department visits. WHO: Based on non-accidental and cause-specific mortality (e.g., cardiovascular, non-malignant respiratory and cerebrovascular mortality). The guideline is derived from the 99th percentile of common distributions of daily air pollution concentrations corresponding to an average long-term concentration equivalent to the annual AQG level. MECP: Based on CCME CAAQS reflecting a 3-year average of the annual 98th percentile of the daily 24-hr average concentrations. This value could also be used "as is" for comparison to the 24hour measurement of air quality data.
Total suspended particulate (TSP)	N/A	**120**	**120**	**NAAQO (1974) = 120**	-	-	-	-	-	YAAQS: Supporting documentation not available. Based on the CCME NAAQO from 1974, derived from geometric mean. BC ENV: Supporting documentation not available. Based on the CCME NAAQO from 1974, derived from geometric mean. CCME NAAQO: Supporting documentation not available. National Ambient Air Quality Objective from 1974. Based on the geometric mean.

AAQC= Ambient Air Quality Criteria; AAQO= Ambient Air Quality Objectives; AQG = Air Quality Guideline; AQO = Air Quality Objectives; ATSDR = Agency for Toxic Substances and Disease Registry; BC ENV = British Columbia Ministry of Environment and Climate Change Strategy; CAAQS= Canadian Air Quality Standards; Cal OEHHA = California Office of Environmental Health Hazard Assessment; CCME = Canadian Council of Ministers of the Environment; ESL = Effects Screening Level; MECP = Ontario Ministry of the Environment, Conservation and Parks; $\mu g/m^3$= microgram per cubic meter; MRL = Minimal Risk Level; NAAQO = National Ambient Air Quality Objectives; NAAQS = National Ambient Air Quality Standard; PM= Particulate Matter; REL = Reference Exposure Level; RSL = Regional Screening Level; TCEQ = Texas Commission on Environmental Quality; US EPA = United States Environmental Protection Agency; US EPA= U.S. Environmental Protection Agency; WHO = World Health Organization; YAAQS= Yukon Ambient Air Quality Standards

[a] For CO, thresholds are based on 8-hour exposures except for WHO, where a 24-hour screening value was available. For CO, thresholds based on 8-hour exposure times as health effects from CO exposure is associated with shorter term exposures (i.e., 1- or 8-hours).
Concentrations are in microgram per cubic metre (µg/m3), unless otherwise noted.
Concentrations in parts per million (ppm) were converted to mg/m3 by applying the formula: molecular weight (grams per mol) x ppm / 24.45.
Grey and bolded cells indicated selected screening value.

Table C: Annual (Chronic) Air Quality Thresholds

Parameter	CAS	Carcinogen Classification	YAAQS (2019)	BC ENV (2021) AAQO	CCME (2023) CAAQS	ATSDR (2023) MRL	US EPA (2023) NAAQS	WHO (2021) AQG	MECP (2020) AAQC	Others Cal OEHHA (2022) REL	TCEQ (2023) ESL	Toxicological Endpoints and Derivations
Criteria Air Contaminants												
Nitrogen dioxide (NO2)	10102-44-0	NC	**CAAQS = 32 (17 ppb) CAAQS = 23 (12 ppb) (effective in 2025)**	**CAAQS = 32 (17 ppb) CAAQS = 23 (12 ppb) (effective in 2025)**	**CAAQS = 32 (17 ppb) CAAQS = 23 (12 ppb) (effective in 2025)**	-	100 (53 ppb)	10	-	-	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: Supporting documentation not available for screening value. The interim AQO is 60 µg/m3 and the CAAQS of 32 µg/m3 took effect on 1 January 2020. A value of 23 µg/m3 is proposed for the year 2025 and it was selected as the screening value as it is more conservative than the 2020 CAAQS of 32 µg/m3. The CAAQS is the annual average of 1-hour average concentrations over one year. The CAAQS of 12 ppb was converted to µg/m3 using a molecular weight of 46.01. CCME CAAQS: Proposed screening value for the year 2025 was selected as it is more conservative than the 2020 CAAQS of 32 µg/m3 (supporting documentation not available). The metric is the average over a single calendar year of all 1-hour average concentrations. The CAAQS of 17 and 12 ppb were converted to µg/m3 using a molecular weight of 46.01. US EPA NAAQS: Screening value based on a large body of evidence for respiratory effects from exposure to nitrogen oxides. The key clinical studies on human health effects are based on shorter exposure durations (0.5 to 3 hours). The health effects reported include increased airway responsiveness in asthmatics, small decreases in forced vital capacity and forced expiratory volume in one second (FEV1) with mild exercise in patients with chronic obstructive pulmonary disease, increased airway responsiveness to bronchoconstrictors in healthy adults, and changes in lung function in healthy adults (US EPA 1993). The key epidemiological studies on human health effects indicated increased risk of lower respiratory symptoms/disease in children (aged 5 to 12 years). Exposure to NO2 in occupational settings was associated with bronchial pneumonia and bronchitis (25 to 100 ppm). In high occupational exposure cases (>200 ppm), effects ranged from hypoxemia/transient airway obstruction to death (US EPA 1993). The NAAQS is a primary and secondary value, which is protective of "sensitive" populations such as asthmatics, children, and the elderly. The NAAQS of 53 ppb was converted to µg/m3 using a molecular weight of 46.01 g/mol. WHO: Based on non-accidental and cause-specific, respiratory mortality (e.g., Chronic obstrucive pulmonary disease, respiratory and acute lower respiratory infection mortality). This screening level is derived from average of the five lowest 5th percentile levels from five studies with the five lowest reported or estimated levels in a meta-analysis of epidemiological evidence.
Sulphur dioxide (SO2)	7446-09-5		**CAAQS = 13 CAAQS = 11 (4 ppb) (effective in 2025)**	**CAAQS = 13 CAAQS = 11 (4 ppb) (effective in 2025)**	**CAAQS = 13 CAAQS = 11 (4 ppb) (effective in 2025)**	-	-	-	-	-	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: Supporting documentation not available. A value of 10 µg/m3 is proposed for the year 2025. The CAAQS is the average over a single calendar year of all the 1-hour average concentrations. The CAAQS of 4 ppb was converted to µg/m3 using a molecular weight of 64.07. CCME CAAQS: The annual screening value of 4.0 ppb is intended to be applied to the average over a single calendar year of all the 1-hour average SO2 concentrations. It was selected as the screening value as it is more conservative than the 2020 CAAQS of 13 µg/m3. Based upon protection of human health and the environment. The CAAQS of 5 and 4 ppb were converted to µg/m3 using a molecular weight of 64.07.
PM2.5	N/A	NC	**CAAQS = 8.8**	**CAAQS = 8.8**	**CAAQS = 8.8**	-	12	5	**8.8**	-	-	YAAQS: Supporting documentation not available. Based on the CCME CAAQS. BC ENV: Supporting documentation not available. The CAAQS is based on the annual average, averaged over three consecutive years. The planning goal of 6 µg/m3 is a voluntary target used to guide airshed planning efforts and encourage communities to maintain good air quality during economic growth and development. The air quality objective of 8 µg/m3 is an air management tool used to guide decisions on environmental impact assessments and authorizations, airshed planning efforts and regulatory development (BC ENV 2008; BC MHLS 2009). The air quality objective is based on the annual average, over one year, and was selected as the screening value because it is more conservative than the CAAQS. CCME CAAQS: Canadian ambient air quality standard protective of human health and the environment. The standard represents a balance between achieving the best health and environmental protection possible and the feasibility and costs of reducing pollutant emissions; a value of 8.8 µg/m3 is proposed for the year 2020. The metric is the 3-year average of the annual average concentrations. US EPA NAAQS: Screening level based on annual mean averaged over 3 years for the health protection of "sensitive" populations such as asthmatics, children, and the elderly. WHO: Based on non-accidental and cause-specific mortality (e.g., circulatory, lung cancer, and non-malignant respiratory mortality). This screening level is derived from average of the five lowest 5th percentile levels from five studies with the five lowest reported or estimated levels in a meta-analysis of epidemiological evidence. MECP: Based on CCME CAAQS reflecting a 3-year average of the annual 98th percentile of the daily 24-hr average concentrations. This value could also be used “as is” for comparison to the 24hour measurement of air quality data.
Diesel particulate matter (DPM)	N/A	NC	-	-	**5 (Health Canada, 2016)**	-	5.2	-	-	**5**	0.15	Health Canada: Screening value based on a NOAEL of 0.46 mg/m3 for effects on the respiratory tract (inflammation, histopathological and/or functional changes) in rats (Health Canada 2016), which is the same study as the US EPA. The NOAEL was adjusted to a human equivalent concentration of 0.12 mg/m3. An uncertainty factor of 25 was applied (100.4 for toxicodynamic differences in animal to human extrapolation and 10 for sensitive individuals in the human population). US EPA NAAQS: Screening level based on reference concentration (RfC) of 5 mg/m3 (NOAEL of 0.46 mg/m3 for pulmonary inflammation and histopathology in rats exposed to DPM for 16 hours/day, 6 days/week for 30 months). The NOAEL was adjusted to a human equivalent concentration of 0.144 µg/m3. An uncertainty factor of 30 was applied (3 for interspecies variability and 10 for intraspecies variability). The US EPA applies a residential scenario exposure factor to derive the screening level. Cal OEHHA: Reference exposure level based on same study as US EPA (described above). TCEQ: Screening value based on a health endpoint (interim, supporting documentation not available), as diesel engine exhaust in PM.
		C	-	-	-	-	0.094 (0.0094)	-	-	**0.033**	-	The US EPA and Cal OEHHA have developed carcinogenic screening values for DPM (see information below); which are over 20 years old. Based on a more current evaluation from Health Canada (2016), there are uncertainties with quantifying unit risks based on rat bioassays of lung tumour induction and Health Canada has not derived guidance value based on cancer effects. Despite the uncertainties, the Cal OEHHA value was used in this assessment in the absence of other guidance. US EPA NAAQS: Screening level based on Cal OEHHA inhalation unit risk (IUR) of 0.0003 per µg/m3 (see below). An incremental lifetime cancer risk of 1 in 100,000 was used to convert the IUR to a risk-based concentration of 0.033 µg/m3. The US EPA applies a residential scenario exposure factor to derive the screening level. Cal OEHHA: Inhalation unit risk (IUR) of 3x10-4 per µg/m3 based on epidemiological data where occupationally-exposed individuals had elevated risks of developing lung cancer (Cal OEHHA 1998). An incremental lifetime cancer risk of 1 in 100,000 was used to convert the IUR to a screening value.
Total suspended particulate (TSP)	N/A	**60**	**60**	**NAAQO (1974) = 60**	-	-	-	-	-	-	-	YAAQS: Supporting documentation not available. Based on the CCME NAAQO from 1974, derived from geometric mean. BC ENV: Supporting documentation not available. Based on the CCME NAAQO from 1974, derived from geometric mean. CCME NAAQO: National Ambient Air Quality Objective from 1974. Supporting documentation not available. Based on the geometric mean.

AAQC= Ambient Air Quality Criteria; AAQO= Ambient Air Quality Objectives; AQG = Air Quality Guideline; AQO = Air Quality Objectives; ATSDR = Agency for Toxic Substances and Disease Registry; BC ENV = British Columbia Ministry of Environment and Climate Change Strategy; C= Carcinogenic; CAAQS= Canadian Air Quality Standards; Cal OEHHA = California Office of Environmental Health Hazard Assessment; CCME = Canadian Council of Ministers of the Environment; ESL = Effects Screening Level; MECP = Ontario Ministry of the Environment, Conservation and Parks; µg/m3= microgram per cubic meter; MRL = Minimal Risk Level; NAAQO = National Ambient Air Quality Objectives; NAAQS = National Ambient Air Quality Standard; NC= Non-carcinogenic; NOAEL= No Observed Adverse Effect Level; PM= Particulate Matter; REL = Reference Exposure Level; RSL = Regional Screening Level; TCEQ = Texas Commission on Environmental Quality; US EPA = United States Environmental Protection Agency; US EPA= U.S. Environmental Protection Agency; WHO = World Health Organization; YAAQS= Yukon Ambient Air Quality Standards
Concentrations are in microgram per cubic metre (µg/m3), unless otherwise noted.
Concentrations in parts per million (ppm) were converted to mg/m3 by applying the formula: molecular weight (grams per mol) x ppm / 24.45.
Grey and bolded cells indicated selected screening value.
- = Guideline not available

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Table D: Screening of Predicted 1-Hour Air Concentrations

Constituent		Air Threshold[a] Current	Air Threshold[a] 2025	Background Concentration	Predicted Air Concentrations: Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario											
NO_2 (OLM)[b]	Max	113	79	73.3	**287**	**196**	**175**	**159**	**172**	**175**	**166**
	P95	113	79	73.3	**223**	103	94	82	**115**	102	**113**
	P75	113	79	73.3	**175**	73	73	73	76	74	79
SO_2[c]	Max	183	170	NV	3.5	1.4	0.67	0.61	0.52	0.59	0.40
CO[c]	Max	15,000	15,000	NV	2451	324	152	132	99	141	113
DPM[c]	Max	10	10	NV	**63**	**28**	9.6	**11**	8.3	**10**	8.1
	P95	10	10	NV	**22**	0.61	0.46	0.16	0.97	0.63	0.91
	P75	10	10	NV	**11**	0.00064	0.0013	0.000046	0.049	0.017	0.10
Emergency (N-1 event) Emission Scenario											
NO_2 (OLM)[b]	Max	113	79	73.3	**555**	**295**	**208**	**192**	**196**	**202**	**184**
	P95	113	79	73.3	**342**	**132**	**118**	97	**141**	**124**	**139**
	P75	113	79	73.3	**229**	74	74	73	81	77	87
SO_2[c]	Max	183	170	NV	7.1	2.7	1.3	1.1	1.1	1.3	0.79
CO[c]	Max	15,000	15,000	NV	2456	386	156	150	117	160	115
DPM[c]	Max	10	10	NV	**161**	**54**	**22**	**22**	**18**	**24**	**19**
	P95	10	10	NV	**42**	2.0	1.2	0.43	2.1	1.5	1.8
	P75	10	10	NV	**21**	0.0048	0.0069	0.00055	0.12	0.051	0.23

Notes:

NO_2 = Nitrogen dioxide; SO_2 = Sulfur dioxide; CO = Carbon monoxide; OLM = Ozone Limiting Method; Max= Maximum concentration; P95= 95th percentile; P75= 75th percentile; NV = No value; DPM= Diesel particulate matter

Concentrations are in micrograms per cubic metre ($\mu g/m^3$)

[a] Air thresholds are the Yukon Ambient Air Quality Standards (YAAQS) for the 1-hour averaging time. Given that the project will extent past January 1, 2025, both the current and 2025 Standards were considered. In the absence of YAAQS, air thresholds from other reputable agencies were considered.

[b] Air predictions for NO2 are the sum of baseline air concentrations (i.e. background) and emissions from the facility.

[c] SO_2, CO and DPM air predictions are for emissions from the Facility only (i.e., baseline air concentrations unavailable).

Grey shading and bolding	= Exceeds current 1-hour air threshold
Grey shading	= Exceeds 2025 1-hour air threshold

Table E: Screening of Predicted 24-Hour Air Concentrations

Constituent		Air Threshold[(a)]	Background Concentration	Predicted Air Concentrations						
		Current and 2025		Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario										
CO (8-hr)[(b)]	Max	6,000	NV	884	78	34	21	35	33	28
$PM_{2.5}$[(c)]	Max	27	17.5	**32**	19	18	18	18	18	18
	P95	27	17.5	**32**	19	18	18	18	18	18
	P75	27	17.5	26	18	18	18	18	18	18
PM_{10}[(c)]	Max	50	35	**56**	40	37	37	37	37	37
	P95	50	35	**51**	36	36	35	36	36	36
	P75	50	35	45	35	35	35	35	35	35
Emergency (N-1 event) Emission Scenario										
CO (8-hr)[(b)]	Max	6,000	NV	884	96	45	33	41	34	36
$PM_{2.5}$[(c)]	Max	27	17.5	**46**	21	19	19	19	19	19
	P95	27	17.5	**45**	20	18	18	19	19	19
	P75	27	17.5	**36**	18	18	18	18	18	18
PM_{10}[(c)]	Max	50	35	**77**	46	38	39	39	39	38
	P95	50	35	**65**	38	36	36	36	36	36
	P75	50	35	**55**	36	35	35	36	35	36

Notes:

CO = Carbon monoxide; PM= Particulate matter; TSP= Total suspended particulate; Max= Maximum concentration; P95= 95th percentile; P75= 75th percentile; NV = No value.

Concentrations are in micrograms per cubic metre ($\mu g/m^3$)

(a) Air thresholds are the Yukon Ambient Air Quality Standards (YAAQS) for the 24-hour averaging time. Given that the project will extent past January 1, 2025, the both the current and 2025 Standards were considered, however for the 24-hour standards there is no change. In the absence of YAAQS, air thresholds from other reputable agencies were considered.

(b) CO air predictions are for emissions from the Facility only (i.e., baseline air concentrations unavailable). CO air predictions were recorded at 8-hour

(c) Air predictions for $PM_{2.5}$, and PM_{10} are the sum of baseline air concentrations (i.e., background) and emissions from the facility.

Grey shading and bolding	= Exceeds current and 2025 24-hour air threshold

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Table F: Screening of Predicted Annual Air Concentrations

Constituent	Air Threshold[a]			Background Concentration	Predicted Air Concentrations					
	Non-carcinogenic		Carcinogenic [d]							
	Current	2025	Current and 2025		Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario										
NO_2 (OLM)[b]	32	23	-	11.2	15	14	13	17	15	18
SO_2[c]	13	11	-	NV	0.019	0.0092	0.0056	0.015	0.012	0.016
$PM_{2.5}$[b]	8.8	8.8	-	4.4	4.6	4.5	4.5	4.6	4.5	4.6
DPM[c]	5	5	0.033	NV	0.21	0.10	0.06	0.16	0.13	0.16
Emergency (N-1 event) Emission Scenario										
NO_2 (OLM)[b]	32	23	-	11.2	19	17	15	22	19	23
SO_2[c]	13	11	-	NV	0.043	0.019	0.012	0.029	0.023	0.029
$PM_{2.5}$[b]	8.8	8.8	-	4.4	4.9	4.6	4.6	4.8	4.7	4.7
DPM[c]	5	5	0.033	NV	0.52	0.23	0.14	0.35	0.28	0.34

Notes:

NO_2= Nitrogen dioxide; SO_2 = Sulfur dioxide; PM= Particulate matter; TSP= Total suspended particulate; DPM= Diesel particulate matter; OLM= Ozone limiting method; Max= Maximum concentration; P95= 95th percentile; P75= 75th percentile; NV = no value.

Concentrations are in micrograms per cubic metre ($\mu g/m^3$)

[a] Air Thresholds are the Yukon Ambient Air Quality Standards (YAAQS) for the annual averaging time. Given that the project will extent past January 1, 2025, both the current and the 2025 Standards were considered. In the absence of YAAQS, air thresholds from other reputable agencies were considered.

[b] Air predictions for NO_2, and $PM_{2.5}$, are the sum of baseline air concentrations (i.e., background) and emissions from the facility.

[c] SO_2 and DPM air predictions are for emissions from the Facility only (i.e., baseline air concentrations unavailable).

[d] Carcinogenic-based toxicity reference value for DPM (Health Canada, 2017)

Grey shading and bolding	= Exceeds current annual air threshold (non-carcinogenic)
Grey shading	= Exceeds 2025 annual air threshold (non-carcinogenic)
Underline	= Exceeds annual air threshold (carcinogenic)

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Table G: Summary of Hazard Quotients - 1-Hour (Current and 2025)

Constituent			TRV[(a)] (µg/m^3)	Hazard Quotients						
				Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario										
NO_2 (OLM)	Current	Max	113	**2.5**	**1.7**	**1.5**	**1.4**	**1.5**	**1.5**	**1.5**
		P95	113	**2.0**	**0.9**	**0.8**	**0.7**	**1.0**	**0.9**	**1.0**
		P75	113	**1.5**	**0.6**	**0.6**	**0.6**	**0.7**	**0.7**	**0.7**
	2025	Max	79	**3.6**	**2.5**	**2.2**	**2.0**	**2.2**	**2.2**	**2.1**
		P95	79	**2.8**	**1.3**	**1.2**	**1.0**	**1.5**	**1.3**	**1.4**
		P75	79	**2.2**	**0.9**	**0.9**	**0.9**	**1.0**	**0.9**	**1.0**
DPM	Current and 2025	Max	10	**6.3**	**2.8**	NA	**1.1**	NA	**1.0**	NA
		P95	10	**2.2**	0.1	NA	0.0	NA	0.1	NA
		P75	10	**1.1**	0.0	NA	0.0	NA	0.0	NA
Emergency (N-1 event) Emission Scenario										
NO_2 (OLM)	Current	Max	113	**4.9**	**2.6**	**1.8**	**1.7**	**1.7**	**1.8**	**1.6**
		P95	113	**3.0**	**1.2**	**1.0**	**0.9**	**1.2**	**1.1**	**1.2**
		P75	113	**2.0**	**0.7**	**0.7**	**0.6**	**0.7**	**0.7**	**0.8**
	2025	Max	79	**7.0**	**3.7**	**2.6**	**2.4**	**2.5**	**2.6**	**2.3**
		P95	79	**4.3**	**1.7**	**1.5**	**1.2**	**1.8**	**1.6**	**1.8**
		P75	79	**2.9**	**0.9**	**0.9**	**0.9**	**1.0**	**1.0**	**1.1**
DPM	Current and 2025	Max	10	**16.1**	**5.4**	**2.2**	**2.2**	**1.8**	**2.4**	**1.9**
		P95	10	**4.2**	**0.2**	0.1	0.0	**0.2**	0.2	0.2
		P75	10	**2.1**	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

NO_2 = Nitrogen dioxide; OLM = Ozone Limiting Method; DPM= Diesel particulate matter; NA = constituent did not screen on at this location; Max= Maximum concentration; P95= 95th percentile; P75= 75th percentile; TRV = Toxicity reference value.

[(a)] TRVs are the selected air thresholds for the 1-hour averaging time. For NO_2, the TRV is the current Yukon Ambient Air Quality Standards (YAAQS).

Grey shading and bolding = exceeds target Hazard Quotient of 0.2

Table H: Summary of Magnitude (% YAAQS) and Contingent Frequency of Exceedances (FOE) for Nitrogen Dioxide (NO_2) – 1-Hour

Constituent				Human Health Receptors						
				Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario										
NO_2	Max	Concentration (μg/m^3)		287	196	175	159	172	175	166
		% YAAQS	Current	**254**	**173**	**155**	**141**	**153**	**155**	**147**
			2025	**363**	**248**	**221**	**201**	**218**	**221**	**211**
		FOE (%)	Current	52	4.0	2.7	1.1	5.4	3.6	5.0
			2025	60	10	10	6.6	19	13	25
	P95	Concentration (μg/m^3)		223	103	94	82	115	102	113
		% YAAQS	Current	**197**	91	84	73	**102**	90	**100**
			2025	**282**	**131**	**119**	**104**	**146**	**128**	**143**
		FOE (%)	Current	47	-	-	-	-	-	-
			2025	55	5	5	2	14	8	20
	P75	Concentration (μg/m^3)		175	73	73	73	76	74	79
		% YAAQS	Current	**155**	65	65	65	67	66	70
			2025	**221**	93	93	93	96	94	100
		FOE (%)	Current	27	-	-	-	-	-	-
			2025	35	-	-	-	-	-	-
Emergency (N-1 event) Emission Scenario										
NO_2	Max	Concentration (μg/m^3)		555	295	208	192	196	202	184
		% YAAQS	Current	**491**	**261**	**184**	**170**	**174**	**178**	**163**
			2025	**702**	**373**	**263**	**243**	**249**	**255**	**233**
		FOE (%)	Current	56	6.8	5.6	2.9	10.6	6.6	12.0
			2025	68	16	16	11	27	21	34
	P95	Concentration (μg/m^3)		342	132	118	97	141	124	139
		% YAAQS	Current	**303**	**117**	**105**	86	**125**	**109**	**123**
			2025	**433**	**167**	**150**	**122**	**179**	**157**	**176**
		FOE (%)	Current	51	1.8	0.64	-	5.6	1.6	7.0
			2025	63	11	11	6.1	22	16	29
	P75	Concentration (μg/m^3)		229	74	74	73	81	77	87
		% YAAQS	Current	**203**	65	65	65	72	68	77
			2025	**290**	93	93	93	**102**	97	**110**
		FOE (%)	Current	31	-	-	-	-	-	-
			2025	43	-	-	-	2.1	-	9.1

Notes:

FOE= Frequency of Exceedance; NO_2= Nitrogen Dioxide; Max= Maximum concentration; P95= 95th Percentile; P75= 75th Percentile; YAAQS= Yukon Ambient Air Quality Standards; "-" = Not available because concentration screened below threshold.

YAAQS for NO2 is 113 μg/m^3 currently, and will changed to 79 μg/m^3 in 2025 (Government of Yukon, 2019).

% YAAQS = Percentage of predicted concentration exceeding the YAAQS, calculated as (predicted concentration/YAAQS)*100

FOE (%) = Frequency of which the predicted concentration exceeds the YAAQS in a year.

Grey shading and bolded	= %YAAQS above 100%

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Table I: Summary of Magnitude (% Threshold) and Contingent Frequency of Exceedances (FOE) for DPM (Diesel Particulate Matter) – 1-Hour

Constituent			Human Health Receptors						
			Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario									
DPM	Max	Concentration (µg/m^3)	63	28	9.6	11	8.3	10	8.1
		% Threshold	**634**	**280**	96	**107**	83	**105**	81
		FOE (%)	27	0.38	-	0.011	-	0.011	-
	P95	Concentration (µg/m^3)	22	0.61	0.46	0.16	0.97	0.63	0.91
		% Threshold	**219**	6.1	4.6	1.6	9.7	6.3	9.1
		FOE (%)	22	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	11	0.00064	0.0013	0.000046	0.049	0.017	0.10
		% Threshold	**105**	0.0064	0.013	0.00046	0.49	0.17	1.04
		FOE (%)	2.50	-	-	-	-	-	-
Emergency (N-1 event) Emission Scenario)									
DPM	Max	Concentration (µg/m^3)	161	54	22	22	18	24	19
		% Threshold	**1607**	**537**	**225**	**217**	**183**	**236**	**185**
		FOE (%)	44	1.7	0.34	0.29	0.29	0.38	0.046
	P95	Concentration (µg/m^3)	42	2.0	1.2	0.43	2.1	1.5	1.8
		% Threshold	**425**	20	12	4.3	21	15	18
		FOE (%)	39	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	21	0.0048	0.0069	0.00055	0.12	0.051	0.23
		% Threshold	**206**	0.048	0.069	0.0055	1.2	0.51	2.3
		FOE (%)	19	-	-	-	-	-	-

Notes:

DPM= Diesel Particulate Matter; FOE= Frequency of Exceedance; Max= Maximum concentration; P95= 95th Percentile; P75= 75th Percentile; "-" = Not available because concentration screened below threshold.

Selected Threshold of 10 µg/m^3 for DPM based on Health Canada (2016) Human Health Risk Assessment for Diesel Exhaust.

% Threshold = Percentage of predicted concentration exceeding the threshold, calculated as (Predicted concentration/threshold)*100

FOE (%) = Frequency of which the predicted concentration exceeds the Threshold in a year.

Grey shading and bolded	= %Threshold above 100%

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Table J: Summary of Hazard Quotients - 24-Hour (Current and 2025)

Constituent		TRV[(a)] ($\mu g/m^3$)	Hazard Quotients						
			Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario									
$PM_{2.5}$	Max	27	**1.2**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P95	27	**1.2**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P75	27	**1.0**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
PM_{10}	Max	50	**1.1**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P95	50	**1.0**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P75	50	**0.9**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
Emergency (N-1 event) Emission Scenario									
$PM_{2.5}$	Max	27	**1.7**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P95	27	**1.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P75	27	**1.3**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
PM_{10}	Max	50	**1.5**	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
	P95	50	**1.3**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
	P75	50	**1.1**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**

Notes:

PM= Particulate Matter; Max= Maximum concentration; P95= 95th percentile; P75= 75th percentile; TRV= Toxicity Reference Value.

[(a)] TRVs are the selected air thresholds for the 24-hour averaging time. For all parameters, the air thresholds are the same for current and after 2025.

Grey shading and bolding = exceeds target Hazard Quotient of 0.2

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Table K: Summary of Magnitude (%YAAQS) and Contingent Frequency of Exceedances (FOE) for $PM_{2.5}$ – 24-Hour

Constituent			Human Health Receptors						
			Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario									
PM2.5	Max	Concentration (µg/m^3)	32	19	18	18	18	18	18
		% YAAQS	**119**	70	67	67	68	67	67
		FOE (%)	22	-	-	-	-	-	-
	P95	Concentration (µg/m^3)	32	19	18	18	18	18	18
		% YAAQS	**117**	69	66	66	67	67	67
		FOE (%)	17	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	26	18	18	18	18	18	18
		% YAAQS	97	68	66	65	67	66	67
		FOE (%)	26	18	18	18	18	18	18
Emergency (N-1 event) Emission Scenario)									
PM2.5	Max	Concentration (µg/m^3)	46	21	19	19	19	19	19
		% YAAQS	**170**	77	70	69	71	70	70
		FOE (%)	54	-	-	-	-	-	-
	P95	Concentration (µg/m^3)	45	20	18	18	19	19	19
		% YAAQS	**167**	73	68	68	69	70	69
		FOE (%)	49	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	36	18	18	18	18	18	18
		% YAAQS	**132**	68	66	65	67	66	67
		FOE (%)	29	-	-	-	-	-	-

Notes:

FOE= Frequency of Exceedance; PM= Particulate Matter; Max= Maximum concentration; P95= 95th Percentile; P75= 75th Percentile; YAAQS= Yukon Ambient Air Quality Standards, "-" = Not available because concentration screened below threshold.

% YAAQS = Percentage of predicted concentration exceeding the YAAQS, calculated as (Predicted concentration/YAAQS)*100

FOE (%) = Frequency of which the predicted concentration exceeds the YAAQS in a year.

Grey shading and bolded	= %YAAQS above 100%

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Table L: Summary of Magnitude (%YAAQS) and Contingent Frequency of Exceedances (FOE) for PM_{10} – 24-Hour

Constituent			Human Health Receptors						
			Maximum Point of Impingement	Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario									
PM_{10}	Max	Concentration (µg/m^3)	56	40	37	37	37	37	37
		% YAAQS	**111**	79	73	74	74	73	73
		FOE (%)	5.8	-	-	-	-	-	-
	P95	Concentration (µg/m^3)	51	36	36	35	36	36	36
		% YAAQS	**101**	72	71	71	71	71	71
		FOE (%)	0.82	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	45	35	35	35	35	35	35
		% YAAQS	90	72	71	70	71	71	71
		FOE (%)	-	-	-	-	-	-	-
Emergency (N-1 event) Emission Scenario)									
PM_{10}	Max	Concentration (µg/m^3)	77	46	38	39	39	39	38
		% YAAQS	**154**	92	77	79	79	78	77
		FOE (%)	40	-	-	-	-	-	-
	P95	Concentration (µg/m^3)	65	38	36	36	36	36	36
		% YAAQS	**130**	75	72	72	73	73	73
		FOE (%)	36	-	-	-	-	-	-
	P75	Concentration (µg/m^3)	55	36	35	35	36	35	36
		% YAAQS	**110**	72	71	70	71	71	71
		FOE (%)	16	-	-	-	-	-	-

Notes:

FOE= Frequency of Exceedance; PM= Particulate Matter; Max= Maximum concentration; P95= 95th Percentile; P75= 75th Percentile; YAAQS= Yukon Ambient Air Quality Standards; "-" = Not available because concentration screened below threshold. concentration screened below threshold.

YAAQS for PM_{10} is 50 ug/m^3 currently and will remain the same in 2025 (Government of Yukon, 2019).

% YAAQS = Percentage of predicted concentration exceeding the YAAQS, calculated as (Predicted concentration/YAAQS)*100

FOE (%) = Frequency of which the predicted concentration exceeds the YAAQS in a year.

Grey shading and bolded = %YAAQS above 100%

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Table M: Summary of Hazard Quotients - Annual (Non-Carcinogenic)

Constituent	Receptor	TRV[(a)] ($\mu g/m^3$)		Hazard Quotients					
				Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario									
NO_2 (OLM)	Adult Resident [(b)]	Current	32	**0.5**	NA	NA	NA	NA	**0.6**
		2025	23	**0.7**	NA	NA	NA	NA	**0.8**
	Hospital Worker /Teacher/Student [(c)]	Current	32	NA	0.1	0.1	0.1	0.1	0.2
		2025	23	NA	0.2	0.2	0.2	0.2	0.2
$PM_{2.5}$	Adult Resident [(b)]	Current & 2025	8.8	**0.5**	NA	NA	NA	NA	**0.5**
	Hospital Worker /Teacher/Student [(c)]	Current & 2025	8.8	NA	0.1	0.1	0.1	0.1	0.1

Notes:

NO_2= Nitrogen dioxide; OLM = Ozone Limiting Method; PM= Particulate Matter; TRV= Toxicity Reference Value; NA= not applicable, hospital worker not evaluated at this location.

[(a)] TRVs are the Yukon Ambient Air Quality Standards (YAAQS) for the annual averaging time. Given that the project will extent past January 1, 2025, both the current and 2025 Standards were considered.

[(b)] Evaluated for long-term effects at the nearest residence and Whitehorse General Hospital only, see Section 4.2 of report for details. Exposure for non-carcinogens does not consider life-stage, therefore, the evaluation of the adult resident is representative of all life stages.

[(c)] Evaluated for long-term effects the Whitehorse General Hospital and school receptor locations, see Section 4.2 of report for details.

Grey shading and bolding	= exceeds target Hazard Quotient of 0.2

September 2023 Reference No. CA-WSP-221-07678-00-001-R-Rev1

Table N: Summary of Incremental Lifetime Cancer Risks - Annual (Carcinogenic)

Constituent	Receptor	Incremental Lifetime Cancer Risk (ILCR)					
		Nearest Residence	Christ the King Elementary School	Grey Mountain Primary School	F.H. Collins Secondary School	Selkirk Elementary School	Whitehorse General Hospital
Expected Emission Scenario							
DPM	Composite Resident [a]	**6.4E-05**	NA	NA	NA	NA	NA
	Adult Resident [b]	**4.8E-05**	NA	NA	NA	NA	**3.7E-05**
	Hospital Worker/Teacher [c]	NA	3.6E-06	2.2E-06	5.9E-06	4.6E-06	5.9E-06

Notes:

DPM= Diesel Particulate Matter; ILCR= Incremental lifetime cancer risk; NA= Not applicable, receptor was not evaluated at this location

Inhalation unit risk (IUR) is 0.0003 micrograms per cubic metre (µg/m^3) (Cal OEHHA, 2023)

[a] Evaluated for carcinogenic effects at the nearest residence only, see Section 4.2 of report for details.

[b] Evaluated for carcinogenic effects the nearest residence and Whitehorse General Hospital, see Section 4.2 of report for details.

[c] Evaluated for carcinogenic effects the Whitehorse General Hospital and school receptor locations, see Section 4.2 of report for details.

Grey shading and bolding	Exceeds risk threshold of $1x10^{-5}$

wsp.com

APPENDIX

C NOISE IMPACT ASSESSMENT

REPORT

Noise Impact Assessment

Whitehorse Rapids Generating Station, Whitehorse, Yukon

Submitted to:

Yukon Energy Corporation

#2 Miles Canyon Road
Whitehorse, YT Y1A 6S7

Submitted by:

WSP Canada Inc.

840 Howe Street
Vancouver, BC V6Z 2M1

221-07678-00

May 24, 2024

Distribution List

1 Electronic Copy - Yukon Energy Corporation

1 Electronic Copy - WSP Canada Inc.

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TABLES

FIGURES

1.0 INTRODUCTION

WSP Canada Inc. (WSP) was retained by Yukon Energy Corporation (Yukon Energy) to conduct a noise impact assessment (NIA) for the Whitehorse Rapids Generating Station (the Station) in Whitehorse, Yukon. The Station is located at the outlet of the Schwatka Lake on the Yukon River (latitude: 60.698º, latitude: -135.045º) and is shown in Figure 1. Yukon Energy is installing additional permanent diesel generation capacity at the Station (the Project). The NIA was conducted to evaluate the potential effects of the Station's future noise emissions on the existing acoustic environment surrounding the Station.

Due to the lack of noise guidance in the Yukon, the NIA followed the BC Oil and Gas Commission's (OGC) *British Columbia Noise Control Best Practice Guideline* (OGC Guideline) (OGC 2023), which is guidance specifically for oil and gas facilities located within British Columbia, and Health Canada's *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise* (Health Canada Guidance) (Health Canada 2017), which is Health Canada's guidance for assessing human health impacts related to noise in environmental assessments.

2.0 PROJECT DESCRIPTION

The Station provides reliable energy supply to supplement renewable energy sources. The Station is designed to quickly provide electricity during loss of hydro generation, peak hours consumption, low water periods, extremely low temperatures, and emergencies.

The Station currently has 13.125 MW of permanent natural gas generation capacity and 10.8 MW of permanent diesel generation capacity. The additional permitted diesel generation capacity of approximately 5.4 MW is supplied at this time by three (3) mobile rental diesel engines. The Station is planning on installing two new Tier 4 diesel generators for approximately 5.2 MW of permanent diesel generation capacity to replace a unit, Whitehorse Diesel Number 3 (WD3), which retired several years ago. During the emergency (N-1)[1] events, the Station needs access to an additional 12 MW of capacity from six (6) temporary mobile diesel generators for a total capacity of 42 MW at the Station. One additional mobile diesel is installed at the Station in winter as redundant back up. The last N-1 event was approximately 17 years ago, so this event is expected to be short-term and very infrequent.

Expected typical operations would include the 13.125 MW permanent natural gas generation, 5.2 MW from the new Tier 4 permanent diesel generators and 3 MW from either the other permanent diesel units or from the temporary mobile diesel generators for a capacity of 21 MW.

[1] N-1 (Single Contingency) Planning Criterion: A reliability planning criterion used to determine the capacity requirements of the system. Yukon Energy's N-1 criterion requires that each part of the Yukon Energy transmission grid should be able to carry the forecast peak winter demand, excluding major industrial demand, under the largest single contingency. The single largest contingency is defined as loss of the largest single element which could be either a transmission line or generating station. This criterion considers the ability to interrupt large industrial customers during an emergency event, which is why only non-industrial peak demand is included.

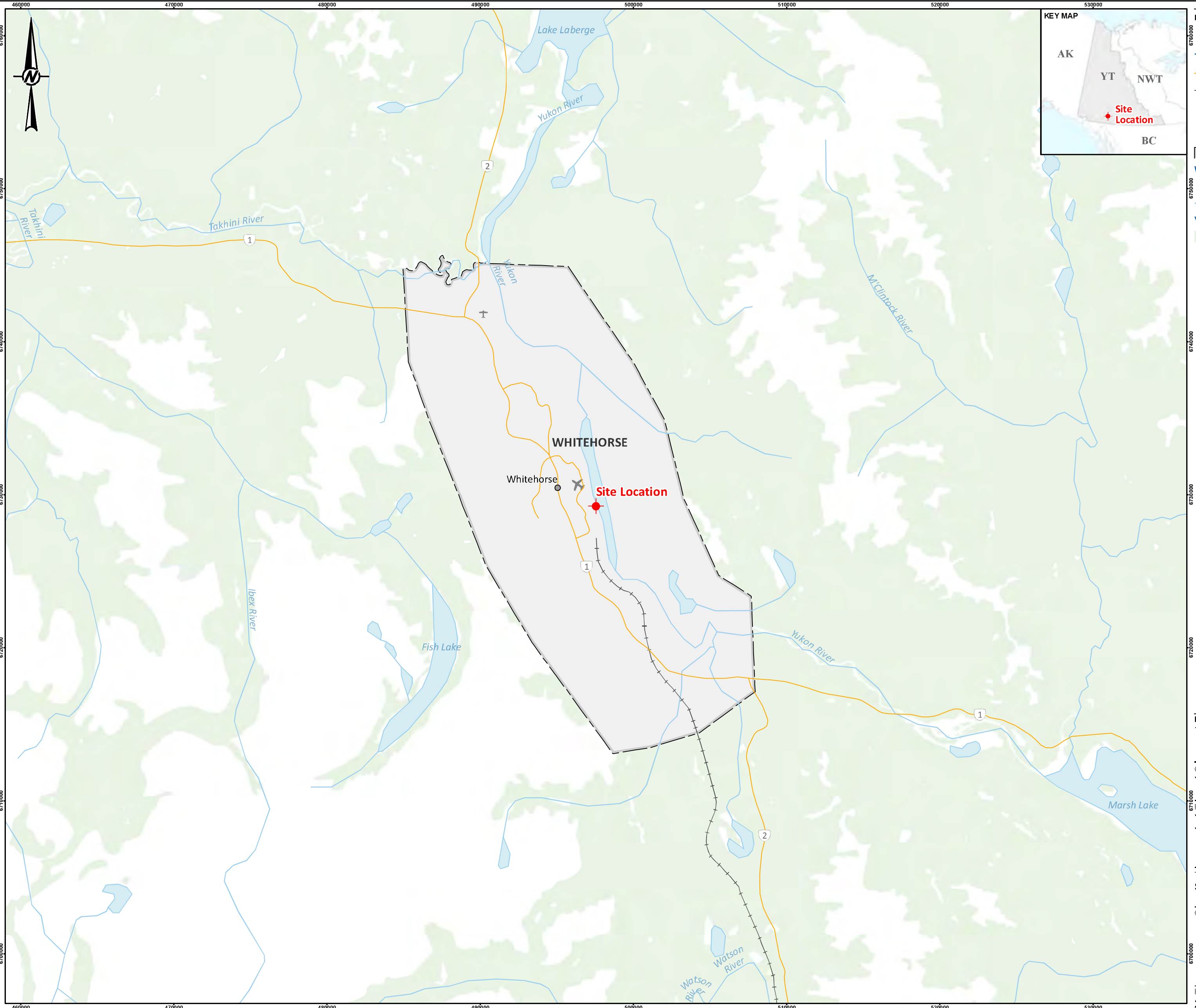
Capacity Planning Criterion: This criterion ensures that the system has sufficient capacity to meet peak demand (peak capacity) for two consecutive weeks under extreme cold winter conditions. The capacity planning criterion is based on the single contingency (N-1) criterion, which states that each part of the Yukon Energy transmission grid shall supply the forecast non-industrial peak winter demand, excluding major industrial demand, under the largest single contingency. Yukon Energy's current largest single contingency corresponds to the loss of the 37 MW Aishihik Generation Station, either through an outage of the generating station itself or an outage of the L171 transmission line that interconnects the Aishihik Generating Station to the Takhini Substation.

Based on Yukon Energy projections, the frequency with which the units are used under the expected typical operations are:

- Permanent natural gas units: all three units will be used in the winter from December through April; in the shoulder months (May and November) typically, only one or two units would be used.
- New Tier 4 permanent diesel generators: these two units will typically only run in the winter (December through April) and will not run continuously. During those months, the units would run for approximately 24 hours (nonconsecutively) within any given two-week period.
- Permanent diesel generators or temporary mobile diesel generators: these units will typically only run during the winter (December through April) and will not run continuously. During those months, the units would run for approximately six hours (nonconsecutively) within any given two-week period.

In addition to the expected typical operations and emergency (N-1) events, all thermal units are operated for short periods (1 to 2 hours) on a monthly basis throughout the year for maintenance/operational readiness purposes.

The site boundary, along with the buildings and generator locations, is shown in Figure 2.



LEGEND

- Site Location

Transportation

- Paved Roads
- Railways
- Airport
- Airfield
- Major Urban Centre

Water Features

- Major Lake/River
- Perennial Creeks/Streams

Vegetation & Parks

- Vegetation

0 5 10 15 20

1:250,000 Kilometers

Coordinate System: NAD 1983 UTM Zone 8N

REFERENCE(S)

1. DATA PROVIDED BY ALTALIS;NATURAL RESOURCE CANADA; ESRI BASEMAPS;GEOGRATIS

CLIENT
YUKON ENERGY

PROJECT
YUKON ENERGY WHITEHORSE RAPID GENERATION STATION
YUKON

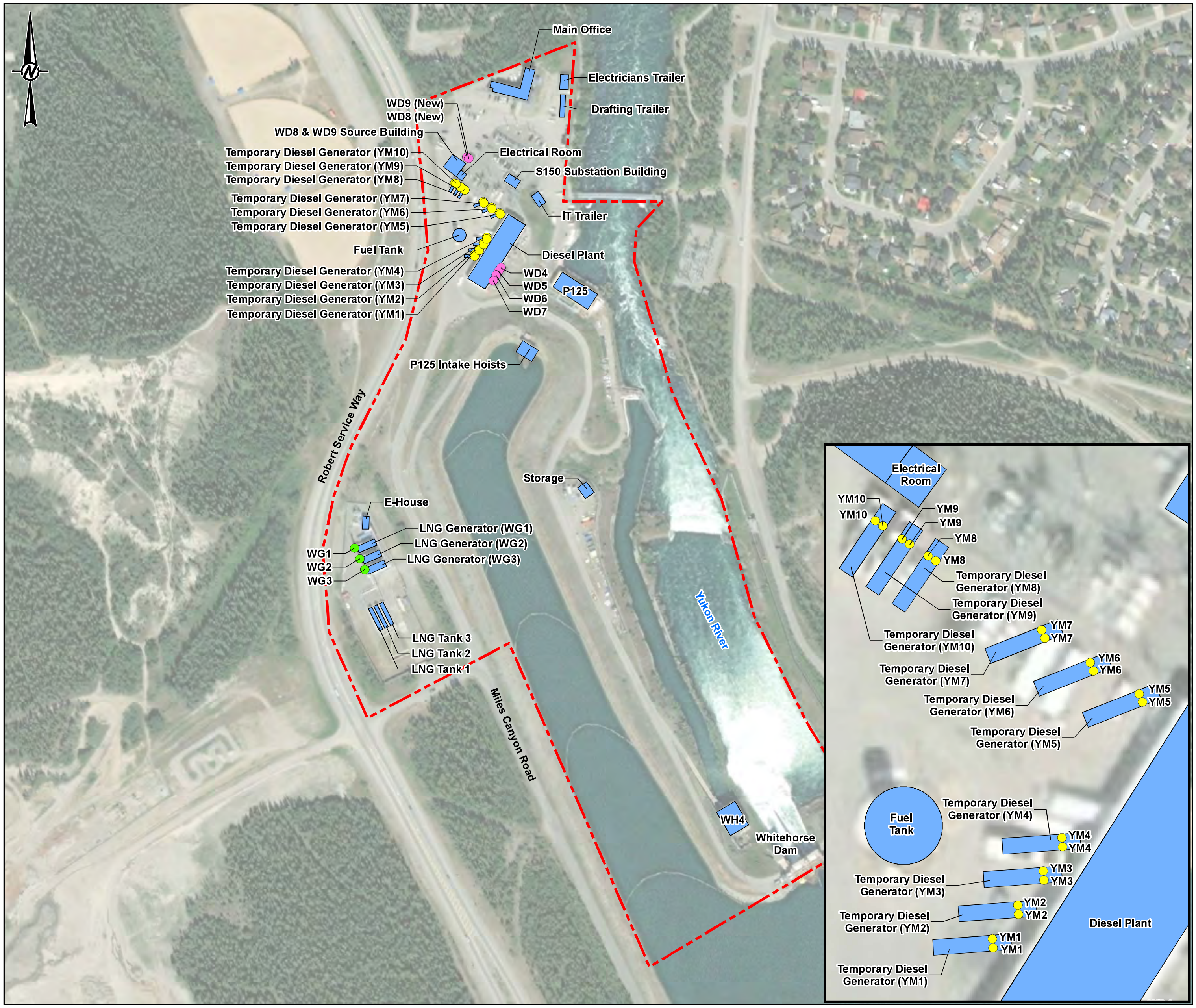
TITLE
SITE LOCATION MAP

CONSULTANT

YYYY-MM-DD	2024-04-22
REPORT BY	AC
DRAWN BY	JH
REVIEWED BY	SD
OFFICE	CALGARY

PROJECT NO.
221-07678-00

FIGURE



LEGEND
- Site Boundary
- Buildings
- Mobile Diesel Generators
- Permanent Diesel Generators
- Permanent Natural Gas Generators

0 50 100 150 200 250
1:600 Meters
Coordinate System: NAD 1983 UTM Zone 8N

REFERENCE(S)
1. IMAGERY SOURCE: ESRI IMAGERY SERVICE [2021]

CLIENT
YUKON ENERGY

PROJECT
YUKON ENERGY WHITEHORSE RAPID GENERATION STATION
YUKON

TITLE
SITE DIAGRAM

CONSULTANT
wsp

YYYY-MM-DD	2024-04-22
REPORT BY	AC
DRAWN BY	JH
REVIEWED BY	SD
OFFICE	CALGARY

PROJECT NO.
221-07678-00

FIGURE
2

PATH: \\golder.gds\gal\Calgary\CAD\MGIS\Active\WSPAB\00_Projects_2022\221-07678-00_YukonEnergyCorp\221-07678-00_NRF\figure2_SiteDiagram.mxd PRINTED ON: 2024-04-22 AT: 12:31:53 PM

3.0 NOISE CRITERIA

In the absence of noise guidance in the Yukon, the NIA followed the OGC Guideline and Health Canada Guidance. Both guidance documents assess noise from a receptor perspective; the OGC Guideline defines noise receptors as permanent or seasonally occupied dwellings. In the absence of occupied dwellings within 1.5 km of the Project Boundary, the OGC Guideline indicates that noise levels should be assessed at the most impacted unoccupied location 1.5 km from the Project Boundary. Receptors considered for the NIA are discussed in Section 4.2.

The OGC Guideline considers broadband compliance and assessment of potential low frequency noise (LFN) issues. The Health Canada Guidance considers the change in the percentage of highly annoyed people due to changes in noise levels.

3.1 Broadband Noise

Broadband compliance is typically assessed by comparing cumulative noise level predictions at each receptor to Permissible Sound Level (PSL) values specified by the OGC Guideline. Cumulative noise levels should be calculated as the sum of the following:

- An assumed Ambient Sound Level (ASL) meant to represent the contribution of natural and non-industrial noise sources under representative conditions. The value of the ASL is mandated by the OGC Guideline.
- The noise contribution from existing and approved energy resource and power generating facilities in the area.
- The noise contribution from the Project.

The PSL is calculated starting from a Basic Sound Level (BSL), derived from the population density in the area and proximity to transportation infrastructure. The BSL can then be adjusted for the following:

- The time of day (to account for the fact that nighttime noise is more disruptive than daytime noise) – the OGC Guideline defines daytime as 07:00 am to 10:00 pm and nighttime as 10:00 pm to 07:00 am.
- Season (i.e., wintertime conditions) – not to be included when determining the PSL for design purposes[2].
- Measured ambient noise levels in the area – applied only with OGC permission.
- Temporary activities – the temporary activity adjustment is not applicable to the Project noise assessment since the Project is assumed to run for more than 60 days.

Note that the PSL is not applicable for emergency situations.

3.2 Low Frequency Noise

In addition to broadband compliance, the OGC Guideline also requires an assessment of potential LFN issues. The separate assessment of LFN addresses the fact that, depending on spectral shape, noise effects associated with LFN can be observed even when the overall broadband noise level is otherwise acceptable.

[2] As a majority of noise concerns occur during the summer months (i.e., when windows are typically open), the PSL definition is based on summertime conditions. The OGC Guideline states that the wintertime adjustment (+5 dB) should not be included when determining the PSL for design purposes and only be considered when assessing wintertime complaints. Therefore, it was not considered when determining the applicable PSL for the Project, even though the majority of equipment use at the Station is limited to the wintertime.

The OGC Guideline provides two criteria for identifying potential LFN issues. According to the OGC Guideline, a LFN condition may exist when:

- The value of the predicted noise level, expressed in C-weighted decibels (dBC), minus the predicted noise level, expressed in A-weighted decibels (dBA), is greater than or equal to 20 decibels (dB).
- A clear tonal component exists at a frequency below 250 Hertz (Hz).

The first condition can be assessed with model predictions. The second condition can only be assessed with actual noise measurements, since computer noise models typically cannot provide noise level predictions at a 1/3 octave-band resolution, and according to the OGC Guideline, 1/3 octave-band results are required to identify the presence (or absence) of a tone.

3.3 Percent Highly Annoyed

Expected noise from the Project was assessed using the highly annoyed (%HA) criterion described in the Health Canada Guidance. The %HA criterion uses an equation, based on empirical studies of human reaction to noise, to estimate the percentage of residents that would be highly annoyed (%HA) by a given noise level. The %HA is intended to assess long-term (i.e., greater than one year) noise levels and, therefore, is not applicable for emergency, infrequent scenarios.

The %HA is calculated based on L_{dn} using the following formula:

$$\%HA = \frac{100}{1+e^{(10.4-0.132\times L_{dn})}},$$

where L_{dn} is defined in the formula presented below based on the 15-hour $L_{eq,day}$ and 9 hour $L_{eq,night}$:

$$L_{eq} = 10log_{10}\left(\frac{15\times10^{L_{eq,day}/10}+9\times10^{(L_{eq,night}+10)/10}}{24}\right).$$

$L_{eq,day}$ and $L_{eq,night}$ are the application daytime and nighttime noise levels calculated through the logarithmic addition of measured, or estimated baseline noise levels and predicted noise contribution from the Project construction or operation for the periods of daytime and nighttime, respectively.

If the %HA increases by more than 6.5% as a result of the Project, then the Health Canada Guidance recommends mitigation be considered.

4.0 METHODOLOGY

The objective of the NIA was to assess potential changes in the noise levels due to the Project and determine if the Project meets the noise criteria specified in the OGC Guideline and Health Canada Guidance. The following approach was used to conduct the NIA:

- Establish baseline noise levels (background) in the area using the OGC Guideline.
- Determine noise emissions resulting from the Project.
- Predict Project noise levels at each identified representative receptor.
- Compare noise level predictions to the criteria outlined in Section 3 to characterize the potential noise effects associated with the Project.

4.1 Baseline Noise Levels

As directed by the OGC Guideline, the Ambient Sound Levels (ASL) from the OGC Guideline were used as the baseline noise levels for the Project. According to the OGC Guideline, the ASL is representative of the natural and non-industrial noise sources in the vicinity of the Station. There are rapids located between the Station and the nearest receptor; it was expected that any contribution to noise levels from the rapids were captured in the ASLs. As shown in Table 4-1, the ASLs at the nearest receptor to the Station were 56 dBA during the daytime and 46 dBA during the nighttime.

Baseline noise monitoring was carried out by Hemmera in 2020 at the Station's fenceline and at the nearby substation (Hemmera 2020). While baseline monitoring was not carried out at any receptors, the ASLs were compared to the measured data to confirm their suitability. Baseline noise levels measured at the substation, the nearest location to the nearest receptor to the Project, were 54 dBA during the daytime and 49 dBA during the nighttime.

There are no significant existing and approved third-party facilities in the vicinity of the Station; therefore, there was no noise contribution from industrial sources towards the baseline noise levels.

The Erik Nielsen Whitehorse International Airport is located approximately 2 km from the Station, with the nearest point on the runway located approximately 600 m from the Station. Arriving and departing flights are infrequent (i.e., less than 10 arrivals and 10 departures per day) and therefore, noise from the airport was not considered in the NIA.

4.2 Receptors

The noise levels were assessed at three dwellings identified within 1.5 km of the Station. These representative receptors were chosen as the most impacted locations representative of various directions from the Project (Table 4-1).

Receptor R01 is located 200 m east of the Station, in an area with dwelling unit density of greater than the 160 dwellings per quarter section (dwellings within a 451 m radius) and is more than 100 m and less than 500 m from a heavily travelled road. Therefore, the daytime PSL for this location is 61 dBA. R01 is the nearest receptor to the Station and is considered to be representative of its neighbourhood; predicted noise levels from the Project at R01 are expected to be similar to or higher than those at the surrounding dwellings that are located further from the Station.

Receptor R02 is located 1.3 km north of the Station, also in an area with a population density greater than 160 dwellings per quarter section. It is located less than 100 m from a heavily travelled road, and therefore, the daytime PSL is 66 dBA. R02 is the nearest receptor in the northern direction from the Station.

Receptor R03 is a RV Park (Hi Country RV Park), located 1.4 km southwest of the Station, within 100 m of the Alaska Highway and with a population density of 9 to 160 dwellings per quarter section. Therefore, the daytime PSL for this location is 63 dBA. R03 is the nearest receptor in the southern and western directions from the Station.

The receptors are shown in Figure 3.

Table 4-1: Noise Receptors

Noise Receptor	Monitoring Location Description	Universal Transverse Mercator Location (Zone 8, NAD 83)		Ambient Sound Level[(a)] (dBA)		Permissible Sound Level[(b)] (dBA)	
		Easting (m)	Northing (m)	Daytime	Nighttime	Daytime	Nighttime
R01	200 m east of the Station	497811	6729264	56	46	61	51
R02	1.3 km north of the Station	497045	6730581	61	51	66	56
R03	1.4 km southwest of the Station	496707	6727622	58	48	63	53

Notes: (a) ASL is 5 dBA less than the PSL
(b) Nighttime PSL is 10 dBA less than the Daytime PSL

LEGEND

- Site Boundary
- Receptor Location

0 100 200 300 400 500
1:12,500 Meters

Coordinate System: NAD 1983 UTM Zone 8N

REFERENCE(S)
1. IMAGERY SOURCE: ESRI IMAGERY SERVICE [2021]

CLIENT
YUKON ENERGY

PROJECT
YUKON ENERGY WHITEHORSE RAPID GENERATION STATION
YUKON

TITLE
RECEPTOR LOCATIONS

CONSULTANT
wsp

YYYY-MM-DD	2024-04-22
REPORT BY	AC
DRAWN BY	JH
REVIEWED BY	SD
OFFICE	CALGARY

PROJECT NO.
221-07678-00

FIGURE
3

4.3 Assessment Cases

The NIA assessed two variants of an Expected Case (i.e., typical operations) and an Emergency (N-1) Case, as follows:

- The Expected Case consists of the cumulative noise level associated with the baseline in combination with the Project's expected operating scenario:
  1) **Expected Scenario 1 (21.312 MW):** 3 existing permanent natural gas units (13.125 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 2 existing diesel units (3 MW)
  2) **Expected Scenario 2 (21.312 MW):** 3 existing permanent natural gas units (13.125 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 2 mobile diesel units (3 MW).
- The Emergency (N-1) Case consists of the cumulative noise level associated with the baseline in combination with the Project's emergency scenario.
  1) **Emergency (N-1) Scenario (41.725 MW):** 3 existing permanent natural gas units (13.125 MW) + 4 existing permanent diesel units (10.8 MW) + 2 new Tier 4 diesel generators (5.2 MW) + 7 of 10 mobile diesel units (12.6 MW).

Table 4-2 provides a summary of the active generators at the Station during the various assessment scenarios. WG1 to WG3 and WD4 to WD7 are currently in operation, while WD8 and WD9 are expected to be installed in Q2 and Q3 in 2024 with commissioning in time for use in Q4 2024. YM1 to YM10 are representative of the existing temporary mobile diesel generators used at the Station.

Table 4-2: Summary of Operating Scenarios and Associated Equipment

Assessment Case	WRGS Genset ID	Status	WRGS Genset Engine Model	Fuel Type	Output Unit Power Generation [MW]
Expected Scenario 1	WG1	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG2	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG3	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WD4	Existing	Electro-Motive Diesel (EMD) 20C	Diesel	2.5
	WD5	Existing	Electro-Motive Diesel (EMD) 20C	Diesel	2.5
	WD8	New	CAT C175-16 with SCR	Diesel	2.6
	WD9	New	CAT C175-16 with SCR	Diesel	2.6
Expected Scenario 2	WG1	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG2	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG3	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WD8	New	CAT C175-16 with SCR	Diesel	2.6
	WD9	New	CAT C175-16 with SCR	Diesel	2.6
	YM1	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM2	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825

Table 4-2: Summary of Operating Scenarios and Associated Equipment

Assessment Case	WRGS Genset ID	Status	WRGS Genset Engine Model	Fuel Type	Output Unit Power Generation [MW]
Emergency (N-1) Scenario	WG1	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG2	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WG3	Existing	General Electric (GE) Jenbacher JMC 624 GS-NL	NG	4.375
	WD4	Existing	Electro-Motive Diesel (EMD) 20C	Diesel	2.5
	WD5	Existing	Electro-Motive Diesel (EMD) 20C	Diesel	2.5
	WD6	Existing	Electro-Motive Diesel (EMD) 20C	Diesel	2.5
	WD7	Existing	CAT 3612	Diesel	3.3
	WD8	New	CAT C175-16 with SCR	Diesel	2.6
	WD9	New	CAT C175-16 with SCR	Diesel	2.6
	YM1	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM2	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM3	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM4	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM5	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM6	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825
	YM7	Mobile/Temp	Yukon Mobile CAT 3516	Diesel	1.825

4.4 Noise Sources and Emissions

The Station's noise sources are shown on Figure 2. Noise emissions for Station sources were established using manufacturers' data and previous site measurements. Octave-band sound power levels for each piece of equipment are presented in Table 4-3. Other parameters such as height, location, operating scenario, noise source component, and modelled noise control of each equipment piece are also included in Table 4-3.

Table 4-3: Whitehorse Rapids Generating Station Noise Emission Sources

Source ID	Source Name	Operating Scenario	Noise Source Component	Noise Controls	Height [m]	Octave-Band Sound Power Level [dBA]									Sound Power Level [dBA]
						31.5	63	125	250	500	1000	2000	4000	8000	
WG1	LNG Generator 1	Expected/Emergency	Mechanical	Selective Catalytic Reduction (SCR)	3	112.9	119.9	99.9	97.9	83.9	82.9	77.9	77.9	79.9	96
			Exhaust	Silencer	12.2	117.0	99.0	87.0	74.0	78.0	89.0	91.0	98.0	80.0	100
			Fans	None	3	-	100.0	93.5	95.5	101.5	98.5	93.5	85.0	78.5	103
WG2	LNG Generator 2	Expected/Emergency	Mechanical	SCR	3	112.9	119.9	99.9	97.9	83.9	82.9	77.9	77.9	79.9	96
			Exhaust	Silencer	12.2	117.0	99.0	87.0	74.0	78.0	89.0	91.0	98.0	80.0	100
			Fans	None	3	-	100.0	93.5	95.5	101.5	98.5	93.5	85.0	78.5	103
WG3	LNG Generator 3	Expected/Emergency	Mechanical	SCR	3	112.9	119.9	99.9	97.9	83.9	82.9	77.9	77.9	79.9	96
			Exhaust	Silencer	12.2	117.0	99.0	87.0	74.0	78.0	89.0	91.0	98.0	80.0	100
			Fans	None	3	-	100.0	93.5	95.5	101.5	98.5	93.5	85.0	78.5	103
WD4	Diesel Generator 1	Expected 1/ Emergency	Mechanical	n/a	6	93.2	98.4	104.9	108.1	106.7	104.8	112.9	115.2	93.2	98.4
			Exhaust	n/a	12	-	-	88.2	72.4	72.9	89.4	96.5	98.4	97.6	103.0
WD5	Diesel Generator 2	Expected 1/ Emergency	Mechanical	n/a	6	93.2	98.4	104.9	108.1	106.7	104.8	112.9	115.2	93.2	98.4
			Exhaust	n/a	12	-	-	88.2	72.4	72.9	89.4	96.5	98.4	97.6	103.0
WD6	Diesel Generator 3	Emergency	Mechanical	n/a	6	93.2	98.4	104.9	108.1	106.7	104.8	112.9	115.2	93.2	98.4
			Exhaust	n/a	12	-	-	88.2	72.4	72.9	89.4	96.5	98.4	97.6	103.0
WD7	Diesel Generator 4	Emergency	Mechanical	n/a	6	93.2	98.4	104.9	108.1	106.7	104.8	112.9	115.2	93.2	98.4
			Exhaust	n/a	12	-	-	88.2	72.4	72.9	89.4	96.5	98.4	97.6	103.0
WD8	Diesel Generator 5	Expected/Emergency	Mechanical	SCR	3	79.9	83.8	81.5	82.7	80.0	74.8	82.1	88	79.9	83.8
			Exhaust	SCR	15	79.9	83.8	81.5	82.7	80.0	74.8	82.1	88	79.9	83.8
WD9	Diesel Generator 6	Expected/Emergency	Mechanical	SCR	3	79.9	83.8	81.5	82.7	80.0	74.8	82.1	88	79.9	83.8
			Exhaust	SCR	15	79.9	83.8	81.5	82.7	80.0	74.8	82.1	88	79.9	83.8
YM1	Temporary Diesel Generator 1	Expected 2/Emergency	Mechanical	Enclosure	3	-	-	84.7	89.9	96.4	99.6	98.2	96.3	104.4	107
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM2	Temporary Diesel Generator 2	Expected 2/Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM3	Temporary Diesel Generator 3	Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM4	Temporary Diesel Generator 4	Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM5	Temporary Diesel Generator 5	Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM6	Temporary Diesel Generator 6	Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
YM7	Temporary Diesel Generator 7	Emergency	Mechanical	Enclosure	3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91
			Exhaust	Silencer	4.3	-	-	76.7	60.9	61.4	77.9	85.0	86.9	86.1	91

Note: n/a = noise levels calculated based on existing measurement results (Hemmera 2020, 2021) and therefore no noise controls were considered to derive noise emissions

4.5 Noise Prediction Methodology

4.5.1 Noise Model

The Computer Aided Noise Attenuation (CadnaA) prediction model (version 2023 MR2), developed by DataKustik GmbH, was identified as the appropriate software to develop predictive noise models for this Project. This model is capable of assessing the noise effects associated with the Project. The algorithms used by CadnaA are consistent with international standards, including ISO 9613-2 Acoustics–Attenuation of sound during propagation outdoors–Part 2: General method of calculation (ISO 1996), as accepted by the OGC Guideline. CadnaA has the capability to simulate a series of point, line and area emission sources. For this NIA, all sources were modelled as point sources and assumed to operate continuously during the daytime and nighttime period. Each source type can be characterized by entering noise emissions in terms of frequency components of the emission. Other parameters, such as building dimensions and equipment enclosure noise attenuation ratings, are also used to define the nature of noise emissions. The CadnaA model also accounts for noise attenuation related to meteorological conditions (such as temperature and humidity), ground cover and physical barriers, either natural (terrain based) or man-made.

4.5.2 Model Input Parameters

The configuration of the calculation parameters used to complete the noise modelling for the NIA is listed in Table 4-4.

Table 4-4: Noise Model Input Parameters

Parameter	Model Setting	Description/Notes
Software	CadnaA Version 2023 MR2	CadnaA is a widely-used environmental noise monitoring software package developed by DataKustik GmbH.
Standards	ISO 9613-2	All sources and attenuation effects were treated as required by this standard.
Ground Absorption	0.2 – ground within the Station 0.0 – water 1.0 – rest of modelling domain	These values represent the acoustic properties of the ground in accordance with ISO 9613-2: 0.0 represents acoustically hard ground, and 1.0 represents porous ground.
Reflections	second-order	Second order reflections are included in the modelling in a manner consistent with ISO 9613-2.
Temperature/Humidity	10°C / 70% relative humidity	Consistent with representative summer conditions in the area.
Wind Conditions	3 m/s; all receivers downwind from all sources	Consistent with standard ISO 9613-2.

4.5.3 Building/Structures

The buildings/structures used in the model are presented in Table 4-5 and shown on Figure 2.

Table 4-5: Buildings/Structure Parameters

Building ID	Building Name	Width (X) (m)	Length (Y) (m)	Height (m)	Reflection Loss Setting
DP	Diesel Plant	69.0	18.3	9.5	Structured Facade
FT	Fuel Tank	12.1 (diameter)		13.4	Smooth Façade
S150_SB	S150 Substation Building	8.0	12.4	5	Structured Facade
IT	IT Trailer	12.3	7.5	4	Structured Facade
MO	Main Office	28.5	35.8	13.2	Structured Facade
ET	Electricians Trailer	13.5	7.5	4	Structured Facade
DT	Drafting Trailer	20.3	4.5	4	Structured Facade
P125_1	P125	15.9	37.9	8.4	Structured Facade
WH4_1	WH4	24.8	19.4	10.5	Structured Facade
ST	Storage	12.1	9.8	4	Structured Facade
P125_IH	P125 Intake Hoists	12.0	16.8	7.2	Structured Facade
EH	E-House	11.6	5.7	4.3	Structured Facade
WG1	LNG Generator (WG1)	6.2	17.6	4.3	Structured Facade
WG2	LNG Generator (WG2)	6.2	17.6	4.3	Structured Facade
WG3	LNG Generator (WG3)	6.2	17.6	4.3	Structured Facade
TK_1	LNG Tank 1	22.5	3.5	4.2	Structured Facade
TK_2	LNG Tank 2	22.5	3.5	4.2	Structured Facade
TK_3	LNG Tank 3	22.5	3.5	4.2	Structured Facade
WD8_WD9_SB	WD8 & WD9 Source Building	14.5	14.7	6.5	Structured Facade
ER	Electrical Room	7.3	6.5	6.5	Structured Facade
YM1	Temporary Diesel Generator (YM1)	2.4	14.5	4.3	Structured Facade
YM2	Temporary Diesel Generator (YM2)	2.4	14.5	4.3	Structured Facade
YM3	Temporary Diesel Generator (YM3)	2.4	14.5	4.3	Structured Facade
YM4	Temporary Diesel Generator (YM4)	2.4	14.5	4.3	Structured Facade
YM5	Temporary Diesel Generator (YM5)	2.4	14.5	4.3	Structured Facade
YM6	Temporary Diesel Generator (YM6)	2.4	14.5	4.3	Structured Facade
YM7	Temporary Diesel Generator (YM7)	2.4	14.5	4.3	Structured Facade
YM8	Temporary Diesel Generator (YM8)	14.5	2.4	4.3	Structured Facade
YM9	Temporary Diesel Generator (YM9)	14.5	2.4	4.3	Structured Facade
YM10	Temporary Diesel Generator (YM10)	14.5	2.4	4.3	Structured Facade

4.5.4 Prediction Confidence and Uncertainty

According to ISO 9613-2 (ISO 1996), the overall accuracy of the propagation algorithms is +/-3 dB for distances between source and receptor up to 1 km. The accuracy for propagation distances greater than 1 km is not stated in the standard. Model accuracy will also depend on the accuracy of the noise emission inputs, which is often +/- 2 dB for measured sources and potentially larger for empirical formulae and manufacturer noise ratings. Accounting for both these sources of uncertainty, the overall accuracy of noise level predictions presented here is expected to be +/-3.6 dB.

Conservative assumptions regarding the Project have been made to account for the level of uncertainty inherent in the noise level predictions. All receptors are assumed to be downwind from all sources 100% of the time; because downwind conditions tend to enhance noise propagation, this assumption will tend to overestimate the noise effect of the Project.

5.0 ASSESSMENT RESULTS

Assessment noise levels were calculated by summing the baseline noise levels (i.e., the ASLs provided in Table 4-1) and the contribution from the noise prediction modelling of the Project assessment cases. The assessment cases included two scenarios of the Expected Case and an Emergency (N-1) Case, as described in Section 4.3.

The daytime and nighttime Project-only noise levels and assessment scenario cumulative noise levels are presented in Table 5-1, Table 5-2, and Table 5-3 for the Expected Cases 1 and 2 and the Emergency Case, respectively. For each noise receptor, cumulative noise levels are compared to the relevant PSL values and the change in %HA is compared to the 6.5% threshold. As discussed in Section 3, the PSLs and %HA criteria do not apply to emergency scenarios, and therefore, Emergency Case noise levels are not compared to these thresholds; results are presented for information purposes.

Table 5-1: Expected Case Scenario 1 Noise Levels

Noise Receptor	Baseline Sound Level (dBA)			Project Noise Contribution (dBA)		Cumulative Noise Level (dBA)			Permissible Sound Level (dBA)		Margin of Compliance (dBA)		Change in %HA
	Day	Night	%HA	Day	Night	Day	Night	%HA	Day	Night	Day	Night	%HA
R01	56	46	4.7	59	59	61	59	15.4	61	51	0	-8	10.7
R02	61	51	8.7	25	25	61	51	8.7	66	56	5	5	0.0
R03	58	48	6.0	34	34	58	48	6.1	63	53	5	5	0.1

Table 5-2: Expected Case Scenario 2 Noise Levels

Noise Receptor	Baseline Sound Level (dBA)			Project Noise Contribution (dBA)		Cumulative Noise Level (dBA)			Permissible Sound Level (dBA)		Margin of Compliance (dBA)		Change in %HA
	Day	Night	%HA	Day	Night	Day	Night	%HA	Day	Night	Day	Night	%HA
R01	56	46	4.7	42	42	56	48	5.1	61	51	5	3	0.4
R02	61	51	8.7	24	24	61	51	8.7	66	56	5	5	0.0
R03	58	48	6.0	27	27	58	48	6.1	63	53	5	5	0.1

Table 5-3: Emergency Case Noise Levels

Noise Receptor	Baseline Case Sound Level (dBA)			Project Noise Contribution (dBA)		Cumulative Noise Level (dBA)			Permissible Sound Level (dBA)		Margin of Compliance (dBA)		Change in %HA
	Day	Night	%HA	Day	Night	Day	Night	%HA	Day	Night	Day	Night	%HA
R01	56	46	4.7	62	62	63	62	20.8	n/a	n/a	n/a	n/a	16.1
R02	61	51	8.7	28	28	61	51	8.7	n/a	n/a	n/a	n/a	0.0
R03	58	48	6.0	37	37	58	48	6.2	n/a	n/a	n/a	n/a	0.1

For the Expected Case, the results indicate that noise levels at all receptors are below the PSL during both the daytime and nighttime periods except for R01 for Scenario 1. Noise levels at R01 for the Expected Case Scenario 1 is above the PSL and result in a change in %HA greater than 6.5% during the nighttime period. Therefore, mitigation was investigated for this scenario. Note that Hemmera carried out noise monitoring and modelling for the Station in 2021 (Hemmera 2021). Short and long term monitoring was carried out at the substation while diesel generators WD4 to WD7 were operating; measured daytime noise levels ranged from 61 dBA to 66 dBA. Hemmera's noise modelling indicated predicted levels were 3 dB lower at the nearest receptor (i.e., R01) than at the substation. Therefore, Expected Case Scenario 1 cumulative daytime noise levels at R01 (61 dBA) were very similar to the findings of the 2021 noise assessment (Hemmera 2021), An 8 m tall noise barrier was modelled surrounding WD4 through WD7, which was consistent with the recommendation provided in Hemmera's 2021 noise monitoring report (Hemmera 2021) for the operation of these generators. The barrier was modelled to be continuous with no gaps with a surface density of at least 20 kg/m^2. Table 5-4 indicates that with the installation of this barrier, predicted noise levels from the Expected Scenario 1 are below the PSLs, and the change in %HA is less than 6.5% at all receptors. Other acoustically equivalent noise controls, such as larger silencers or acoustics louvers, are also feasible.

Table 5-4: Expected Case Scenario 1 Mitigated Noise Levels

Noise Receptor	Baseline Sound Level (dBA)			Project Noise Contribution (dBA)		Cumulative Noise Level (dBA)			Permissible Sound Level (dBA)		Margin of Compliance (dBA)		Change in %HA
	Day	Night	%HA	Day	Night	Day	Night	%HA	Day	Night	Day	Night	%HA
R01	56	46	4.7	48	48	57	50	6.4	61	51	4	1	1.7
R02	61	51	8.7	25	25	61	51	8.7	66	56	5	5	0.0
R03	58	48	6.0	34	34	58	48	6.1	63	53	5	5	0.1

Table 5-5 presents the LFN analysis for all assessment cases. The results indicate the difference between the dBC and dBA noise levels is less than 20 dB for all assessment cases at all receptor locations. Note that the octave-band sound power levels considered in the noise modelling were based on manufacturer's data and not on-site measurements.

Therefore, based on the limited data available, LFN issues as per the OGC Guideline are not expected. However, it is recommended that if there are any complaints upon Project initiation, a further investigation into LFN is carried out, including conducting site-specific noise measurements at the Station and at nearby receptors.

Table 5-5: Low Frequency Noise Analysis

Noise Receptor	Project Noise Contribution (dBC)			Project Noise Contribution (dBA)			Difference between dBC and dBA Noise Levels (dB)		
	Expected Scenario 1	Expected Scenario 2	Emerg	Expected Scenario 1	Expected Scenario 2	Emerg	Expected Scenario 1	Expected Scenario 2	Emerg
R01	61	56	63	59	42	62	2	14	1
R02	43	43	43	25	24	28	18	19	15
R03	46	46	46	34	27	37	12	19	9

6.0 CONCLUSIONS

The NIA indicates that the operation of Expected Case Scenario 2, where two mobile generators are used in place of two permanent diesel generators, results in predicted noise levels that meet applicable guidance documents with no further mitigation. Expected Case Scenario 1, which considers the two permanent diesel generators instead of the two mobile generators, results in noise levels above guidance documents during the nighttime period. Therefore, if Expected Case Scenario 1 is to operate during the nighttime period, mitigation is required to meet applicable guidelines. With an 8 m tall noise barrier surrounding WD4 to WD7 (consistent with the recommendation provided in Hemmera's 2021 noise monitoring report [Hemmera 2021]), or acoustically equivalent, applicable guidelines are met.

Guidelines used for this NIA are not applicable for emergency scenarios. Noise levels due to the Emergency Case will increase but are expected to be short-term and occur very infrequently.

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