FINAL REPORT

CALPUFF Air Dispersion Modelling for the L'Anse-au-Loup Diesel Generating Station Environmental Registration Application

Newfoundland & Labrador Hydro

ENVIRONMENT & WATER

2014 | 11 | 07

REPORT > ORIGINAL

Internal ref. 620213-ENVI-4EER-0001_00

CALPUFF Air Dispersion Modelling for the L'Anse-au-Loup Diesel Generating Station Environmental Registration Application

Final Report

Newfoundland & Labrador Hydro

November 2014

Project: 620213

Prepared by :	Éric Delisle, B.Sc.A. Senior Air Quality Specialist	Date :	November 7, 2014
Verified by: :	Nuran Attarmigiroglu, Eng.	Date :	November 7, 2014
Reviewed by :	Andrew Peach, P. Geo., EP Project Manager	Date :	November 7, 2014

SNC · LAVALIN

Certified ISO 9001

NOTICE TO READER

This report has been prepared and the work referred to in this report has been undertaken by SNC-Lavalin Inc. (SNC-Lavalin), for the exclusive use of Newfoundland & Labrador Hydro (the Client), who has been party to the development of the scope of work and understands its limitations. The methodology, findings, conclusions and recommendations in this report are based solely upon the scope of work and subject to the time and budgetary considerations described in the proposal and/or contract pursuant to which this report was issued. Any use, reliance on, or decision made by a third party based on this report is the sole responsibility of such third party. SNC-Lavalin accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

The findings, conclusions and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made with respect to the professional services provided to Client or the findings, conclusions and recommendations contained in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered or project parameters change, modifications to this report may be necessary.

This report must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final version of this report, it is the final version that takes precedence. Nothing in this report is intended to constitute or provide a legal opinion.

COMMITMENT TO QUALITY

To demonstrate its commitment to the importance of quality, its priority to meet the requirements of its clients and its commitment to continuous improvement, the Environment & Water Business Unit of SNC-Lavalin inc. has developed a Quality Policy and a Quality Management System tailored to its activities.

At Environment & Water, we place a high value on our clients, the environment, and the communities in which we work. We apply our Quality Management Systems consistently, and continually work to improve them. Hence, we recognize that the quality of our services is based upon:

- Safely executing our work;
- Collecting information in a systematic way that avoids introduction of bias;
- Providing deliverables that are technically sound, clear and concise;
- Meeting deadlines;
- Delivering projects on budget;
- Providing invoices that are timely, clear and accurate;
- Providing a highly competent team.

At Environment & Water, we understand that our clients' satisfaction is vital to our business success. We strive to be a full partner in delivering sustainable projects and endeavour to exceed our clients' expectations.

Our quality management system is based on this Policy which is reviewed annually during the Quality Management Review. All the Environment & Water staff are conscious of this statement and understands the importance of its application in the business's operations.

EXCUTIVE SUMMARY

The L'Anse-au-Loup Diesel Generating Station (LAL DGS) constructed in 1972 contains five (5) diesel generators and a mobile generator installed outside the plant building. A planned increase of the installed generating power from 5,925 kW to 7,150 kW is to be undertaken in 2014, in order to meet peak demand forecast for 2018. The increase will be achieved through the replacement of a 600 kW unit with a larger 1,825 kW unit. Currently, approximately 96% of the energy is supplied into the L'Anse-au-Loup system through Hydro-Quebec. The LAL DGS is primarily operated by Newfoundland and Labrador Hydro (HYDRO) in a stand-by capacity in the event that power is not available from Hydro-Quebec. Although the LAL DGS is considered a stand-by facility, based on its annual operating hours, the facility must still register with the Department of Environment and Conservation (DOEC) as a prime diesel generating facility.

As part of the registration and approval process, air dispersion modelling using the CALPUFF modelling system was performed for several air contaminants (SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$) resulting from the operation of the LAL DGS under various plant configurations and power production scenarios (with and without transmission from Hydro-Quebec). Selection of the number of operating generators per month was based on the total generating power required and considered that generator efficiencies are at their highest in the 70-85% load range. Emissions parameters (temperature, velocity, pollutant emission rates) were modulated on a monthly basis, obtained from emissions curves based on manufacturer data for each unit. For SO_2, emissions were based on the fuel consumption and a mass balance of sulphur assuming an ultra-low sulphur fuel. For PM_{10} and $PM_{2.5}$, emissions were estimated from manufacturer's PM_t emissions and the ratios for filterable particulates found in the US-EPA AP42 emission factors for large stationary diesel engines.

Meteorological data sets for the 2010 to 2013 period generated by the WRF meteorological model at a 4 km horizontal resolution were used as input to CALMET, CALPUFF's meteorological model and processor.

Results show that operational changes at the LAL DGS would have a very low contribution to ambient air ground level concentrations of SO_2, CO, PM_t and PM_{10}. The maximum predicted ground level concentrations for these pollutants in all scenarios are all below their respective provincial Ambient Air Quality Standard (AAQS) thresholds for all averaging periods.

The most significant impacts on local air quality are shown to be from NO_2 and $PM_{2.5}$.

- For the current stack configuration under Scenarios A (current condition) and Scenario A (replacing unit 247 with 2091), significant exceedances of all AAQS for NO_2 and $PM_{2.5}$ are predicted for all periods.

- Whether stack heights are raised (Scenario B) and a more environmentally efficient model of generator is also installed (Scenarios D - (Tier II compliant engine) and Scenario E (engine with diesel particulate filter (DPF), the short-term ground level concentrations for NO_2 and $PM_{2.5}$ still exceed AAQS, but annual NO_2 would be met.

- By considering Hydro-Quebec transmission in Scenario C (normal production with increased stack heights), maximum predicted ground level concentrations decrease significantly and $PM_{2.5}$ AAQS would be met. However, NO_2 exceedances are still predicted for hourly and daily concentrations, despite being significantly lower than with the other scenarios. Non-compliance with the hourly NO_2 AAQS is predicted between 0.18% and 0.73% of the time on an annual basis (16 to 64 hours respectively) and non-compliance with the daily NO_2 AAQS is predicted for three out of four years, with an exceedance frequency of up to 2.2% (8 days per year). The non-compliance area ranges from the plant boundary up to 400 m away for the worst case meteorological conditions.

- For the worst case production scenario with increased stack heights and a new engine with a DPF (Scenario E) and without Hydro-Quebec power transmission, the LAL DGS would not be compliant with the daily $PM_{2.5}$ AAQS 1.1 % to 2.7% of the time (4 to 10 days per year). Non-compliance with the hourly and daily NO_2 AAQS frequencies would be in the 49% to 55% range, somewhere in the modelling domain. The non-compliance area ranges from the plant boundary up to 1.5 km away for the worst case meteorological conditions.

Finally, to achieve the most meaningful reduction to air quality impacts associated with the operation of the LAL DGS, following the facility upgrade it would be preferable to operate the most modern units (existing unit 2082 and new unit 2091) in priority and restrict the use of older units when possible.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAQS	Ambient Air Quality Standards
BPIP	Building Profile Input Program
CALMET	California Meteorological Model
CALPUFF	California Puff Model
CDEM	Canadian Digital Elevation Model
CO	Carbon Monoxide
COARE	Coupled Ocean Atmosphere Response Experiment (overwater boundary layer model)
DPF	Diesel Particulate Filter
DOEC	Department of Environment and Conservation
LAL DGS	L'Anse-au-Loup Diesel Generating Station
NL	Newfoundland and Labrador
NCEP	National Centres for Environmental Prediction
NOAA	National Oceanographic and Atmospheric Administration
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides (NO + NO_2)
PM_t	Total Particulate Matter (includes PM_{10} and $PM_{2.5}$)
PM_{10}	Particulate Matter smaller than 10 µm in diameter (includes $PM_{2.5}$)
$PM_{2.5}$	Particulate Matter smaller than 2.5 µm in diameter (also called fine particulates)
PRIME	Plume Rise Model Enhancements (building wake effects sub-model)
SO_2	Sulphur Dioxide
WRF	Weather Research and Forecast
US-EPA	United Sates Environmental Protection Agency)
US-NCAR	United States National Centre for Atmospheric Research

1 INTRODUCTION

The L'Anse-au-Loup Diesel Generating Station (LAL DGS) constructed in 1972 contains five (5) diesel generators and a mobile generator installed outside the plant building. A planned increase of the installed generating power from 5,925 kW to 7,150 kW is to be undertaken in 2014. The increase will be achieved through the replacement of a 600 kW unit with a larger 1,825 kW unit. Currently, approximately 96% of the energy is supplied into the L'Anse-au-Loup system through Hydro-Quebec. The LAL DGS is primarily operated by Newfoundland and Labrador Hydro (HYDRO) in a stand-by capacity in the event that power is not available from Hydro-Quebec.

Although the LAL DGS is considered a stand-by facility, based on the annual operating hours, which have ranged from 900 hours to 3,863 hours in the last 10 years, there is a requirement that the facility be registered with the Department of Environment and Conservation (DOEC) as a prime diesel generating facility. Diesel generating facilities having a total installed capacity greater than 100 kW and which operate or are anticipated to operate more than 500 hours per year require registration through the Pollution Prevention Division of the DOEC, so that a Certificate of Approval (C of A) can be issued. In addition, the proposed unit change for the LAL DGS will result in an increase of 1,225 kW (1.2 MW) and this will require that the proposed project (undertaking) be registered with the Environmental Assessment Division of the Department of Environment and Conservation as required under the Environmental Protection Act, 2002.

As part of the registration and approval process of the undertaking by the DOEC, air dispersion modelling using the CALPUFF modelling system was performed for various configurations and power production scenarios in order to evaluate the impacts of the LAL DGS on local air quality in relation with NL Ambient Air Quality Standards (AAQS).

Air dispersion modelling and interpretation of results were conducted following the requirements of the DOEC defined in the following guidance documents:

- *Guideline for Plume Dispersion Modelling. GD-PPD-019.2,* Newfoundland & Labrador Department of Environment & Conservation (DOEC, 2012a).

- *Determination of Compliance with the Ambient Air Quality Standards. GD-PPD-009.4,* Newfoundland & Labrador Department of Environment & Conservation (DOEC, 2012b).

Figure 1 shows a general site layout and indicates the location of the exhaust stacks on the overall site plan. Note that the new generator unit 2091 replaces the old 247 generator unit.

The CALMET/CALPUFF air dispersion modelling system was used to estimate the ground level concentrations of several air contaminants (SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$) resulting from the operation of the LAL DGS for various configurations and in consideration with and without Hydro-Quebec transmission. Data from a meteorological model (WRF) for the 2010-2013 period, local land use and topography were used as the main inputs for CALMET.

The CALMET/CALPUFF modelling system input files were provided under separate cover to the DOEC for review and validation.

The modelling methodology and system set-up is described in Section 2. Production scenarios, air emission rates and source parameters are presented in Section 3. Modelling results are summarized in Section 4 and conclusions are presented in Section 5.

Figure 1 Overall Site Plan for the LAL DGS

Notes: Engine stacks are represented by a red point.
Building heights above ground are indicated in meters.

2 METHODOLOGY

2.1 Air Dispersion Model

The CALMET/CALPUFF (EarthTech, 2000a, 2000b) air dispersion modelling system was used to estimate the ground level concentrations of contaminants in ambient air, as per the DOEC guidance document for dispersion modelling (DOEC, 2012a). CALPUFF is an advanced non-steady-state meteorological air quality modelling system developed by the Atmospheric Science Group of EarthTech the USA. CALMET is the meteorological model for CALPUFF that generates 3D meteorological fields and boundary layer parameters from hourly surface and twice daily upper air observations and/or from the hourly outputs of meteorological models. Overwater observations, from meteorological buoys or meteorological models, especially the sea-air temperature differential is also preferable for modelling in coastal regions.

The basic data required by the CALMET/CALPUFF modelling system includes:

- Gridded topographical and land use data.
- Hourly meteorological surface observations, upper air observation soundings (at least twice per day) and/or 3D meteorological fields generated by an advanced prognostic meteorological model (temperature, wind speed and direction, etc.).
- Source emission characteristics: emission rates of contaminants in the exhaust gas, the gas exit temperature and velocity, stack coordinates, configuration, diameter and height.
- Location and elevation of receptors.
- Dimensions and coordinates of buildings on-site that present wake effects causing plume downwash.

The CALPUFF model calculates the concentration of pollutants at all receptors on an hourly basis during the period under consideration. When there are multiple emission sources, the resulting concentration at each receptor is estimated by summing the individual contributions from each source. Average long-term concentrations (3, 8 and 24 hours, 1 year) are obtained by combining the average hourly concentration at each receptor for the period.

2.2 Meteorological Data and Configuration of CALMET

2.2.1 Meteorological Domain, Topography and Land Use

CALMET was used to produce refined meteorological fields for a 13 x 13 km domain with a 200 m horizontal resolution and 11 vertical levels (top faces at: 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500 and 3000 metres above ground). Figure 2 presents the CALMET/CALPUFF modelling domains with land use and topography.

The Canadian Digital Elevation Model (CDEM) topographic data was used to set the elevation of each cell in the domain and also to set the ground elevation of receptors. Gridded land use classifications were provided by the DOEC for the CALMET meteorological domain.

Surface characteristics parameters per land use classification and by season used in CALMET for the region are reproduced in Table 1, as provided in the plume modelling guidance document from the DOEC. For winter conditions however, the values of surface roughness for evergreen and mixed forest were modified from the guidance document values to be coherent with non-winter values (for example, 1.0 m instead of 1.3 m for evergreen forests). Table 1 only shows parameters for land use classes present in the CALMET domain.

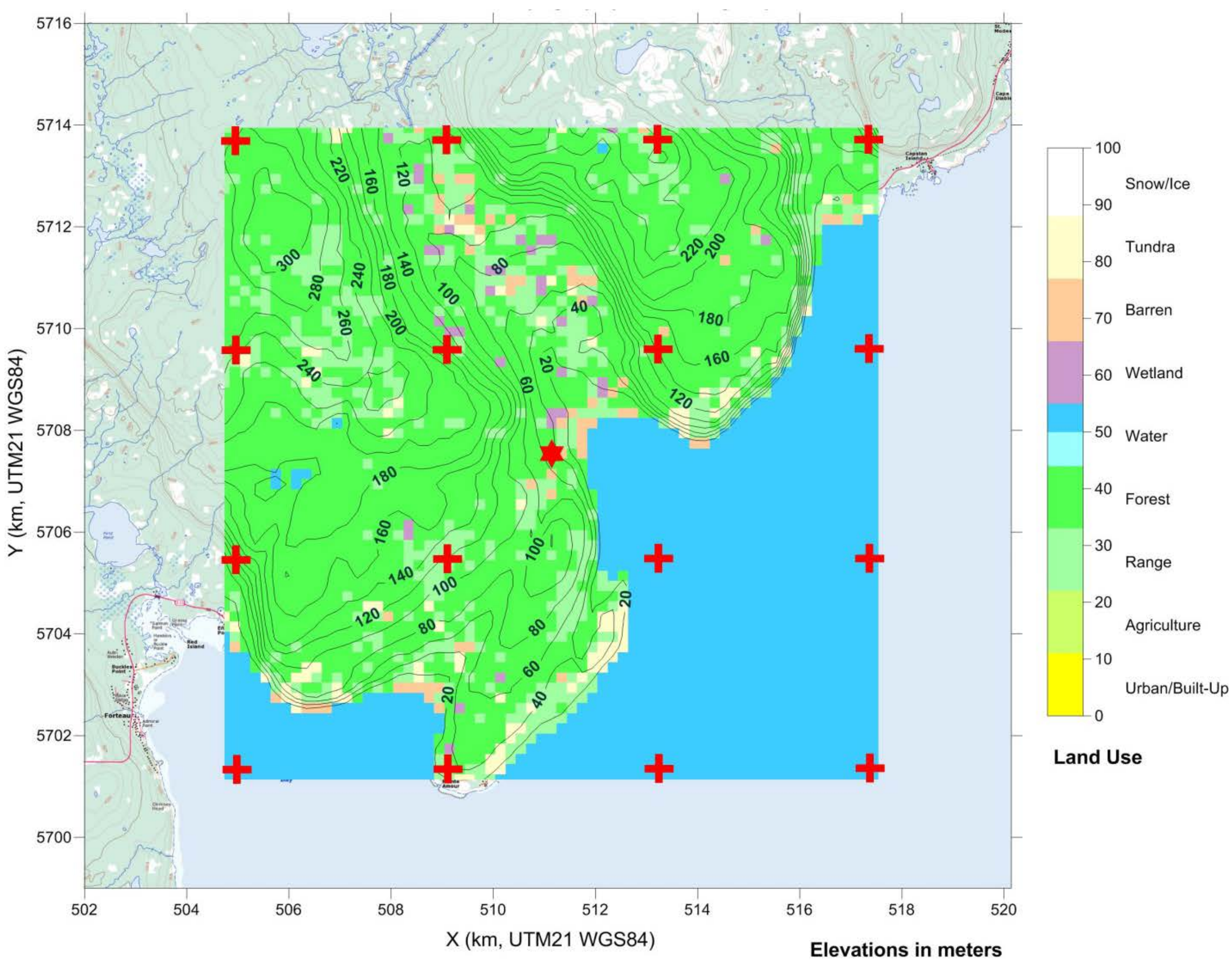
Sea ice is present in the Strait of Belle Isle for a few months during winter. According to the long-term normal “freeze-up” and “break-up” maps found in the Sea Ice Climatic Atlas – East Coast 1981-2010 produced by the Canadian Ice Service of Environment Canada, sea ice is normally present from mid-January to mid-April. Since CALMET’s overwater sub-models are only valid for ice free waters, terrestrial sub-models were used for overwater cells from January 16 to April 15 and an additional season “winter with snow cover and sea-ice” was added to the DOEC standard season definitions.

2.2.2 Meteorological Data

For this modelling project, 3D meteorological data fields (wind, temperature, humidity, pressure and geo-potential height) covering a 50 x 50 km domain centered on the generating station with a 4 km horizontal resolution generated by the *Weather Research and Forecast* (WRF) meteorological model for the 2010 to 2013 period were used to provide all meteorological information for CALMET. WRF is a prognostic meteorological model developed by the Pennsylvania State University and the U.S. National Center for Atmospheric Research (NCAR). Figure 2 shows some of the WRF grid points over the CALMET/CALPUFF domains.

The WRF data was provided by Lakes Environmental who run the WRF meteorological model based on the National Centers for Environmental Prediction (NCEP) Final Operational Global Analysis (1° x 1° resolution) data sets using nested grids covering a much larger domain than above. The data was provided in CALMET’s 3D.DAT format version 2.12, which includes sea surface temperature and above water air temperature required for the COARE overwater boundary layer model in CALMET and hourly precipitation rates for the wet deposition model.

Figure 2 CALMET/CALPUFF Modelling Domain, Land Use and Topography



Note: Topographic contours every 20 metres.

2.2.3 Local Wind Rose Diagram

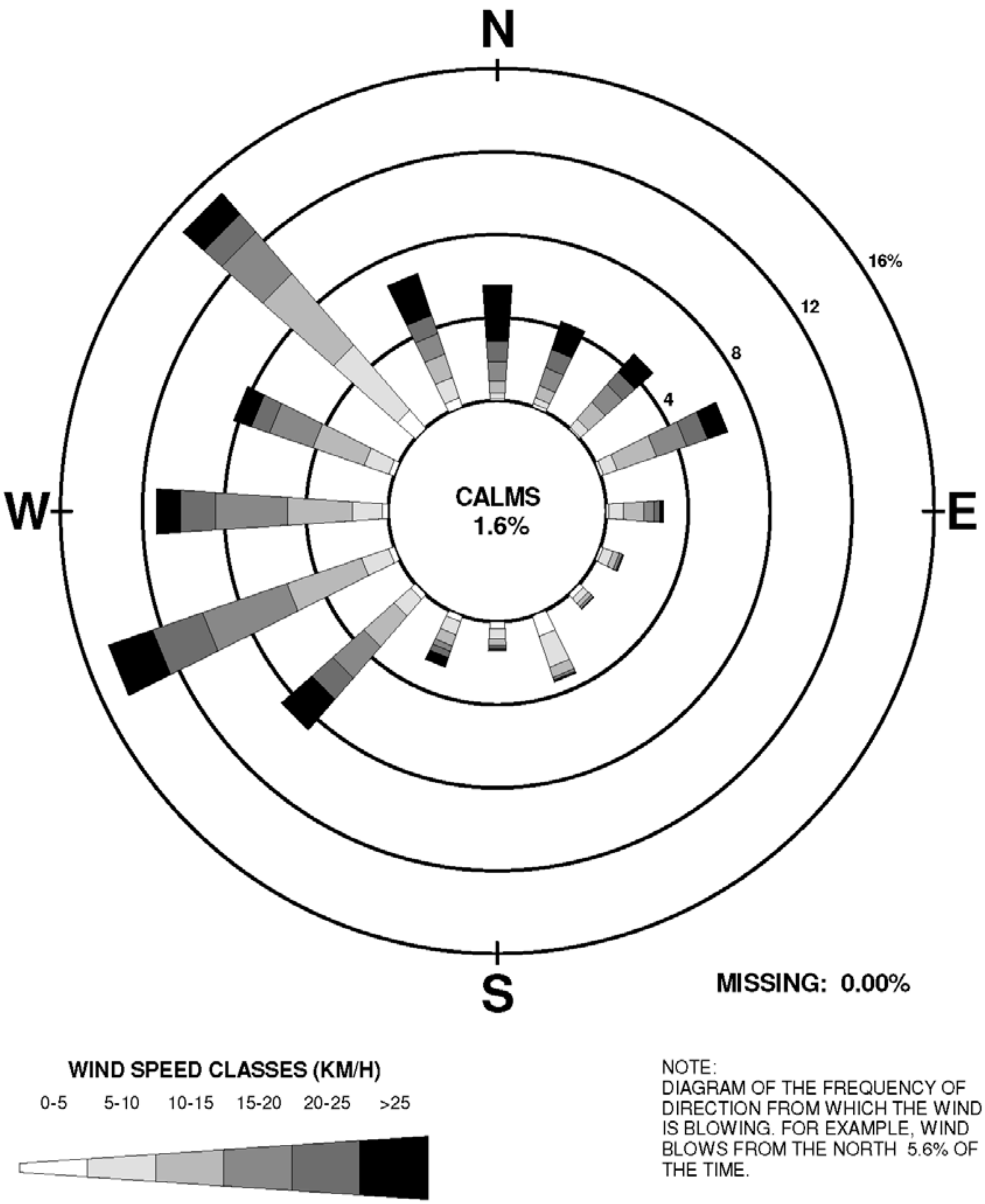
Figure 3 presents the near surface (10 m) wind rose diagram for the entire meteorological period (2010-2013) derived from the CALMET modelled winds for the generating station. Dominant winds are from the WSW and the NW on an annual basis and winds from the SE are less frequent.

Table 1 Surface Parameters per Land Use Class and Season used in CALMET

Land Use	z_0 (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
Non-winter: June 1st to October 15th.						
31 - Herbaceous Rangeland	0.05	0.25	1.0	0.15	0.0	0.5
32 - Shrub/Brush Rangeland	0.05	0.25	1.0	0.15	0.0	0.5
41 - Deciduous Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
42 - Evergreen Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
43 - Mixed Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
51 - Fresh Water	0.001	0.1	0.0	1.0	0.0	0.0
55 - Salt Water (1)	0.001	0.1	0.0	1.0	0.0	0.0
61 - Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62 - Non-Forested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
74 - Bare Exposed Rock	0.05	0.3	1.0	0.15	0.0	0.05
77 - Mixed Barren Land	0.05	0.3	1.0	0.15	0.0	0.05
82 -Herbaceous tundra	0.2	0.3	0.5	0.15	0.0	0.0
Winter without snow cover: May 1st to May 31st and October 16th to November 30th.						
31 - Herbaceous Rangeland	0.01	0.2	1.0	0.15	0.0	0.5
32 - Shrub/Brush Rangeland	0.01	0.2	1.0	0.15	0.0	0.5
41 - Deciduous Forest Land	0.6	0.17	1.0	0.15	0.0	7.0
42 - Evergreen Forest Land	1.0	0.12	0.8	0.15	0.0	7.0
43 - Mixed Forest Land	0.77	0.14	0.9	0.15	0.0	7.0
51 - Fresh Water	0.001	0.1	0.0	1.0	0.0	0.0
55 - Salt Water (1)	0.001	0.1	0.0	1.0	0.0	0.0
61 - Forested Wetland	0.6	0.14	0.3	0.25	0.0	2.0
62 - Non-Forested Wetland	0.2	0.14	0.1	0.25	0.0	1.0
74 - Bare Exposed Rock	0.05	0.2	1.5	0.15	0.0	0.05
77 - Mixed Barren Land	0.05	0.2	1.5	0.15	0.0	0.05
82 -Herbaceous tundra	0.1	0.2	1.0	0.15	0.0	0.0
Winter with snow cover: December 1st to April 30th. Sea ice from January 16th to April 30th.						
31 - Herbaceous Rangeland	0.005	0.7	0.5	0.15	0.0	0.5
32 - Shrub/Brush Rangeland	0.005	0.7	0.5	0.15	0.0	0.5
41 - Deciduous Forest Land	0.5	0.5	0.5	0.15	0.0	0.0
42 - Evergreen Forest Land	1.0	0.35	0.5	0.15	0.0	7.0
43 - Mixed Forest Land	0.71	0.42	0.5	0.15	0.0	3.5
51 - Fresh Water (iced)	0.002	0.7	0.5	0.15	0.0	0.0
55 - Salt Water (ice free) (1)	0.001	0.7	0.5	0.15	0.0	0.0
55 - Salt Water (sea ice) (2)	0.002	0.7	0.5	0.15	0.0	0.0
61 - Forested Wetland	0.5	0.3	0.5	0.15	0.0	0.0
62 - Non-Forested Wetland	0.2	0.6	0.5	0.15	0.0	0.0
74 - Bare Exposed Rock	0.002	0.7	0.5	0.15	0.0	0.0
77 - Mixed Barren Land	0.002	0.7	0.5	0.15	0.0	0.0
82 -Herbaceous tundra	0.005	0.7	0.5	0.15	0.0	0.0

(1) Overwater boundary layer sub-model is used for this land use class, surface parameters are not used by the model.
(2) With an ice cover, the land boundary layer sub model is used with the given surface parameters.

Figure 3 Annual Wind Rose at the LAL DGS Derived from CALMET Data (2010-2013)



2.2.4 CALMET Options and Generation of Meteorological Fields

In general, most default CALMET options were selected, with the exception of options related to the use of a data set from a weather model and coastal effects. The wind field calculations were initialized using the WRF data. All non-default CALMET selected options are listed in Table 2.

2.3 Configuration of CALPUFF

2.3.1 Receptors

A nested grid pattern covering a 10 x 10 km domain that follows the general requirements of the DOEC plume dispersion modelling guidelines was used for the receptors:

- 50 metre spacing from the centre of the operation out to 1 km;
- 200 metre spacing from 1 km out to 2 km;
- 500 metre spacing from 2 km out to 5 km.

Additional receptors were placed at a finer resolution every 20 metres along the property line, for a total of 2,378 receptor points located at ground level (flagpole height at zero). The receptor grids and additional receptors are shown in Figure 4.

2.3.2 Building Wake Effects

Building wake effects on plume rise and atmospheric dispersion were considered within CALPUFF. Building dimensions and stack heights (presented in Figure 1) were processed with the Building Profile Input Program (BPIP) to generate the characteristic dimensions required by CALPUFF's PRIME building wake sub-model.

2.3.3 Special CALPUFF Options

CALPUFF default options were used in the model configuration, with the exceptions presented in Table 3 as required by the DOEC modelling guidance document.

Table 2 CALMET Configuration - Non Default CALMET Options

CALMET options	Selected non-default option values	
No observation mode	NOOBS = 2	No surface, overwater, or upper air observations Use MM4/MM5/3D.DAT for surface, overwater, and upper air data
Cloud data option	ICLOUD = 4	Gridded cloud cover from prognostic relative humidity at all levels
Relative humidity option	IRHPROG = 1	3D relative humidity from prognostic data
Spatial averaging search radius	MNMDAV = 5	Temperature and mixing height spatial averaging is based on a 5 grid cell distance (5 x 200 m =1 km)
Wind Field Options (1)		
Use gridded prognostic wind field model output fields as input to the diagnostic wind field model	IPROG = 14	Yes, use winds from MM5/3D.DAT file as initial guess field.
Radius of influence of terrain features	TERRAD = 5 (no default)	Terrain effects are considered up to 5 km for each grid point.
Temperature Field Options		
3D temperature from observations or from prognostic data	ITPROG = 2	No surface or upper air observations. Use MM5/3D.DAT for surface and upper air data.
Land use categories for temperature interpolation over water (2)	JWAT1= 55 JWAT2= 55	Temperature overwater for land use code 55 (salty water, Strait of Belle Isle) was based on WRF overwater air temperatures.
Overwater Options		
Option for overwater lapse rates used in convective mixing height growth	ITWPROG = 2	Use prognostic lapse rates and prognostic delta T.
Land use categories for using the overwater boundary layer sub model (2)	IWAT1= 55 IWAT2= 55 (defined in GEO.DAT)	For land use code 55 (salty water, Strait of Belle Isle) the overwater boundary layer sub-model was used.

(1) Wind field generation parameters (R1, R2, RMAX1, RMAX2, RMAX3, RMIN, and LVARY) are irrelevant when no observation mode is used.

(2) For the sea ice period, all overwater specific parameters and sub models are deactivated: IWAT1, IWAT2, JWAT1, JWAT2 =99.

Figure 4 Receptor Grids over the Modelling Domain

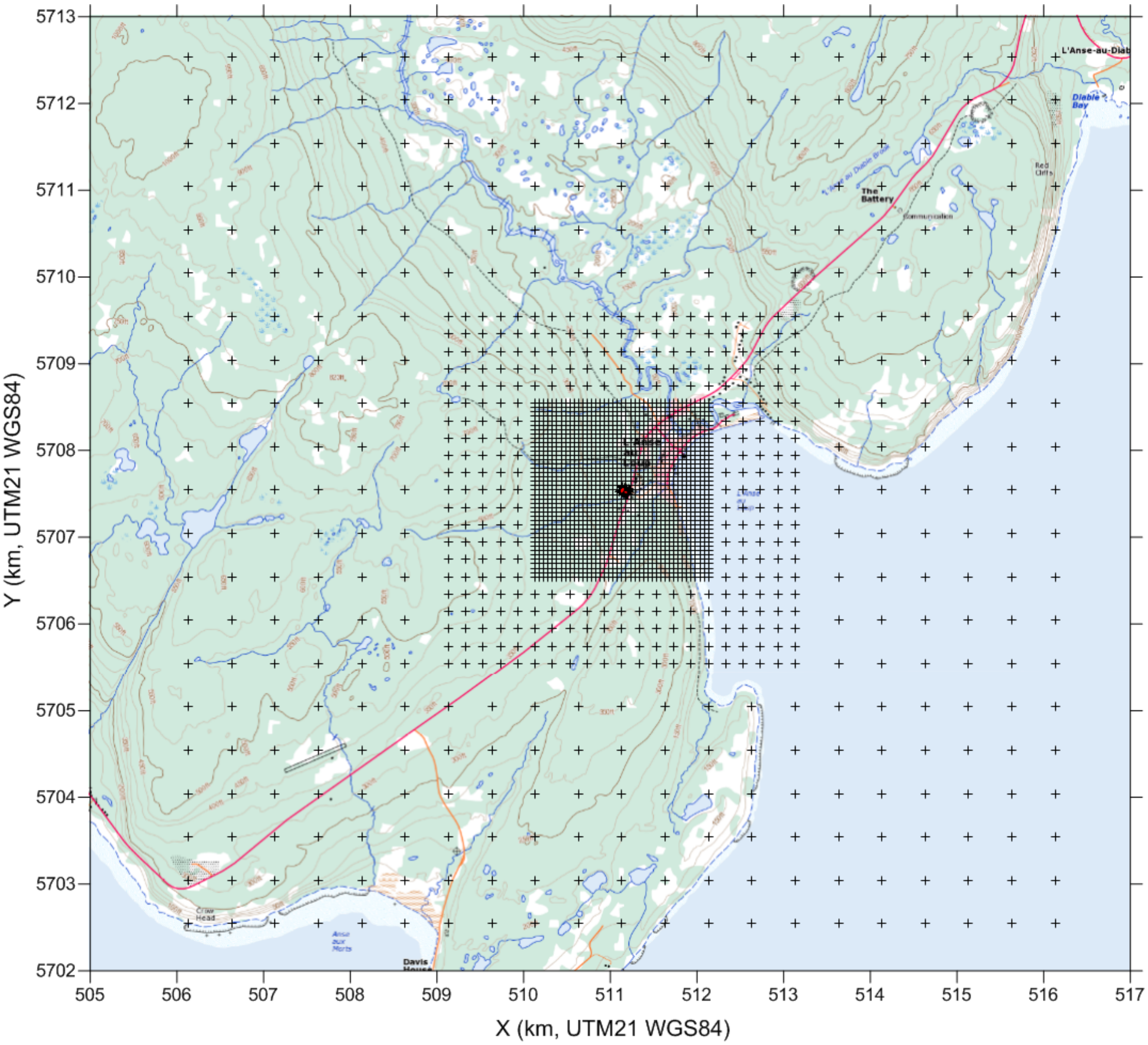


Table 3 CALPUFF Configuration - Non Default CALPUFF Options

Parameter	Name of parameter and interpretation	Default value	Selected value [1]	Selected value interpretation
NSE	Number of emitted species	3	7 [2]	Emitted species [3]
NSPEC	Number of chemical species	5	10 [2]	Emitted species and species implicated in chemical transformations [4]
MBDW	Method used to simulate building downwash	1	2	PRIME method
MSPLIT	Puff splitting allowed	0	1	Yes
MCHEM	Chemical mechanism	1	6	Updated RIVAD scheme with ISORROPIA equilibrium
MAQCHEM	Aqueous phase transformation	0	1	Transformation rates and wet scavenging coefficients adjusted for in-cloud aqueous phase reactions
MLWC	Liquid water content	1	0	Water content estimated from cloud cover and presence of precipitation
MDISP	Method used to compute dispersion coefficients	3	2	Dispersion coefficients from internally calculated micrometeorological variables
MPDF	Probability density function (PDF) used for dispersion under convective conditions	0	1	Yes
MREG	Test options specified to verify if they conform to (US-EPA) regulatory values	1	0	No checks are made
MOZ	Ozone data input option	1	0	Monthly background value
MH2O2	H_2O_2 data input option	1	0	Monthly background value
NINT	Number of particle size intervals	9	5	Used to evaluate effective particle deposition velocity

(1) DOEC requirements or recommended values.

(2) Project specific values.

(3) Emitted species: SO_2, NO, NO_2, CO and PM divided into three class sizes (P1 (d < 2.5 µm), P2 (2.5 µm <d < 10 µm), P3 (d > 10 µm)).

(4) Emitted species plus species implicated in NOx/SOx chemistry: SO_4, NO_3, HNO_3.

2.3.4 Chemical transformation, deposition and particulate classes

For chemical transformation modelling, the monthly background concentration values for ozone, ammonia and H_2O_2 recommended in the DOEC's plume modelling guidance document were used and are presented in Table 4. For wet and dry deposition of gaseous and particulate species, default values found in the CALPUFF libraries were used and are listed in Tables 5 to 7.

Furthermore, as per the DOEC requirements, particulate emissions were modelled as three distinct size groups (P1, P2 and P3) as defined in Table 5 and the CALPUFF default particulate density of 1 g/m³ was also considered. The POSTUTIL utility was used to obtain PM_t, PM_{10} and $PM_{2.5}$ concentrations in the following way

$$PM_{2.5} = P1$$

$$PM_{10} = P1 + P2$$

$$PM_t = P1 + P2 + P3$$

Table 4 Monthly Background Concentrations for RIVAD/ISORROPIA Chemistry

Month	Ozone (O_3) (ppb)	Ammonia (NH_3) (ppb)	Hydrogen Peroxide (H_2O_2) (ppb)
January	32	0.5	0.2
February	34	0.5	0.2
March	37	0.5	0.2
April	38	0.5	0.2
May	32	0.5	0.2
June	26	0.5	0.2
July	23	0.5	0.2
August	21	0.5	0.2
September	23	0.5	0.2
October	25	0.5	0.2
November	28	0.5	0.2
December	31	0.5	0.2

Table 5 Dry Deposition Parameters for Modelled Particulate Species

Modelled Particulate Species	Geometric Mass Mean Diameter (µm)	Geometric Standard Deviation (µm)
SO_4	0.48	2.0
NO_3	0.48	2.0
P1 (d < 2.5 µm)	1.25	1.242
P2 (2.5 µm < d < 10 µm)	5.0	1.242
P3 (d >10 µm)	20.0	1.242

Table 6 Dry Deposition Parameters for Modelled Gaseous Species

Modelled Gaseous Species	Diffusivity (cm²/s)	Alpha Star	Reactivity	Mesophyllic Resistance (s/cm)	Henry's Law Coefficient (dimensionless)
SO_2	0.1509	1000	8	0	0.04
HNO_3	0.1628	1	18	0	8.0×10^{-8}
NO	0.1345	1	2	25	18
NO_2	0.1656	1	8	5	3.5
CO	0.1860	1	2	61	44

Table 7 Wet Deposition Parameters for Modelled Species

Modelled Species (G: gas, P: particulate)	Scavenging Coefficient (s^{-1})	
	Liquid Precipitation	Frozen Precipitation
SO_2 (G)	3.00×10^{-5}	0.0
SO_4 (P)	1.00×10^{-4}	3.00×10^{-5}
HNO_3 (G)	6.00×10^{-5}	0.0
NO_3 (P)	1.00×10^{-4}	3.00×10^{-5}
NO (G)	0.0	0.0
NO_2 (G)	0.0	0.0
CO (G)	0.0	0.0
P1 (P)	6.03×10^{-5}	2.01×10^{-5}
P2 (P)	3.54×10^{-4}	1.18×10^{-4}
P3 (P)	6.64×10^{-4}	2.21×10^{-4}

3 PRODUCTION SCENARIOS AND AIR EMISSIONS

The current L'Anse-au-Loup Diesel Generating Station (LAL DGS) is composed of six diesel generating units ranging from 600 kW to 1,825 kW for a total installed capacity of 5,925 kW (see Table 8). To meet the peak demand forecast for 2018, it is proposed to replace an older 600 kW unit (unit 247) with a new 1,825 kW unit for a total installed capacity of 7,150 kW.

Table 8 Current and Proposed Configuration of the LAL DGS

Engine Unit	Current Capacity	Proposed Capacity
	kW	kW
246	600	600
247	600	Replaced with unit 2091.
2005	800	800
2012	1,100	1,100
2041	1,000	1,000
2082 (mobile unit)	1,825	1,825
2091	-	1,825
Total	**5,925**	**7,150**

3.1 PRODUCTION SCENARIOS

The LAL DGS is designed to meet peak demand, but the generating station is used only for a few thousand generation-hours per year, mainly because of a contract with Hydro-Quebec who provides up to 3,000 kW of electricity on a quasi-continuous basis. Modelling scenarios evaluating diesel plant production with and without power transmission from Hydro-Quebec were considered in this study to meet the peak monthly demand forecast. The total monthly production for the diesel generators and the loads per generator for both production scenarios are provided in Tables 9 and 10 respectively. Selection of the operating generators per month was based on the generating power required and considered that generator efficiencies are at their highest in the 70-85% load range.

3.2 AIR DISPERSION MODELLING SCENARIOS

A total of six air dispersion modelling scenarios where considered in this study. These scenarios are listed in Table 11. The base case Scenario A (current condition) considers the actual installed units while Scenario A (replacement condition) considers the replacement of unit 247 (600 kW) by the new unit 2091 (1,825 kW). Transmission from Hydro-Quebec is not considered for these scenarios. The rectangular stack from the mobile unit 2082 (72" x 5" or 1.83 m x 0.127 m) vent located on top of the unit container) is modelled as an equivalent surface area circular stack.

Table 9 Monthly Loads per Generator Unit without Transmission from Hydro-Quebec

Month	Forecast (kW)	HQ Transmission (kW)	Required Diesel (kW)	Loads per Generator Unit (Maximum Power Indicated)					
				246 600 kW	2005 800 kW	2012 1,100 kW	2041 1,000 kW	2082 1,825 kW	2091 1,825 kW
January	5,960	0,0	5,960	83.4%	83.4%	83.4%	83.4%	83.4%	83.4%
February	5,585	0,0	5,585	78.1%	78.1%	78.1%	78.1%	78.1%	78.1%
March	5,186	0,0	5,186	72.5%	72.5%	72.5%	72.5%	72.5%	72.5%
April	4,774	0,0	4,774	0,0%	72.9%	72.9%	72.9%	72.9%	72.9%
May	4,354	0,0	4,354	81.8%	81.8%	81.8%	81.8%	0.0%	81.8%
June	4,148	0,0	4,148	77.9%	77.9%	77.9%	77.9%	0.0%	77.9%
July	4,084	0,0	4,084	76.7%	76.7%	76.7%	76.7%	0.0%	76.7%
August	4,047	0,0	4,047	76.0%	76.0%	76.0%	76.0%	0.0%	76.0%
September	4,288	0,0	4,288	80.5%	80.5%	80.5%	80.5%	0.0%	80.5%
October	4,210	0,0	4,210	79.1%	79.1%	79.1%	79.1%	0.0%	79.1%
November	4,935	0,0	4,935	0,0%	75.3%	75.3%	75.3%	75.3%	75.3%
December	5,841	0,0	5,841	81.7%	81.7%	81.7%	81.7%	81.7%	81.7%

Used for air dispersion modelling Scenarios A, B, D and E. For the actual situation modelling scenario (Scenario A – current condition)), engine 2091 (1,825 kW) is replaced with engine 247 (600 kW) and accounted for by doubling the contribution from unit 246.

Table 10 Monthly Loads per Generator Unit with Transmission from Hydro-Quebec

Month	Forecast (kW)	HQ Transmission (kW)	Required Diesel (kW)	Loads per Generator Unit (Maximum Power Indicated)					
				246 600 kW	2005 800 kW	2012 1,100 kW	2041 1,000 kW	2082 1,825 kW	2091 1,825 kW
January	5,960	3,000	2,960	0.0%	0.0%	0.0%	0.0%	81.1%	81.1%
February	5,585	3,000	2,585	0.0%	0.0%	0.0%	0.0%	70.8%	70.8%
March	5,186	2,500	2,686	0.0%	72.1%	72.1%	0.0%	0.0%	72.1%
April	4,774	2,500	2,274	0.0%	0.0%	77.7%	0.0%	0.0%	77.7%
May	4,354	2,500	1,854	76.5%	0.0%	0.0%	0.0%	0.0%	76.5%
June	4,148	2,000	2,148	0.0%	0.0%	73.4%	0.0%	0.0%	73.4%
July	4,084	2,000	2,084	0.0%	0.0%	71.2%	0.0%	0.0%	71.2%
August	4,047	2,000	2,047	0.0%	0.0%	70.0%	0.0%	0.0%	70.0%
September	4,288	2,000	2,288	0.0%	0.0%	78.2%	0.0%	0.0%	78.2%
October	4,210	2,000	2,210	0.0%	0.0%	75.6%	0.0%	0.0%	75.6%
November	4,935	2,500	2,435	0.0%	0.0%	83.2%	0.0%	0.0%	83.2%
December	5,841	3,000	2,841	0.0%	0.0%	0.0%	0.0%	77.8%	77.8%

Used for air dispersion modelling Scenario C only.

Scenario A (current condition) represents the existing plant at the LAL DGS with the old unit 247 still in place. Modelling results were approximated by doubling the contribution of the identical unit 246 without considering unit 2091.

For all scenarios from B to E, engine stack heights were raised up to 14.1 m above ground, except for the mobile unit 2082 for which a new stack raising 10.5 m above ground with a 0.44 m diameter was considered. Scenarios B, D and E consider the same production for the generating units as in Scenario A – replacement condition. Scenario C considered that transmission from Hydro-Quebec is occurring, thus diesel electricity generation is greatly reduced. Finally, Scenarios D and E are similar to Scenario B for electricity generation, but the new unit 2091 is replaced by a US-EPA Tier II compliant engine in Scenario D and by an engine with a diesel particulate filter (DFP) in Scenario E. Compared to the original 2091 unit, the 2091-Tier II engine has lower NO_x, CO and PM emissions, while unit 2091-DFP further reduces CO and PM emissions, but slightly increases NO_x emissions.

Table 11 Air Dispersion Modelling Scenarios Definitions

Air Dispersion Modelling Scenarios	Source Configurations	Increased Stack Heights	Hydro-Quebec Transmission	Monthly Loads per Unit
A (current condition)	Current source configuration with unit 247. Unit 247 considered in modelling by doubling the contribution of unit 246, without unit 2091 in operation.	No	No	Table 9
A (replacement condition)	Current source configuration with new 2091 unit replacing engine unit 247.	No	No	Table 9
B	Same as Scenario A-replacement condition, but: All units except 2082: increased stack height to 14.1 m. Unit 2082 increased to 10.5 m height, 0.44 m diameter.	Yes	No	Table 9
C	Same as Scenario B.	Yes	Yes	Table 10
D	Same as Scenario B, but: Generation unit 2091 replaced by a US-EPA Tier II compliant engine (2091-Tier II).	Yes	No	Table 9
E	Same as Scenario B, but: Generation unit 2091 replaced by an engine with a diesel particulate filter (2091-DFP).	Yes	No	Table 9

3.3 AIR EMISSIONS PARAMETERS

In the CALPUFF model runs, emissions parameters (temperature, velocity, pollutant emission rates) were modulated on a monthly basis based on the loads presented in Tables 9 and 10 and emissions curves based on manufacturer data for each unit. For SO_2, emissions are based on the fuel consumption and a mass balance of sulphur assuming an ultra-low sulphur fuel (≤ 15 ppm).

PM_{10} and $PM_{2.5}$ emissions were estimated from manufacturer's PMT emissions and the ratio for filterable particulates found in the AP-42 emission factors for large stationary diesel engines.

Table 12 presents stack heights and diameters for each unit and scenario. Pollutant emission rates by unit at 80% load are given as examples in Table 13, while exhaust temperatures and velocities are given in Table 12, also for 80% load.

3.4 Stack Locations and Building Dimensions

Figure 1 presents a schematic layout of the LAL DGS main buildings and exhaust stacks. These buildings were considered in the wake effect analysis with BPIP and their heights are also indicated on the figure. Table 14 indicates the coordinates of each unit's exhaust stack and the corners of the three buildings considered in the building wake analysis are presented in Table 15.

Table 12 LAL DGS Unit Exhaust Stack Physical Parameters at 80% Load

Engine Unit	Scenarios	Capacity (kW)	Stack Parameters (80% load capacity)				
			Diameter (m)	Original Height (1) (m, AGL)	Raised Height(2) (m, AGL)	Velocity (m/s)	Temperature (°C)
246	A to E	600	0.305	11.30	14.1	24.8	437.0
2005	A to E	800	0.305	11.52	14.1	36.5	481.7
2012	A to E	1,100	0.305	11.62	14.1	51.8	446.8
2041	A to E	1,000	0.254	11.13	14.1	62.3	490.8
2082	A to E	1,825	0.544 (1, 3) 0.44 (2)	4.27	10.5	24.8	406.8
2091	A to C	1,825	0.356	11.13	14.1	62.0	410.9
2091-TIERII	D	1,825	0.356	11.13	14.1	60.4	360.8
2091-DPF	E	1,825	0.356	11.13	14.1	74.9	465.2

(1) For Scenarios A only (current and replacement conditions).

(2) For all other scenarios (B to E).

(3) Equivalent diameter of a circular source of same surface as a rectangular source (72” x 5” or 1.83 m x 0.127 m).

Table 13 LAL DGS Unit Emission Rates at 80% Load

Engine Unit	Scenarios	Capacity (kW)	Emission Rates at 80% Load Capacity (g/s)							
			NOx (as NO_2)	NO (1)	NO_2 (1)	SO_2 (2)	CO	PMt	PM_{10} (3)	$PM_{2.5}$ (3)
246	A to E	600	1.64	0.857	0.329	0.000986	0.287	0.0134	0.0107	0.0104
2005	A to E	800	3.39	1.77	0.678	0.00126	0.519	0.0914	0.0731	0.0706
2012	A to E	1,100	3.94	2.05	0.787	0.00172	0.338	0.0558	0.0446	0.0431
2041	A to E	1,000	4.06	2.12	0.812	0.00152	0.625	0.0943	0.0755	0.0729
2082	A to E	1,825	4.11	2.14	0.822	0.00267	0.125	0.0627	0.0502	0.0484
2091	A to C	1,825	3.22	1.68	0.643	0.00281	0.487	0.116	0.0929	0.0897
2091-TIERII	D	1,825	2.69	1.40	0.537	0.00279	0.210	0.0281	0.0224	0.0217
2091-DPF	E	1,825	4.08	2.13	0.816	0.00352	0.069	0.0192	0.0154	0.0148

(1) Assuming that NO_x is 20% NO_2 and 80% NO on a molar basis as per the DOEC *Plume Modelling Guideline*.

(2) Based on mass balance of sulphur in the fuel (ultra-low sulphur diesel, 15 ppm) and assuming 100% conversion to SO_2.

(3) Based on PM_{10}/PMt ratio of 80% and a $PM_{2.5}$/PM_t ratio of 77.3%, based on US-EPA AP-42 Emissions Factors for large diesel engines.

Table 14 LAL DGS - Point Source Coordinates and Base Elevations

Diesel Unit	X Coordinate (km, UTM21, WGS84)	Y Coordinate (km, UTM21, WGS84)	Base Elevation (m)
246	511.133	5707.542	49.8
2005	511.136	5707.551	49.8
2012	511.135	5707.548	49.8
2041	511.134	5707.545	49.8
2082	511.131	5707.523	50.0
2091	511.131	5707.538	49.8

Table 15 LAL DGS - Building Coordinates and Base Elevations

Building	Corners	X Coordinate (km, UTM21, WGS84)	Y Coordinate (km, UTM21, WGS84)	Base Elevation (m)
Power House	1	511.132	5707.535	49.8
	2	511.142	5707.562	
	3	511.153	5707.557	
	4	511.143	5707.531	
Old Power House	1	511.169	5707.519	47.0
	2	511.172	5707.526	
	3	511.186	5707.520	
	4	511.183	5707.513	
Mobile Unit 2082 Container	1	511.130	5707.520	50.0
	2	511.125	5707.531	
	3	511.127	5707.532	
	4	511.133	5707.521	

4 RESULTS AND DISCUSSION

This section presents the CALPUFF modelling results for modelling scenarios at and beyond the generating station property fence line and over the whole receptor domain. Since preliminary results show that the LAL DGS would have a very low contribution to ambient air ground level concentrations of CO, SO_2, PM_t and PM_{10} and that the most significant impacts would be for NO_2 and $PM_{2.5}$, almost all results presented in this report will focus on these two air contaminants.

4.1 DISPERSION MODELLING RESULTS INTERPRETATION

As per the DOEC guidance document for determination of compliance (DOEC, 2012b), compliance for modelled impacts for any given year was based on the following:

- 9^{th} highest level at any given receptor for a 1-hour averaging period;
- 6^{th} highest level at any given receptor for a 3-hour averaging period;
- 3^{rd} highest level at any given receptor for a 8-hour averaging period;
- 2^{nd} highest level at any given receptor for a 24-hour averaging period;
- 1^{st} highest level at any given receptor for an annual averaging period.

All results presented in the following sections are based on the above interpretation.

As the generating station is located in a rural setting, the DOEC recommended that all background concentrations would be negligible for all the pollutants (i.e. zero). Therefore, modelling results are directly compared with AAQS in the following sections.

4.2 MAXIMUM PREDICTED GROUND LEVEL CONCENTRATIONS OF NO_2 AND $PM_{2.5}$ FOR ALL SCENARIOS

Table 16 presents the maximum predicted ground level concentrations (GLC) for NO_2 and $PM_{2.5}$ obtained for all scenarios. For the current configuration without Hydro-Quebec transmission (Scenario A – current condition), significant exceedances of AAQS for NO_2 and $PM_{2.5}$ are predicted. Replacing the 600 kW unit 247 by the 1,825 kW unit 2091 and increasing power output (Scenario A – replacement condition) leads to a slight decrease in predicted concentrations for NO_2 and an increase for $PM_{2.5}$. Increasing stack heights in Scenario B reduces predicted ground level concentrations significantly for $PM_{2.5}$, but for NO_2 the decrease is less pronounced. For Scenario B, the annual NO_2 AAQS would be met. Unit 2091 being a more environmentally efficient engine (Scenarios D and E), maximum predicted concentrations continue to decrease but exceedances of short-term AAQS for NO_2 and $PM_{2.5}$ are still predicted. By considering Hydro-Quebec transmission in Scenario C, maximum predicted ground level concentrations decrease significantly and $PM_{2.5}$ AAQS would be met. For NO_2, exceedances of less importance are still predicted for hourly and daily concentrations. Tables 17 to 22 present detailed results for NO_2 and $PM_{2.5}$ per generating unit for all scenarios.

Table 16 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS for all Scenarios

Nitrogen Dioxide (NO_2)

Periods	Years	Modelling Scenarios (µg/m³)						AAQS (µg/m³)
		A Current	A Replacement	B	C	D	E	
Hourly	2010	1,501	1,446	1,264	469	1,249	1,262	400
	2011	1,601	1,360	1,011	466	1,003	1,009	
	2012	1,443	1,415	1,193	446	1,169	1,193	
	2013	1,323	1,310	1,142	469	1,118	1,142	
	Max	**1,601**	**1,446**	**1,264**	**469**	**1,249**	**1,262**	
Daily	2010	1,035	1024	924	299	917	923	200
	2011	776	770	540	260	530	539	
	2012	912	882	496	185	489	495	
	2013	818	794	620	349	610	620	
	Max	**1,035**	**1,024**	**924**	**349**	**917**	**923**	
Annual	2010	110	104	64	18	63	64	100
	2011	124	120	59	18	59	59	
	2012	146	140	70	21	70	70	
	2013	149	143	71	20	70	71	
	Max	**149**	**143**	**71**	**21**	**70**	**71**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Modelling Scenarios (µg/m³)						AAQS (µg/m³)
		A Current	A Replacement	B	C	D	E	
Daily	2010	51	62	31	14	29	28	25
	2011	54	66	35	14	32	32	
	2012	61	74	39	15	34	33	
	2013	55	66	33	18	31	31	
	Max	**61**	**74**	**39**	**18**	**34**	**33**	

Notes: Compliance to AAQS is based on the 9^{th} hourly and 2^{nd} daily maximums per receptor on an annual basis. Maximums per unit do not necessarily occur at the same time or at the same receptor.

Table 17 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario A (current condition), no Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	247*	2005	2012	2041	2082		
Hourly	2010	230	230	342	318	375	430	1,501	400
	2011	242	242	390	351	413	293	1,601	
	2012	204	204	351	350	371	312	1,443	
	2013	211	211	352	291	346	395	1,323	
	Max	**242**	**242**	**390**	**351**	**413**	**430**	**1,601**	
Daily	2010	127	127	227	231	239	222	1,035	200
	2011	113	113	160	177	217	128	776	
	2012	138	138	168	187	237	160	912	
	2013	204	204	165	179	213	140	818	
	Max	**204**	**204**	**227**	**231**	**239**	**222**	**1,035**	
Annual	2010	16	16	26	23	30	7.9	110	100
	2011	16	16	27	26	32	8.3	124	
	2012	19	19	30	31	38	9.0	146	
	2013	20	20	33	32	38	7.1	149	
	Max	**20**	**20**	**33**	**32**	**38**	**9.0**	**149**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	247*	2005	2012	2041	2082		
Daily	2010	3.8	3.8	16	9.3	19	12	51	25
	2011	3.5	3.5	17	10	20	8.6	54	
	2012	4.3	4.3	17	10	21	9	61	
	2013	3.6	3.6	17	10	19	7.1	55	
	Max	**4.3**	**4.3**	**17**	**10**	**21**	**12**	**61**	

Notes: * Unit 247 data assumed from model run of Unit 246
Compliance to AAQS is based on the 9th hourly and 2nd daily maximums per receptor on an annual basis.
Maximums per unit do not necessarily occur at the same time or at the same receptor.

Table 18 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario A (with replacement), no Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Hourly	2010	230	342	318	375	430	186	1,446	400
	2011	242	390	351	413	293	187	1,360	
	2012	204	351	350	371	312	199	1,415	
	2013	211	352	291	346	395	177	1,310	
	Max	**242**	**390**	**351**	**413**	**430**	**199**	**1,446**	
Daily	2010	127	227	231	239	222	121	1,024	200
	2011	113	160	177	217	128	105	770	
	2012	138	168	187	237	160	126	882	
	2013	204	165	179	213	140	108	794	
	Max	**204**	**227**	**231**	**239**	**222**	**126**	**1,024**	
Annual	2010	16	26	23	30	7.9	9.5	104	100
	2011	16	27	26	32	8.3	11	120	
	2012	19	30	31	38	9.0	14	140	
	2013	20	33	32	38	7.1	14	143	
	Max	**20**	**33**	**32**	**38**	**9.0**	**14**	**143**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Daily	2010	3.8	16	9.3	19	12	14	62	25
	2011	3.5	17	10	20	8.6	16	66	
	2012	4.3	17	10	21	9.0	17	74	
	2013	3.6	17	10	19	7.1	15	66	
	Max	**4.3**	**17**	**10**	**21**	**12**	**17**	**74**	

Notes: Compliance to AAQS is based on the 9th hourly and 2nd daily maximums per receptor on an annual basis. Maximums per unit do not necessarily occur at the same time or at the same receptor.

Table 19 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario B, no Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Hourly	2010	227	313	293	314	206	151	1,264	400
	2011	246	300	251	250	172	162	1,011	
	2012	205	329	296	322	176	180	1,193	
	2013	210	271	255	288	183	173	1,142	
	Max	**246**	**329**	**296**	**322**	**206**	**180**	**1,264**	
Daily	2010	120	219	212	220	135	107	924	200
	2011	81	113	150	130	83	79	540	
	2012	77	106	123	128	97	66	496	
	2013	81	115	120	158	94	77	620	
	Max	**120**	**219**	**212**	**220**	**135**	**107**	**924**	
Annual	2010	8.5	16	15	15	6.2	6.8	64	100
	2011	8.5	17	14	14	4.0	5.9	59	
	2012	10	20	17	16	4.3	5.1	70	
	2013	11	21	17	16	3.3	5.5	71	
	Max	**11**	**21**	**17**	**16**	**6.2**	**6.8**	**71**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Daily	2010	2.0	11	5.8	9.3	5.1	6.5	31	25
	2011	2.1	11	6.8	11	3.6	5.0	35	
	2012	2.4	11	6.9	11	5.0	5.8	39	
	2013	2.1	14	6.5	10	4.2	5.5	33	
	Max	**2.4**	**14**	**6.9**	**11**	**5.1**	**6.5**	**39**	

Notes: Compliance to AAQS is based on the 9^{th} hourly and 2^{nd} daily maximums per receptor on an annual basis. Maximums per unit do not necessarily occur at the same time or at the same receptor.

Table 20 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario C, with Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Hourly	2010	116	216	217	N.A.	188	146	469	400
	2011	180	164	194	N.A.	148	154	466	
	2012	120	168	224	N.A.	165	181	446	
	2013	186	204	218	N.A.	156	167	469	
	Max	**186**	**216**	**224**	N.A.	**188**	**181**	**469**	
Daily	2010	59	130	126	N.A.	128	104	299	200
	2011	61	105	113	N.A.	59	76	260	
	2012	54	71	120	N.A.	79	63	185	
	2013	55	137	150	N.A.	73	76	349	
	Max	**61**	**137**	**150**	N.A.	**128**	**104**	**349**	
Annual	2010	1.3	1.8	11.0	N.A.	4.6	6.7	18	100
	2011	1.3	2.5	11.7	N.A.	1.4	5.9	18	
	2012	1.5	2.1	14.1	N.A.	2.0	5.1	21	
	2013	1.7	2.1	13.6	N.A.	1.4	5.5	20	
	Max	**1.7**	**2.5**	**14.1**	N.A.	**4.6**	**6.7**	**21**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091		
Daily	2010	1.2	8.3	5.9	N.A.	3.4	6.6	14	25
	2011	1.9	7.5	5.9	N.A.	2.9	5.2	14	
	2012	1.2	7.4	6.7	N.A.	4.9	6.0	15	
	2013	1.3	8.5	6.6	N.A.	2.5	5.7	18	
	Max	**1.9**	**8.5**	**6.7**	N.A.	**4.9**	**6.6**	**18**	

Notes: Compliance to AAQS is based on the 9^{th} hourly and 2^{nd} daily maximums per receptor on an annual basis.
Maximums per unit do not necessarily occur at the same time or at the same receptor.

Table 21 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario D, no Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091-TierII		
Hourly	2010	227	313	293	314	206	135	1,249	400
	2011	246	300	251	250	172	142	1,003	
	2012	205	329	296	322	176	160	1,169	
	2013	210	271	255	288	183	149	1,118	
	Max	**246**	**329**	**296**	**322**	**206**	**160**	**1,249**	
Daily	2010	120	219	212	220	135	94	917	200
	2011	81	113	150	130	83	68	530	
	2012	77	106	123	128	97	59	489	
	2013	81	115	120	158	94	62	610	
	Max	**120**	**219**	**212**	**220**	**135**	**94**	**917**	
Annual	2010	8.5	16	15	15	6.2	6.0	63	100
	2011	8.5	17	14	14	4.0	5.1	59	
	2012	10	20	17	16	4.3	4.6	70	
	2013	11	21	17	16	3.3	4.9	70	
	Max	**11**	**21**	**17**	**16**	**6.2**	**6.0**	**70**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091-TierII		
Daily	2010	2.0	11	5.8	9.3	5.1	1.6	29	25
	2011	2.1	11	6.8	11	3.6	1.2	32	
	2012	2.4	11	6.9	11	5.0	1.4	34	
	2013	2.1	14	6.5	10	4.2	1.3	31	
	Max	**2.4**	**14**	**6.9**	**11**	**5.1**	**1.6**	**34**	

Notes: Compliance to AAQS is based on the 9^{th} hourly and 2^{nd} daily maximums per receptor on an annual basis.

Maximums per unit do not necessarily occur at the same time or at the same receptor.

Plant production and stack heights are the same as Scenario B, but with an US-EPA Tier II compliant engine for unit 2091.

Table 22 Summary of Maximum Predicted Concentrations of NO_2 and $PM_{2.5}$ over all Receptors for the LAL DGS – Scenario E, no Hydro-Quebec Transmission

Nitrogen Dioxide (NO_2)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091-DPF		
Hourly	2010	227	313	293	314	206	150	1,262	400
	2011	246	300	251	250	172	160	1,009	
	2012	205	329	296	322	176	180	1,193	
	2013	210	271	255	288	183	172	1,142	
	Max	**246**	**329**	**296**	**322**	**206**	**180**	**1,262**	
Daily	2010	120	219	212	220	135	105	923	200
	2011	81	113	150	130	83	79	539	
	2012	77	106	123	128	97	66	495	
	2013	81	115	120	158	94	77	620	
	Max	**120**	**219**	**212**	**220**	**135**	**105**	**923**	
Annual	2010	8.5	16	15	15	6.2	6.8	64	100
	2011	8.5	17	14	14	4.0	5.9	59	
	2012	10	20	17	16	4.3	5.1	70	
	2013	11	21	17	16	3.3	5.5	71	
	Max	**11**	**21**	**17**	**16**	**6.2**	**6.8**	**71**	

Fine Particulates ($PM_{2.5}$)

Periods	Years	Individual units (µg/m³)						All units (µg/m³)	AAQS (µg/m³)
		246	2005	2012	2041	2082	2091-DPF		
Daily	2010	2.0	11	5.8	9.3	5.1	1.0	28	25
	2011	2.1	11	6.8	11	3.6	0.7	32	
	2012	2.4	11	6.9	11	5.0	0.9	33	
	2013	2.1	14	6.5	10	4.2	0.8	31	
	Max	**2.4**	**14**	**6.9**	**11**	**5.1**	**1.0**	**33**	

Notes: Compliance to AAQS is based on the 9th hourly and 2nd daily maximums per receptor on an annual basis.
Maximums per unit do not necessarily occur at the same time or at the same receptor.
Plant production and stack heights are the same as Scenarios B and D, but with an engine with a diesel particulates filter for unit 2091.

4.3 Maps of Maximum Predicted Ground Level Concentrations of NO_2 and $PM_{2.5}$

Several maps showing maximum annual predicted hourly and daily predicted NO_2 concentrations and maximum annual daily $PM_{2.5}$ predicted concentrations over the modelling domain with replacement of engine 247 are presented for Scenarios A to E on Figures 5 to 19:

- Maximum Annual Hourly Average Predicted Concentrations of NO_2 are presented on Figures 5 to 9.
- Maximum Annual Daily Average Predicted Concentrations of NO_2 are presented on Figures 10 to 14.
- Maximum Annual Daily Average Predicted Concentrations of $PM_{2.5}$ are presented on Figures 15 to 19;

Maps for scenarios without Hydro-Quebec transmission (Scenarios A, B, D and E) are very similar in terms of concentrations and extent of non-compliance areas for a given contaminant and averaging period. Only maps for Scenario C with Hydro-Quebec transmission show a significant reduction, both in term of the maximum concentrations and the extent of non-compliance areas, when applicable.

4.4 Exceedances of the AAQS and Top-50 Events for NO_2 and $PM_{2.5}$ for Scenarios C and E

Tables 23 and 24 present statistics for predicted exceedances of hourly and daily NO_2 concentrations respectively for Scenarios C and E. Table 25 presents similar results for both scenarios for daily average $PM_{2.5}$ predicted concentrations. Each of these three tables present the maximum predicted exceedances above the permitted guideline values at any given receptor and the total number of events and frequency of exceedances somewhere within the modelling domain. The distance from the LAL DGS where the impacts have been predicted and the surface area of the impacts (km^2) has also been included.

For the normal production (Scenario C), with Hydro-Quebec power transmission, the LAL DGS would be compliant with the daily $PM_{2.5}$ AQS. Non-compliance with the hourly NO_2 AAQS is predicted between 0.18% and 0.73% of the time on an annual basis (16 to 64 hours) and non-compliance with the daily NO_2 AAQS is predicted three out of four years, with an exceedance frequency of up to 2.2% (8 days per year). The non-compliance area covers an area less than 0.035 km^2 and ranges from the plant boundary up to 400 m away under the worst case meteorological conditions.

For the worst case production (Scenario E), without Hydro-Quebec power transmission, the LAL DGS would not be compliant with the daily $PM_{2.5}$ AAQS 1.1 % to 2.7% of the time (4 to 10 days per year) impacting an area estimated at 0.0025 km^2. Non-compliance with the hourly and daily NO_2 AAQS frequencies would be in the 49% to 55% range somewhere in the modelling domain. The non-compliance area ranges from the plant boundary up to 1.5 km away under worst case meteorological conditions. The surface area of these impacts is 1.1 km^2 to 1.3 km^2 for hourly NO_2 and 0.36 km^2 to 0.52 km^2 for daily NO_2.

For Scenario C, the top-50 events and the predicted concentrations are presented in Table 26 for hourly NO_2, in Table 27 for daily NO_2 and in Table 28 for daily $PM_{2.5}$. Similar results are presented for Scenario E in Tables 29 to 31. These tables of top-50 events present the maximum concentration over the domain per event, as well as the distance and direction from the plant center to the location of the maximum concentration per event.

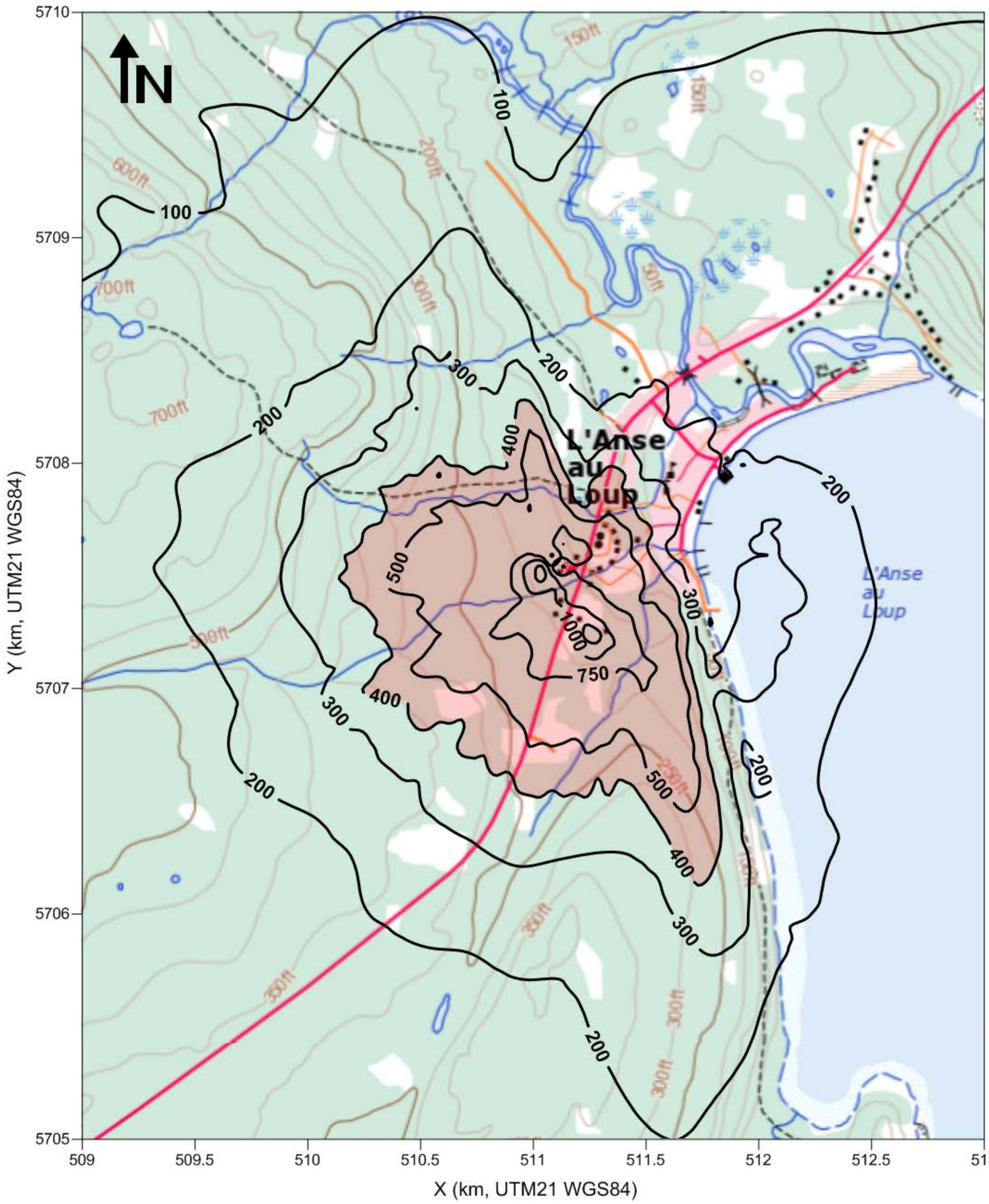
For Scenario C, most top events also coincide with exceedances of hourly or daily NO_2 AAQS (Tables 26 and 27). Most of the top events are predicted in the winter season and especially during March. The Scenario definition, in terms of which engines are running, rather than specific climate conditions, can explain why most top events are predicted in March. In the Scenario definition (Table 10), production in March is based on three engines (units 2005, 2012 and 2091). This production scenario was configured and approved in the early stages of the modelling study and did not account for the increase in stack height at the facility. The scenario was defined to try and avoid using mobile unit 2082, which had the greatest individual impact (Tables 17 and 18) on air quality. Based on subsequent model results with increased stack heights in Table 20, it is quite clear that increasing stack height on unit 2082 has a considerable impact and it would be preferable to use unit 2082 rather than units 2005 and 2012 with unit 2091 in March as defined in the scenario.

For Scenario E, all events in the top-50 for hourly or daily NO_2 and most events for daily $PM_{2.5}$ coincide with an exceedance of the relevant AAQS. Most of the events in the top-50 for NO_2 are predicted during the winter months corresponding to higher emissions while top events for daily $PM_{2.5}$ are mainly distributed throughout the year.

4.5 Maximum Predicted Ground Level Concentrations of other Contaminants

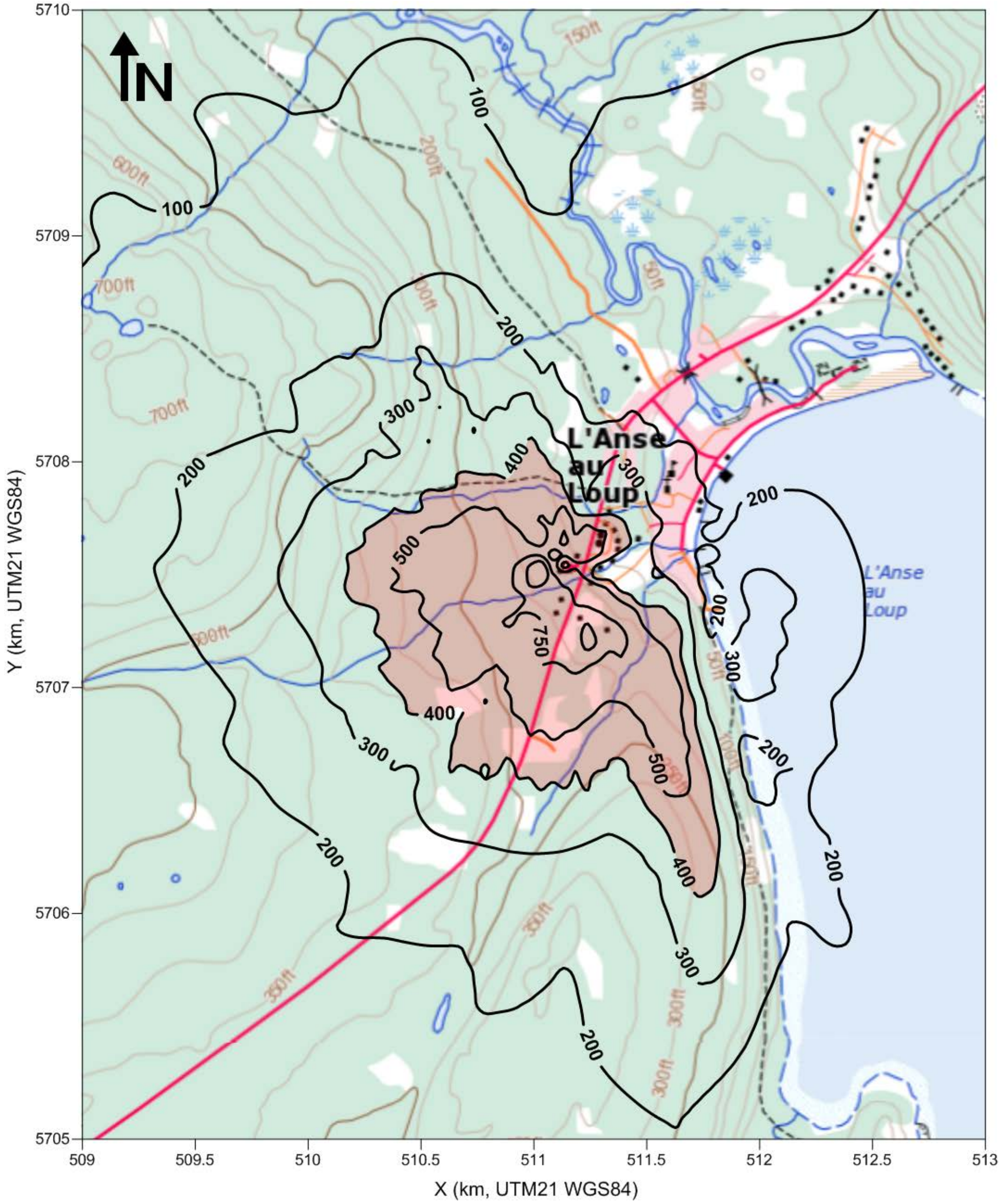
Tables 32 to 37 present maximum predicted concentrations of other contaminants (SO_2, CO, PM_t and PM_{10}) for each scenario. The maximum predicted concentrations of these other pollutants for all scenarios are all below their respective AAQS thresholds for all averaging periods.

Figure 5 **Maximum Hourly Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario A (Replacement)**



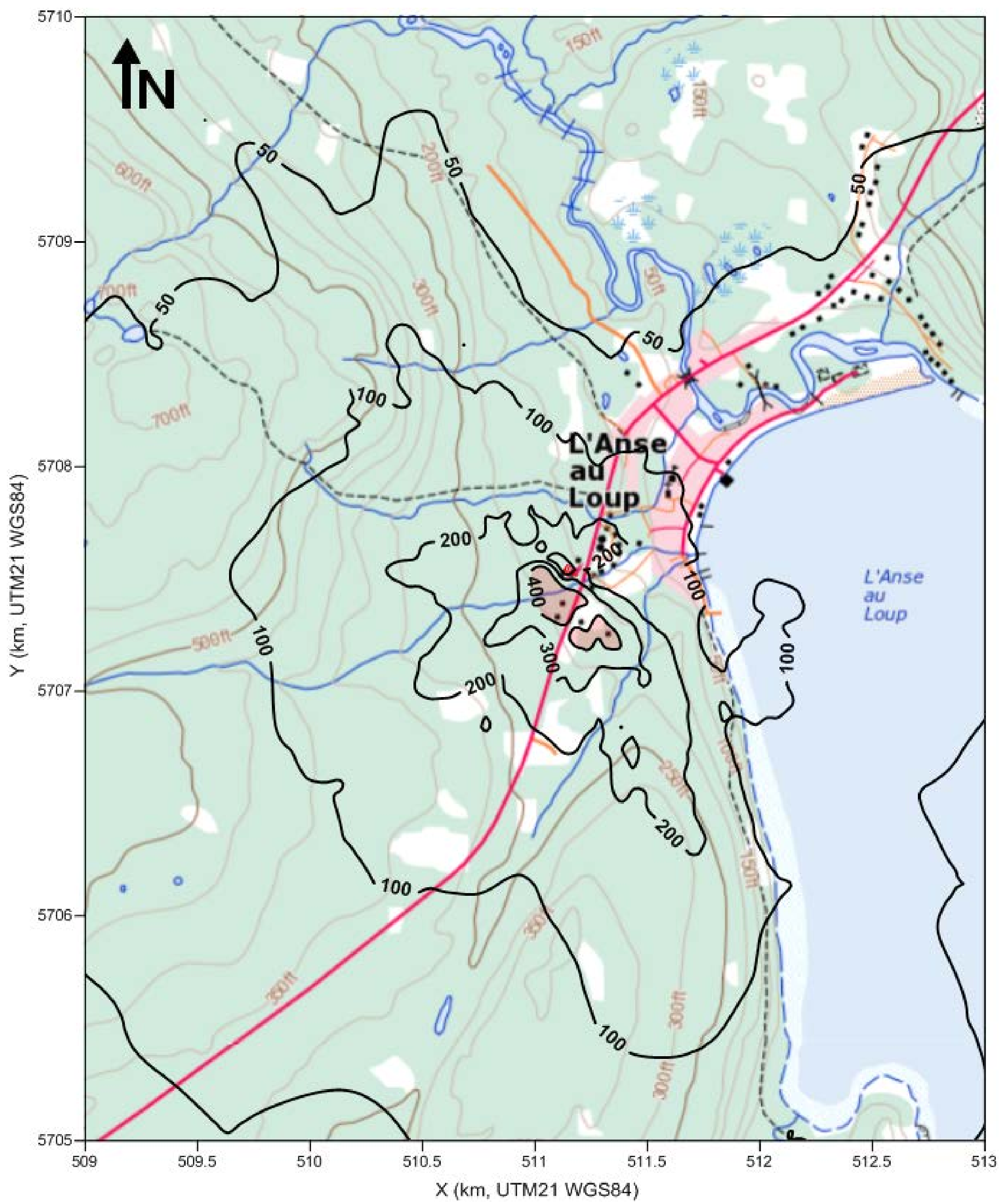
The pink shaded area represents the area of exceedance with respect to the 400 µg/m³ AAQS for hourly NO_2.

Figure 6 Maximum Hourly Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario B



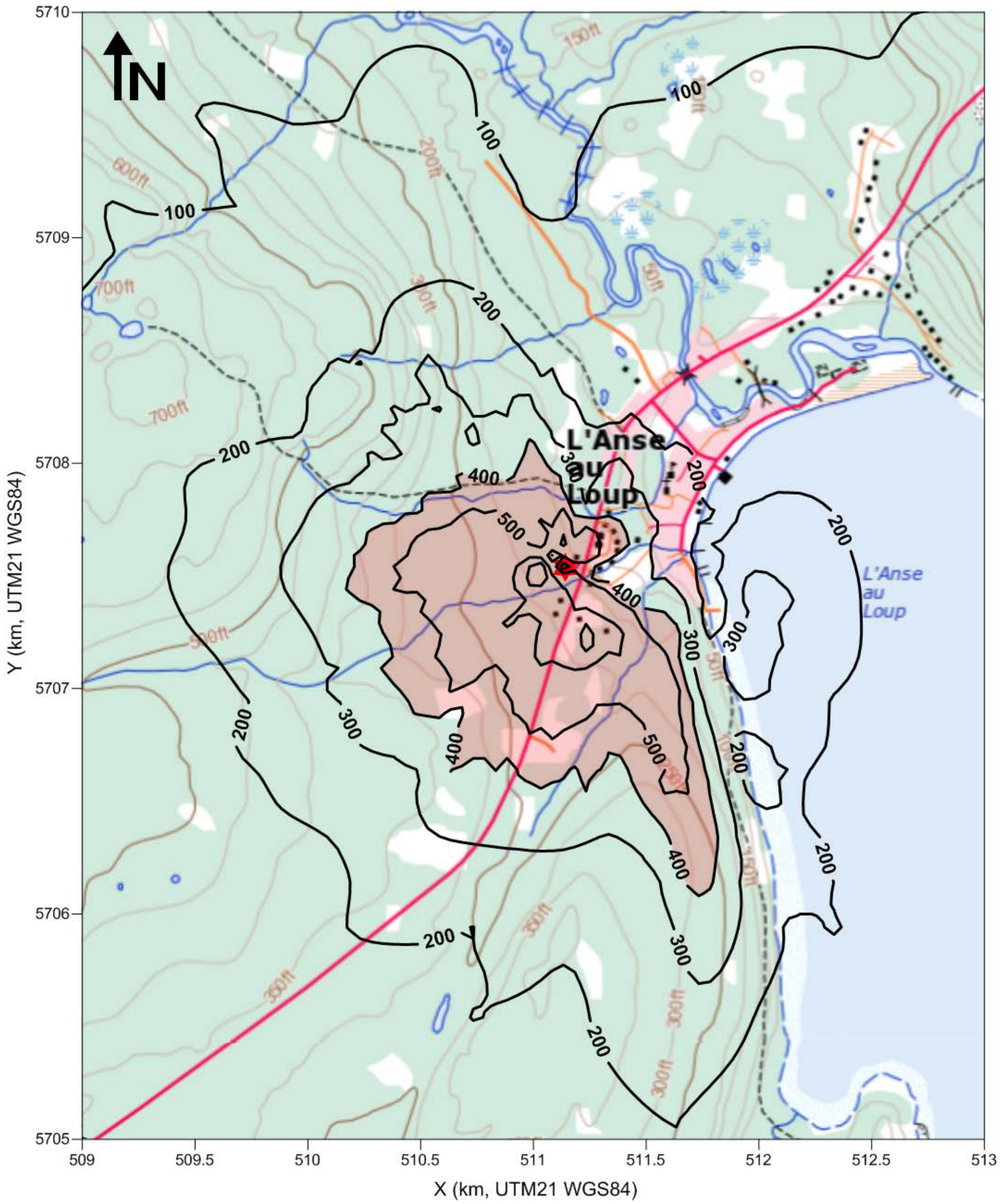
The pink shaded area represents the area of exceedance with respect to the 400 µg/m³ AAQS for hourly NO_2.

Figure 7 Maximum Hourly Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario C



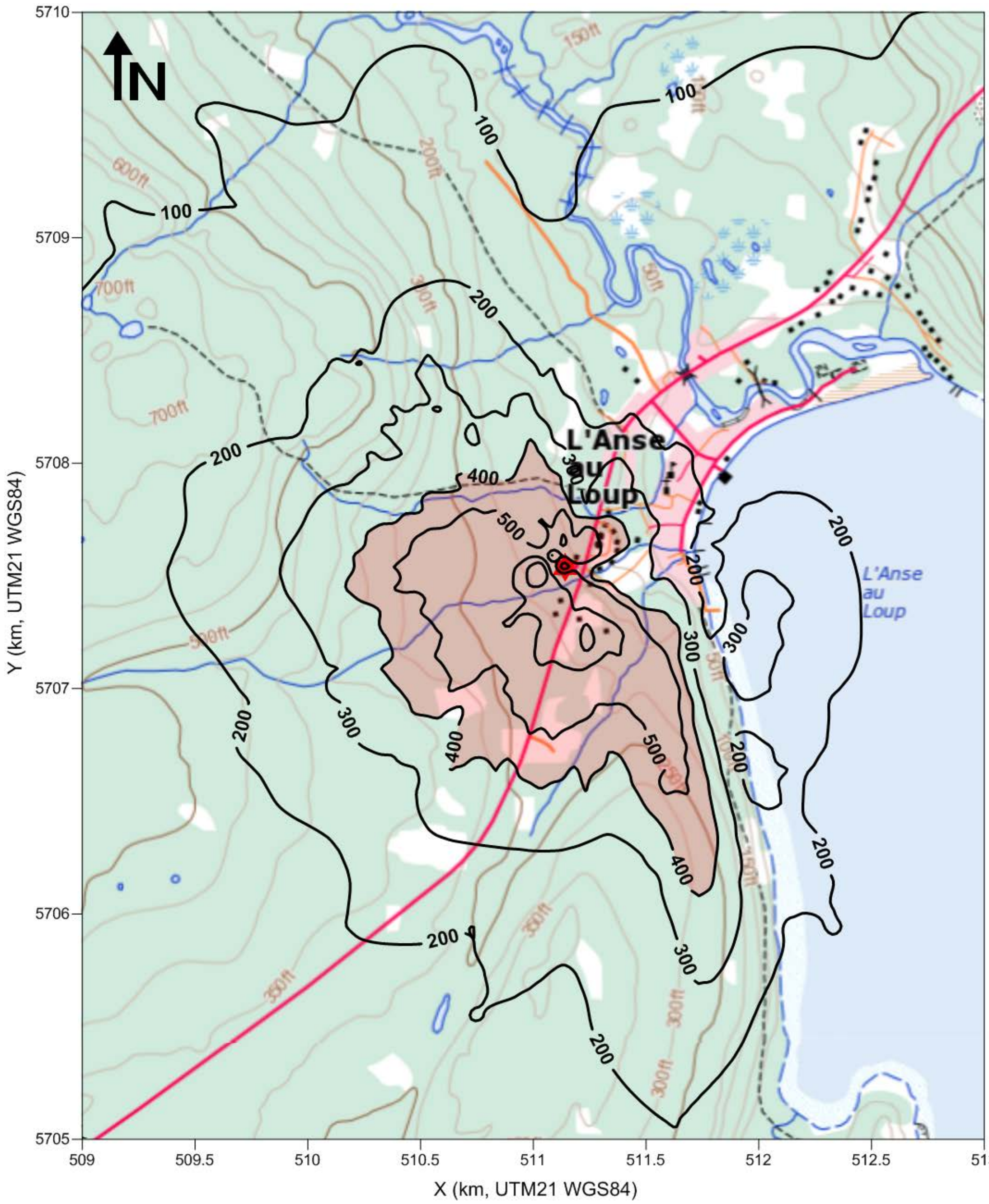
The pink shaded area represents the area of exceedance with respect to the 400 µg/m³ AAQS for hourly NO_2.

Figure 8 **Maximum Hourly Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario D**



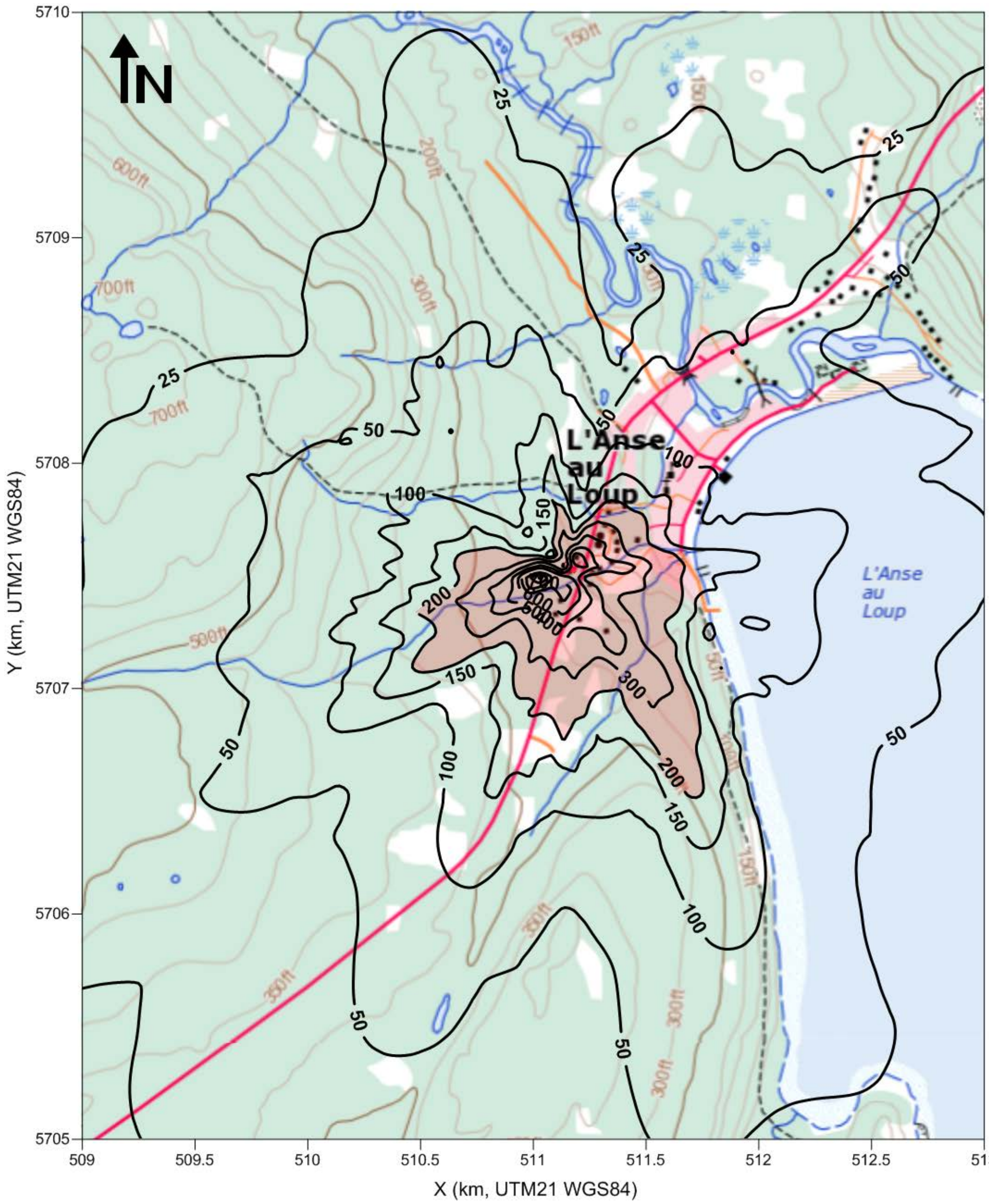
The pink shaded area represents the area of exceedance with respect to the 400 µg/m³ AAQS for hourly NO_2.

Figure 9 **Maximum Hourly Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario E**



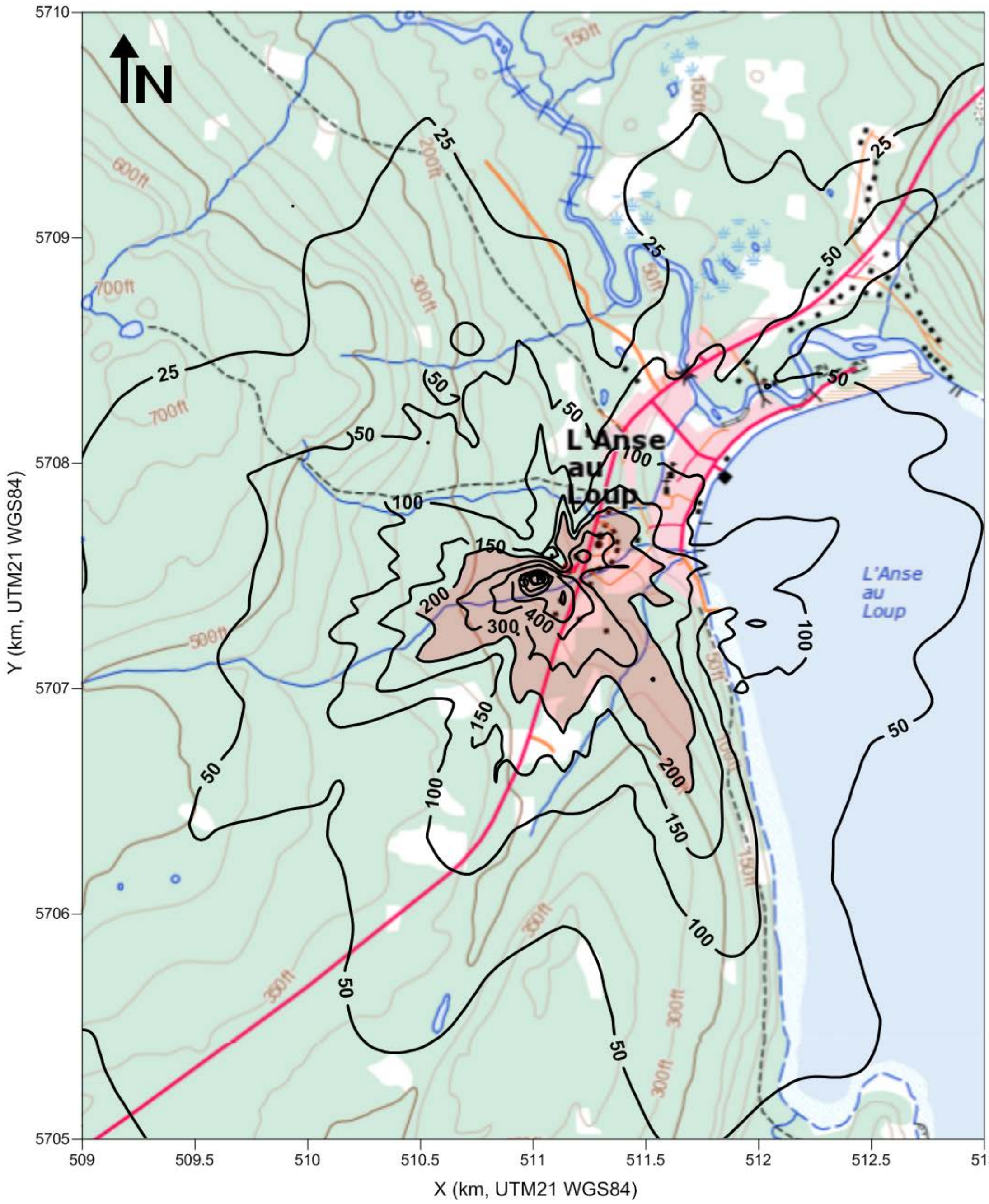
The pink shaded area represents the area of exceedance with respect to the 400 µg/m³ AAQS for hourly NO_2.

Figure 10 Maximum Daily Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario A (Replacement)



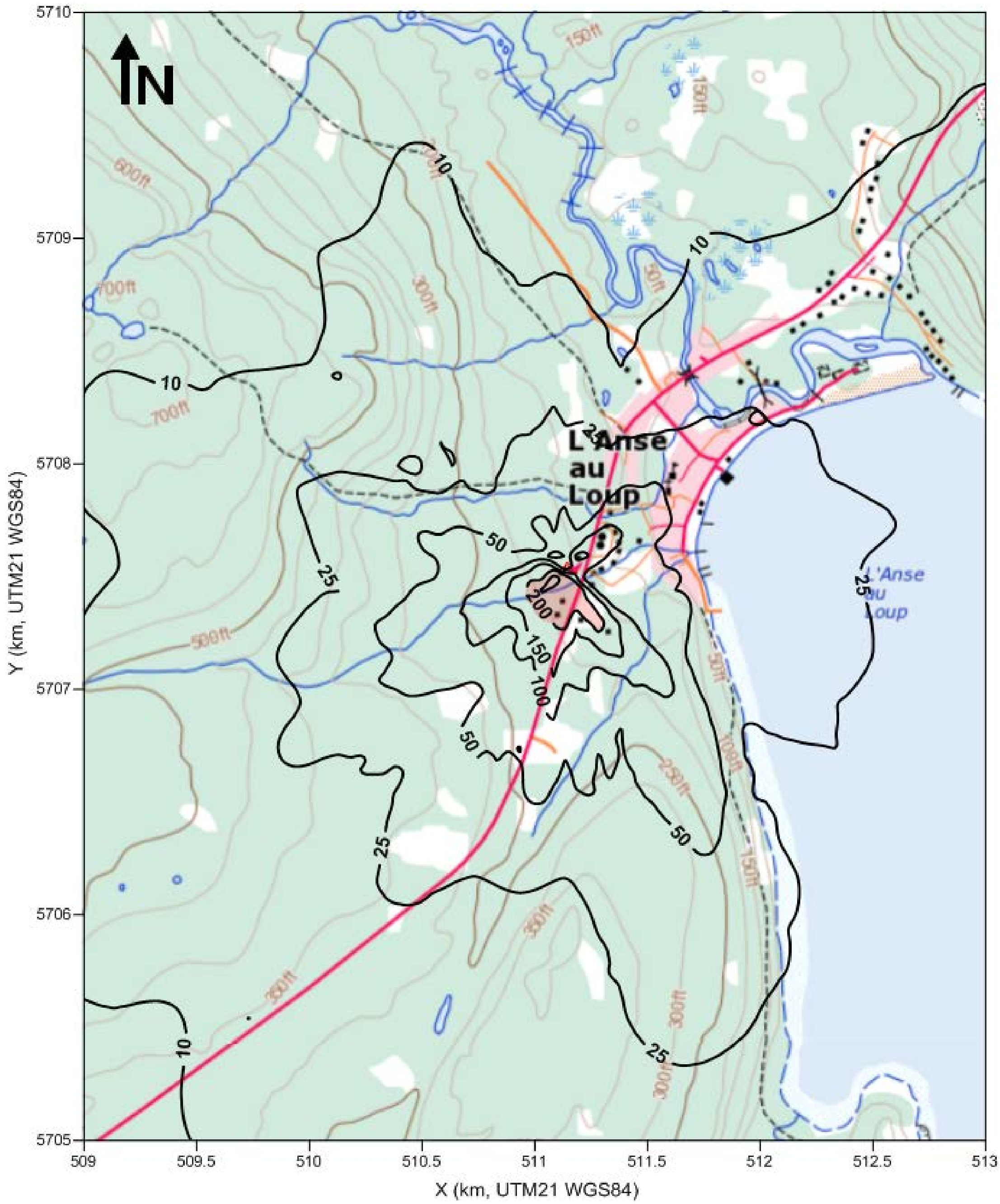
The pink shaded area represents the area of exceedance with respect to the 200 µg/m³ AAQS for daily NO_2.

Figure 11 Maximum Daily Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario B



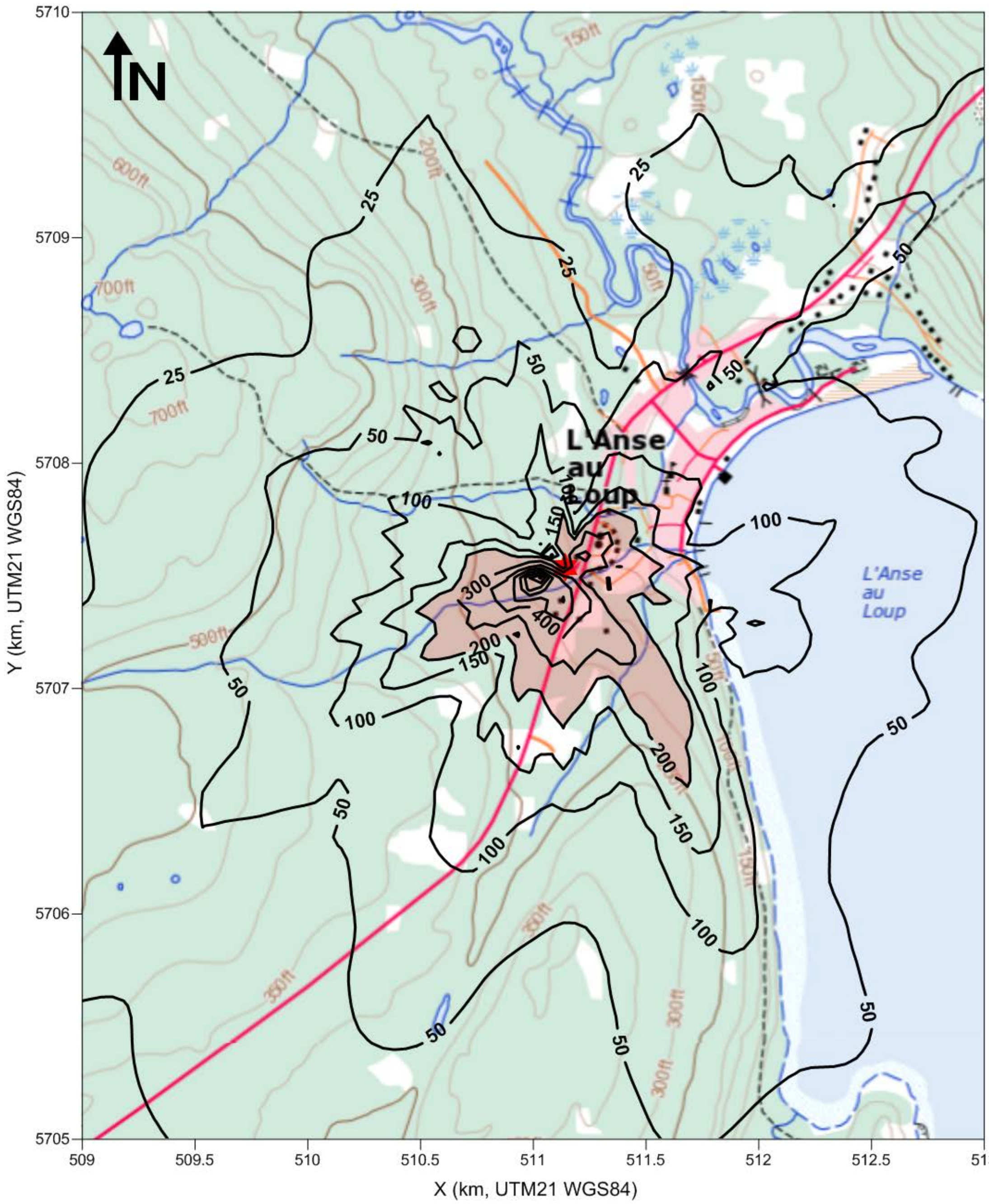
The pink shaded area represents the area of exceedance with respect to the 200 µg/m³ AAQS for daily NO_2.

Figure 12 Maximum Daily Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario C



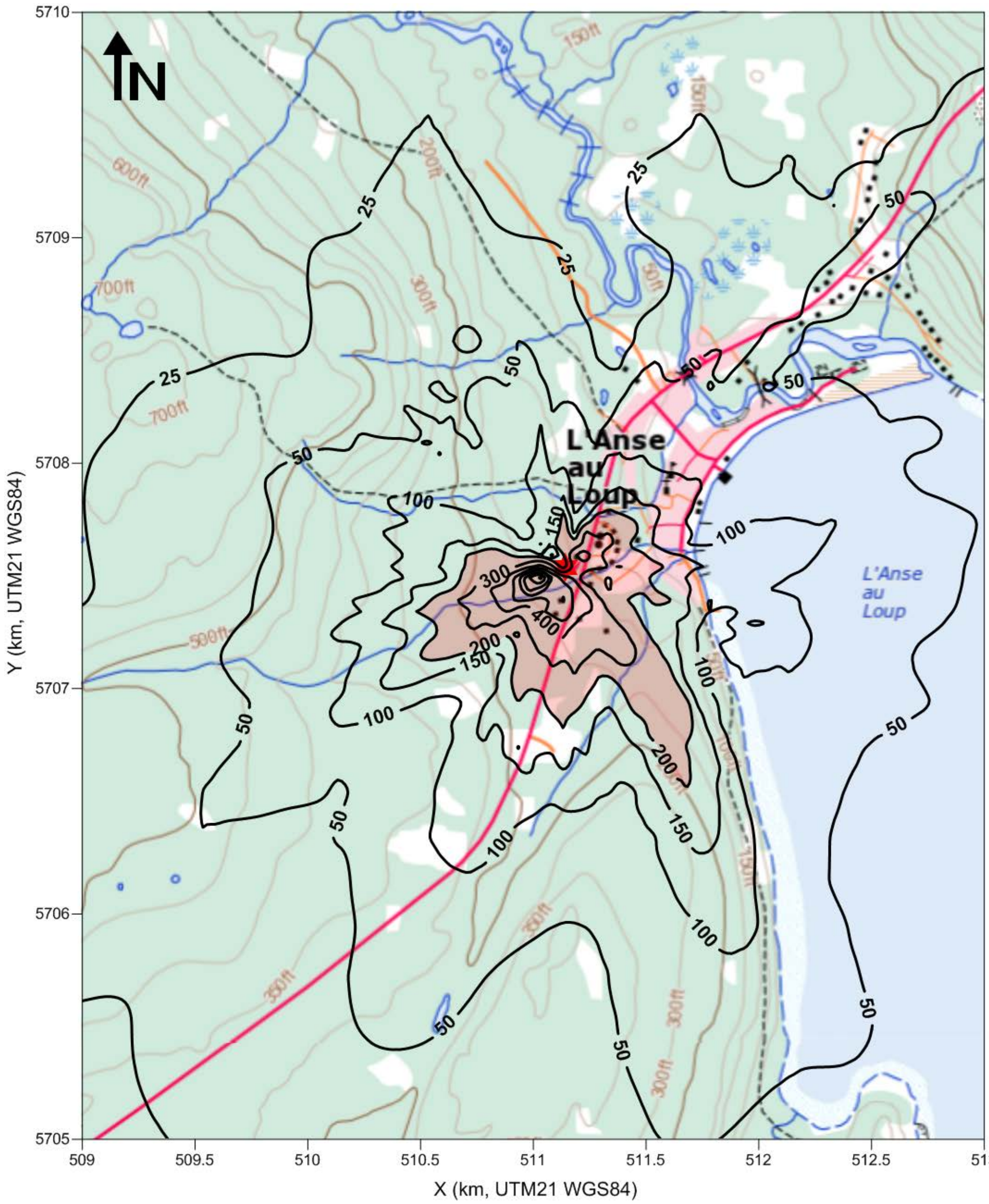
The pink shaded area represents the area of exceedance with respect to the 200 µg/m³ AAQS for daily NO_2.

Figure 13 Maximum Daily Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario D



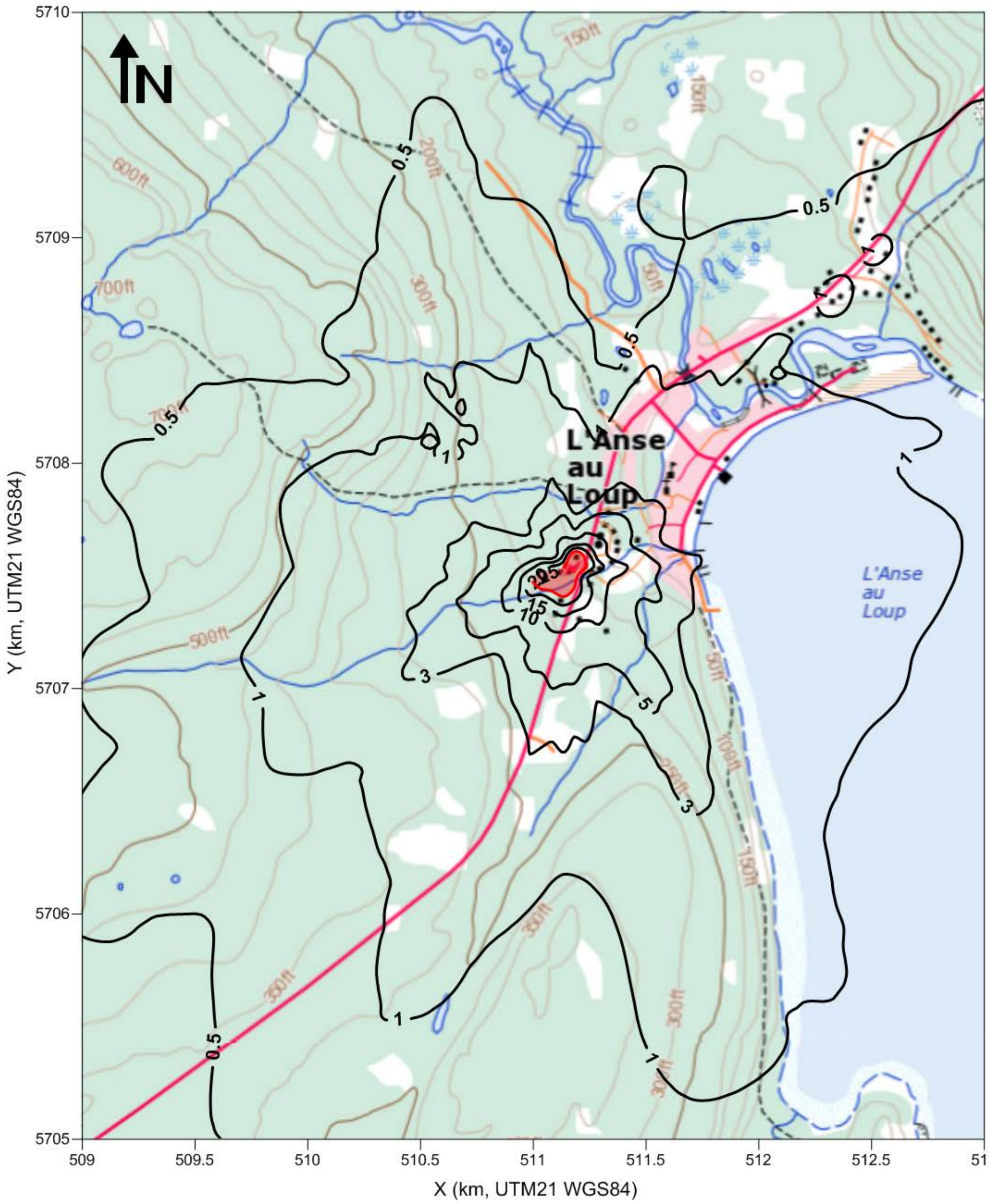
The pink shaded area represents the area of exceedance with respect to the 200 µg/m³ AAQS for daily NO_2.

Figure 14 Maximum Daily Average Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the LAL DGS (2010-2013) – Scenario E



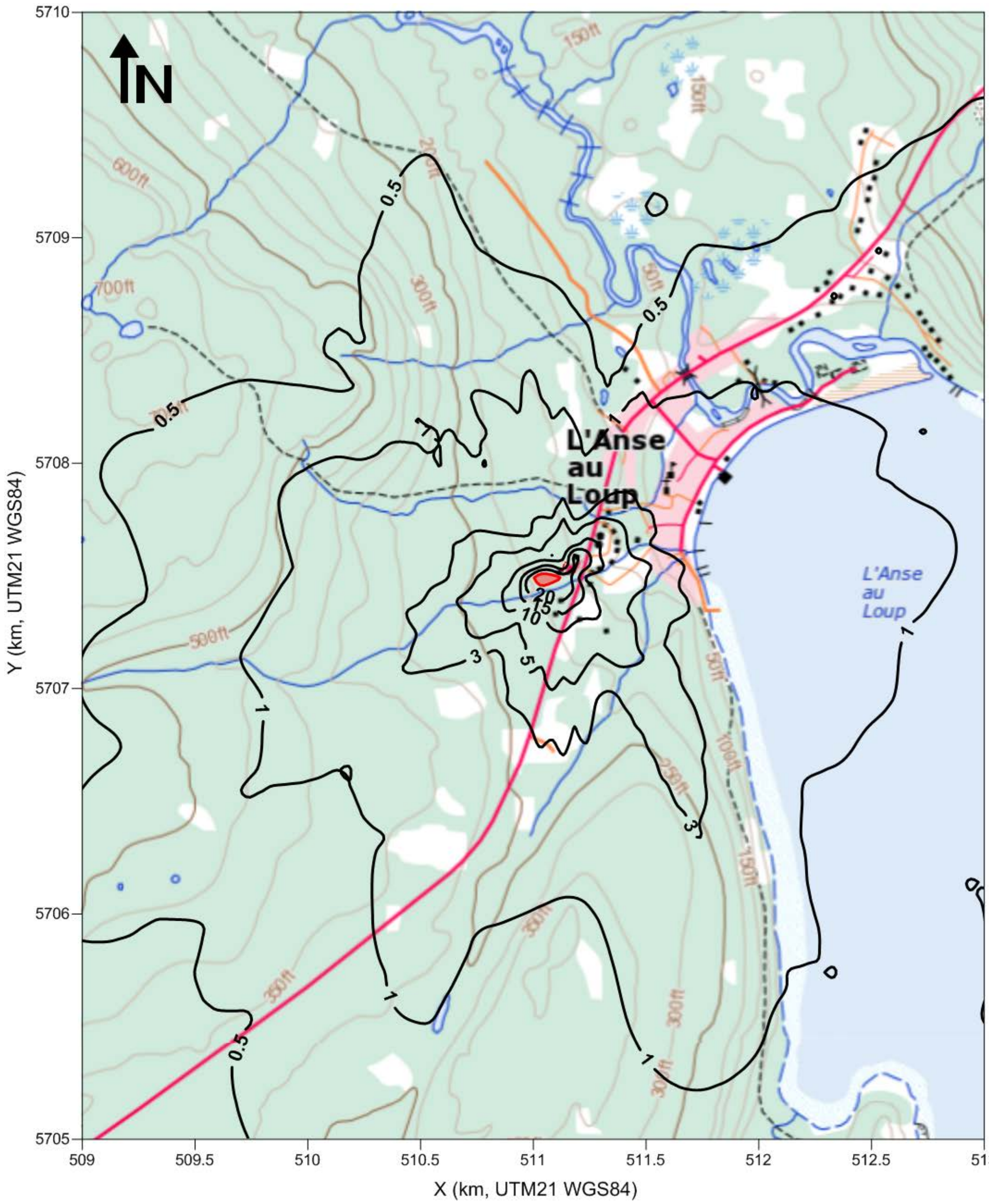
The pink shaded area represents the area of exceedance with respect to the 200 µg/m³ AAQS for daily NO_2.

Figure 15 Maximum Daily Average Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the LAL DGS (2010-2013) – Scenario A (Replacement)



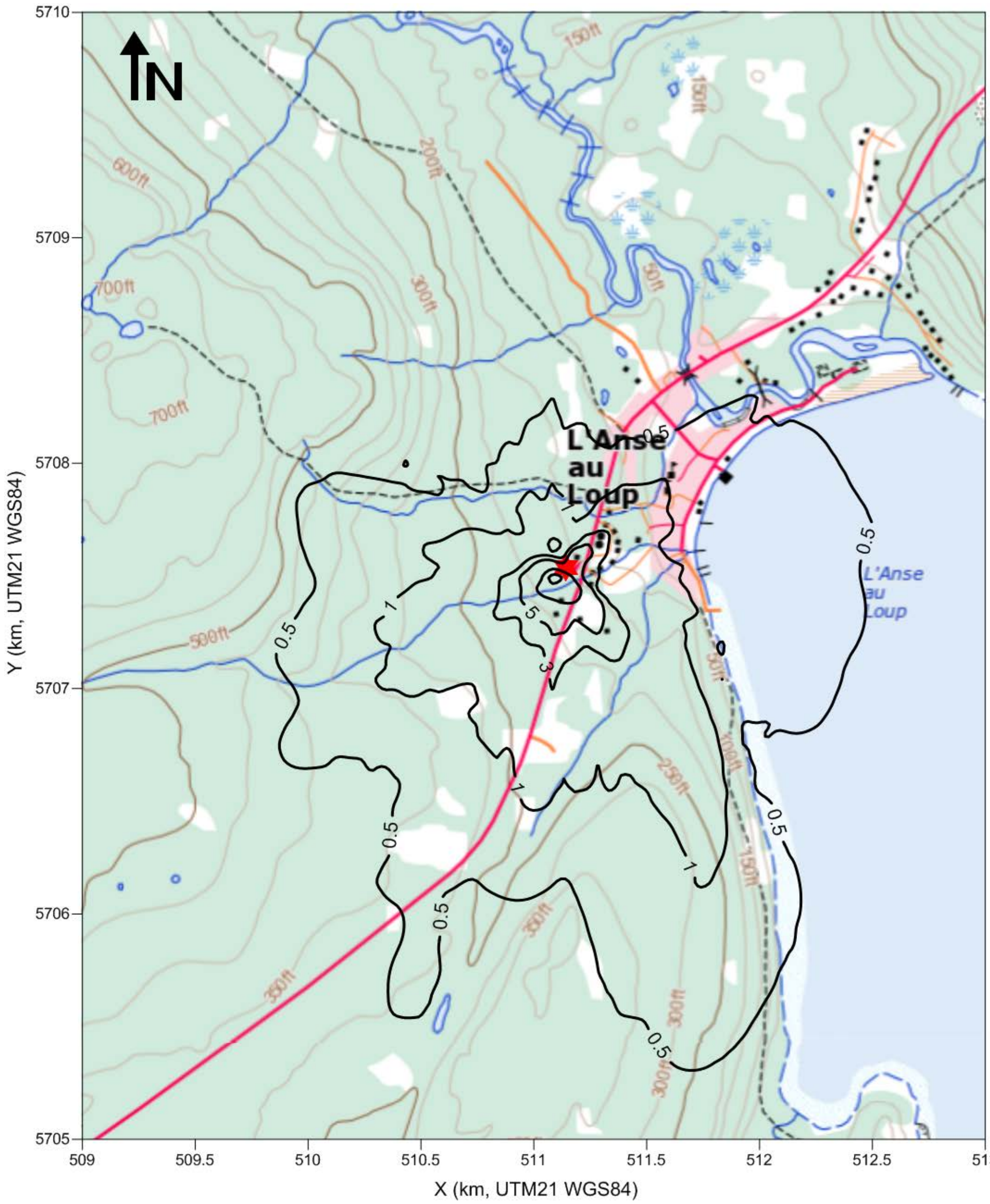
The pink shaded area represents the area of exceedance with respect to the 25 µg/m³ AAQS for daily $PM_{2.5}$.

Figure 16 Maximum Daily Average Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the LAL DGS (2010-2013) – Scenario B



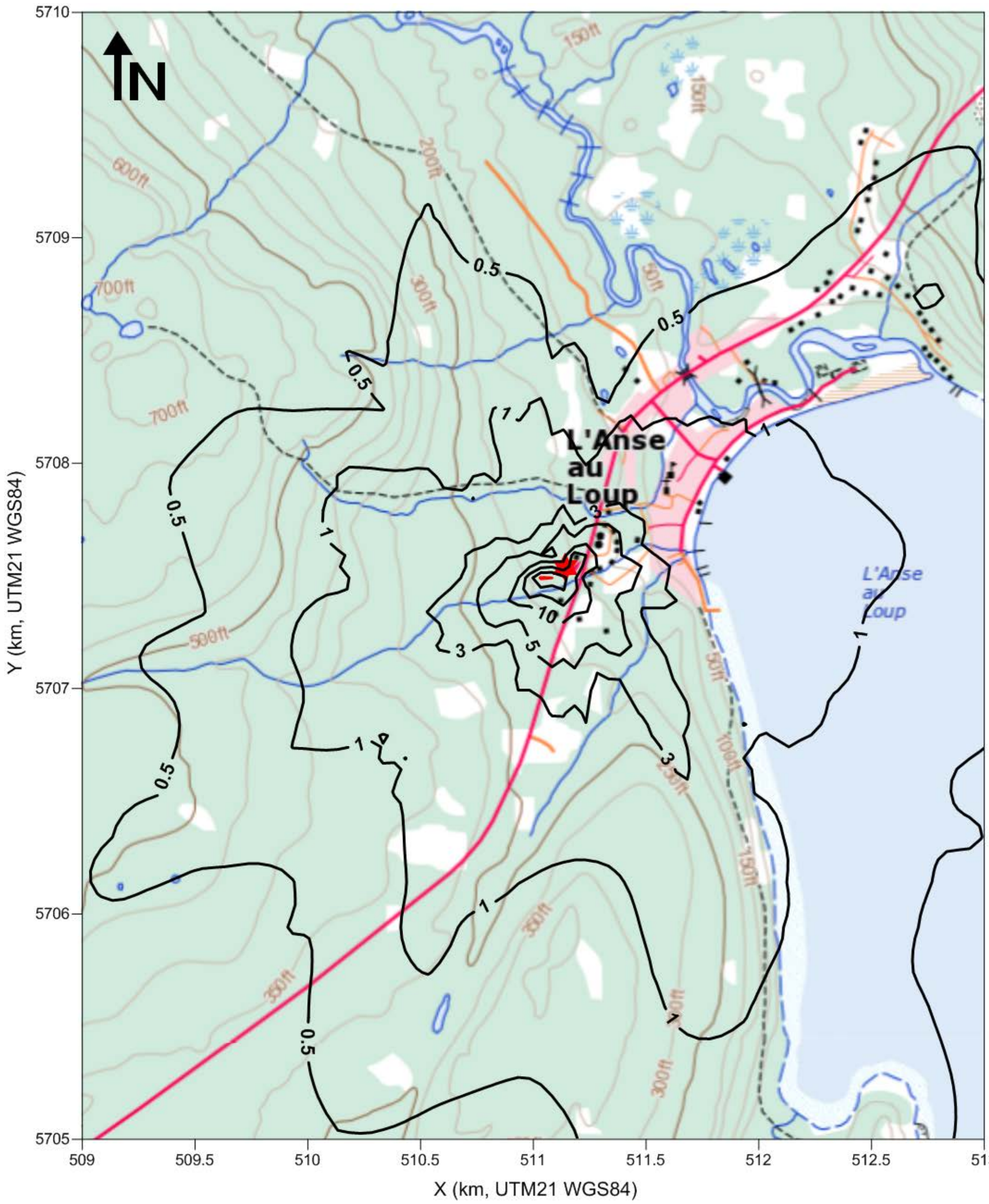
The pink shaded area represents the area of exceedance with respect to the 25 µg/m³ AAQS for daily $PM_{2.5}$.

Figure 17 **Maximum Daily Average Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the LAL DGS (2010-2013) – Scenario C**



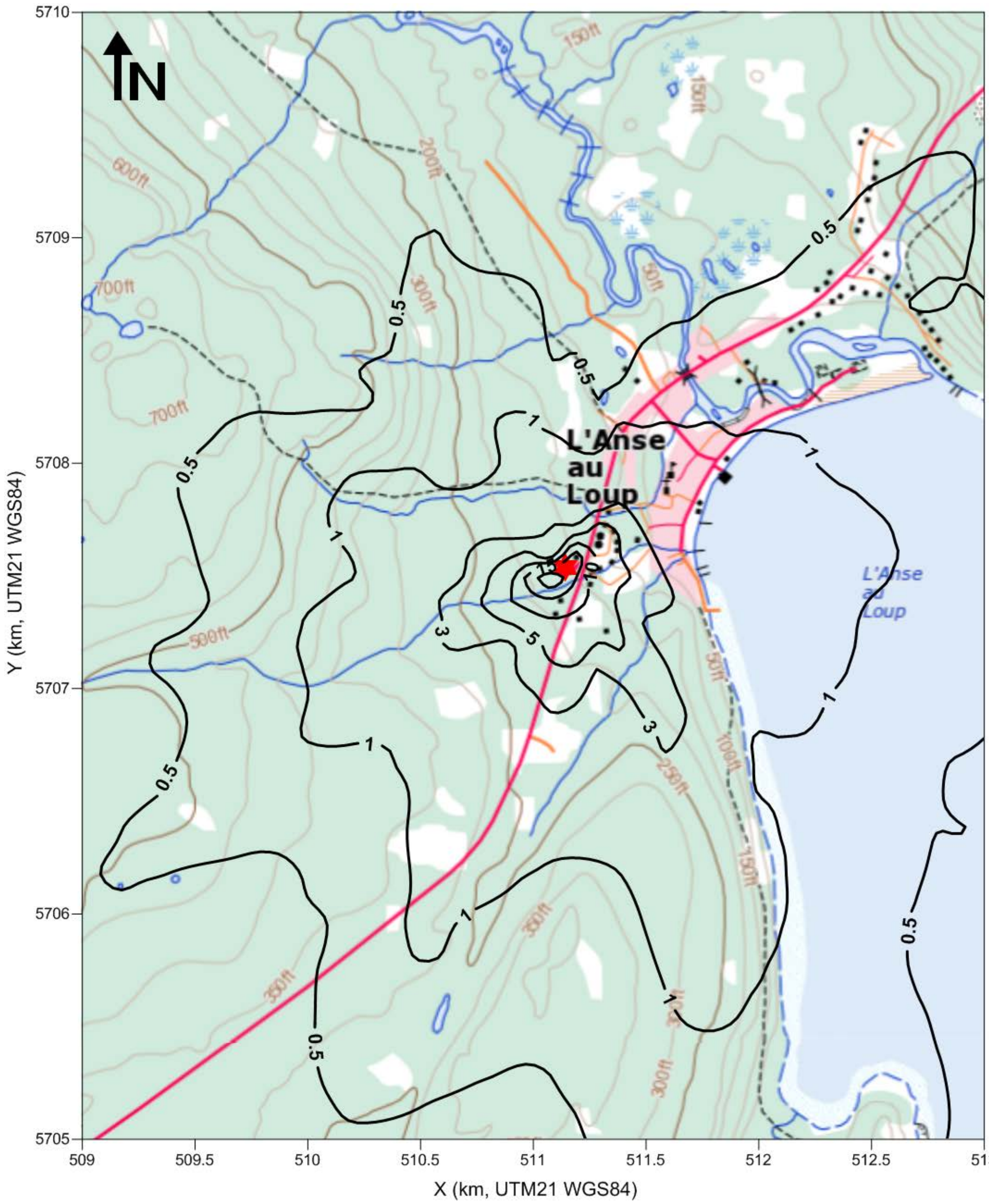
The pink shaded area represents the area of exceedance with respect to the 25 µg/m³ AAQS for daily $PM_{2.5}$.

Figure 18 Maximum Daily Average Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the LAL DGS (2010-2013) – Scenario D



The pink shaded area represents the area of exceedance with respect to the 25 µg/m³ AAQS for daily $PM_{2.5}$.

Figure 19 Maximum Daily Average Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the LAL DGS (2010-2013) – Scenario E



The pink shaded area represents the area of exceedance with respect to the 25 µg/m³ AAQS for daily $PM_{2.5}$.

Table 23 Summary of Predicted Exceedances of Hourly and Daily AAQS for NO_2 for Scenario C

Scenario	Year	Averaging Period	Compliance Maximum Ground Level Concentration (µg/m³)	AAQS (µg/m³)	Total Count and Frequency of Events Leading to Additional Exceedances above Guideline within the Domain		Surface Area of Exceedance (km²)	Exceedances: Distance from Plant (metres)
C	2010	Hourly	469	400	33	0.38%	0.013	100 - 290
	2011	Hourly	466		23	0.26%	0.013	100 - 360
	2012	Hourly	446		16	0.18%	0.0096	290 - 400
	2013	Hourly	469		64	0.73%	0.030	70 - 360
	2010	Daily	299	200	8	2.2%	0.021	50 - 250
	2011	Daily	260		5	1.4%	0.012	45 - 290
	2012	Daily	185		--	--	--	--
	2013	Daily	349		7	1.9%	0.035	35 - 225

Notes:

Scenario C represents normal operations and incorporates Hydro- Quebec transmission.

Compliance Maximum hourly concentration (µg/m³) represents the 9th highest model result.

Compliance Maximum daily concentration (µg/m³) represents the 2nd highest model result.

Compliance Maximum annual concentration (µg/m³) represents the 1st highest model result.

Table 24 Summary of Predicted Exceedances of Hourly and Daily AAQS for NO_2 for Scenario E

Scenario	Year	Averaging Period	Compliance Maximum Ground Level Concentration (µg/m³)	AAQS (µg/m³)	Total Count and Frequency of Events Leading to Additional Exceedances above Guideline within the Domain		Surface Area of Exceedance (km²)	Exceedances: Distance from Plant (metres)
E	2010	Hourly	1,262	400	4,719	54%	1.2	35 - 1,100
	2011	Hourly	1,009		4,389	50%	1.3	35 - 1,100
	2012	Hourly	1,193		4,367	50%	1.3	35 - 1,500
	2013	Hourly	1,142		4,312	49%	1.1	35 - 1,350
	2010	Daily	923	200	199	55%	0.52	30 - 820
	2011	Daily	539		178	49%	0.36	35 - 740
	2012	Daily	495		181	49%	0.45	35 - 930
	2013	Daily	620		192	53%	0.42	30 - 1,140

Notes:

Scenario E represents worst case with 100% diesel generation (new unit with particulate filter).

Compliance Maximum hourly concentration (µg/m³) represents the 9th highest model result.

Compliance Maximum daily concentration (µg/m³) represents the 2nd highest model result.

Compliance Maximum annual concentration (µg/m³) represents the 1st highest model result.

Table 25 Summary of Predicted Exceedances of AAQS for $PM_{2.5}$ for Scenarios C and E

Scenario	Year	Averaging Period	Compliance Maximum Ground Level Concentration (µg/m³)	AAQS (µg/m³)	Total Count and Frequency of Events Leading to Additional Exceedances above Guideline within the Domain		Surface Area of Exceedance (km²)	Exceedances: Distance from Plant (metres)
C	2010	Daily	14	25	--	--	--	--
	2011	Daily	14		--	--	--	--
	2012	Daily	15		--	--	--	--
	2013	Daily	18		--	--	--	--
E	2010	Daily	28	25	4	1.1%	0.0025	45
	2011	Daily	32		7	1.9%	0.0025	45
	2012	Daily	33		10	2.7%	0.0025	45
	2013	Daily	31		5	1.4%	0.0025	45

Notes:

Scenario C represents normal operations and incorporates Hydro-Quebec transmission.

Scenario E represents worst case with 100% diesel generation (new unit with particulate filter)

Compliance maximum daily concentration (µg/m³) represents the 2nd highest model result.

Table 26 Top 50 Events for Hourly NO_2 predicted Concentrations for Scenario C (2010-2013)

Rank	Date/Hour (yyyy/mm/dd hh)	Concentration (µg/m³)	Distance (m)	Direction
1	2013/12/23 17	1365	885	SE
2	2013/12/18 08	1189	806	ESE
3	2011/12/19 17	921	827	ESE
4	2011/01/15 04	829	778	SE
5	2013/03/22 22	803	112	WNW
6	2013/12/31 23	773	700	E
7	2013/12/21 09	730	827	ESE
8	2013/03/22 21	723	112	WNW
9	2011/03/01 06	721	100	W
10	2013/03/20 22	687	100	W
11	2013/03/22 19	659	100	W
12	2013/03/24 20	632	158	WSW
13	2011/06/06 00	631	269	SSE
14	2013/03/24 19	631	112	WSW
15	2011/05/25 22	627	335	SSE
16	2011/06/05 23	622	269	SSE
17	2012/07/18 03	622	316	SSE
18	2013/03/20 04	618	112	WSW
19	2010/03/24 20	614	100	W
20	2013/03/21 01	605	158	WNW
21	2013/03/20 03	605	112	WSW
22	2010/03/24 00	601	269	SSW
23	2013/03/14 14	596	100	W
24	2010/03/24 19	596	100	W
25	2010/03/23 23	595	250	SW
26	2013/03/20 05	595	112	WSW
27	2013/03/20 06	592	112	WSW
28	2010/03/24 01	588	316	SSW
29	2010/03/24 21	569	100	W
30	2010/03/31 22	566	224	SSW
31	2012/03/03 17	564	255	SSE
32	2013/03/22 23	562	112	WNW
33	2010/03/23 22	549	250	SW
34	2010/03/31 19	545	400	W
35	2013/03/20 07	533	112	WSW
36	2010/03/25 01	531	100	W
37	2012/03/04 19	528	350	S
38	2013/03/20 08	524	112	WSW
39	2010/03/01 05	524	250	S
40	2013/03/05 20	523	354	S
41	2012/04/25 20	522	316	SSE
42	2013/12/23 02	521	790	SE
43	2011/03/01 09	520	100	W
44	2013/03/21 02	517	112	WNW
45	2011/03/20 04	514	361	SSE
46	2010/03/23 19	514	283	SW
47	2010/03/18 19	514	403	S
48	2013/03/20 23	512	100	W
49	2013/03/23 01	511	250	NW
50	2013/03/14 18	510	150	W

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 27 Top 50 Events for Daily NO_2 predicted Concentrations for Scenario C (2010-2013)

Rank	Date (yyyy/mm/dd)	Concentration (µg/m³)	Distance (m)	Direction
1	2013/03/03	358	71	SW
2	2013/03/04	349	71	SW
3	2010/03/03	339	100	S
4	2013/03/26	334	112	SSW
5	2011/03/24	300	112	SSE
6	2010/03/04	299	100	S
7	2013/03/20	288	158	WSW
8	2013/03/30	286	112	SSE
9	2013/03/02	281	112	SSW
10	2013/03/01	274	158	SSW
11	2010/03/06	273	100	S
12	2010/03/05	268	100	S
13	2013/03/28	264	158	SSE
14	2013/03/27	264	100	S
15	2011/03/30	260	112	SSE
16	2010/01/02	258	181	WSW
17	2011/03/09	254	224	SSE
18	2013/03/25	245	100	S
19	2010/04/19	245	142	SW
20	2010/03/02	242	71	SW
21	2010/03/12	237	180	SSE
22	2012/03/23	235	58	SE
23	2011/03/23	234	100	S
24	2010/12/21	234	142	SW
25	2012/03/28	232	100	S
26	2010/12/14	232	158	WSW
27	2011/03/20	231	292	SSE
28	2010/12/23	230	158	SSW
29	2013/03/29	228	112	SSE
30	2010/12/19	227	112	WSW
31	2010/12/20	226	181	WSW
32	2013/03/05	218	142	SW
33	2010/03/27	217	283	SE
34	2012/04/08	216	112	WSW
35	2010/03/24	210	100	W
36	2011/04/08	205	180	SSE
37	2010/11/01	205	158	SSE
38	2010/04/18	203	181	WSW
39	2011/03/14	202	158	SSE
40	2011/03/25	202	112	SSE
41	2011/10/21	198	112	WSW
42	2010/02/14	197	112	WSW
43	2010/03/01	196	180	SSW
44	2010/02/20	195	181	WSW
45	2013/03/11	195	70	NE
46	2010/12/15	195	158	WSW
47	2012/03/09	194	42	NE
48	2012/04/04	190	206	SSW
49	2013/03/19	189	158	SSE
50	2011/06/19	189	112	WSW

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 28 Top 50 Events for Daily $PM_{2.5}$ predicted Concentrations for Scenario C (2010-2013)

Rank	Date (yyyy/mm/dd)	Concentration (µg/m³)	Distance (m)	Direction
1	2012/03/09	19	42	NE
2	2013/03/03	18	71	SW
3	2013/03/04	18	71	SW
4	2013/03/11	17	42	NE
5	2011/03/06	17	42	NE
6	2010/03/03	16	100	S
7	2013/03/30	15	45	SSE
8	2012/03/08	15	42	NE
9	2012/03/23	15	58	SE
10	2011/03/30	14	45	SSE
11	2010/03/04	14	50	S
12	2013/03/26	14	112	SSW
13	2010/03/06	14	50	S
14	2011/03/24	14	45	SSE
15	2013/03/28	14	45	SSE
16	2011/03/17	14	42	NE
17	2013/03/29	14	45	SSE
18	2012/03/28	14	50	S
19	2013/03/25	13	50	S
20	2013/03/27	13	50	S
21	2011/03/23	13	50	S
22	2013/09/07	13	42	NE
23	2011/03/14	13	34	S
24	2012/04/29	13	42	NE
25	2010/03/02	12	71	SW
26	2010/03/05	12	50	S
27	2011/03/09	12	112	SSE
28	2013/03/02	12	112	SSW
29	2011/03/13	12	42	NE
30	2010/03/12	12	58	SE
31	2012/08/06	12	42	NE
32	2010/07/29	11	42	NE
33	2013/03/19	11	34	S
34	2013/03/20	11	50	W
35	2011/03/19	11	34	S
36	2011/03/25	11	45	SSE
37	2011/09/03	11	42	NE
38	2012/12/24	11	42	NE
39	2012/03/19	11	58	SE
40	2013/03/05	11	71	SW
41	2011/08/25	11	42	NE
42	2010/12/19	10	112	WSW
43	2012/03/30	10	42	NE
44	2012/11/13	10	42	NE
45	2013/08/22	10	42	NE
46	2013/03/01	10	158	SSW
47	2010/12/14	10	158	WSW
48	2013/09/22	10	42	NE
49	2011/05/24	10	42	NE
50	2012/07/09	10	42	NE

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 29 Top 50 Events for Hourly NO_2 predicted Concentrations for Scenario E (2010-2013)

Rank	Date/Hour (yyyy/mm/dd hh)	Concentration (µg/m³)	Distance (m)	Direction
1	2011/05/25 22	2543	381	SSE
2	2010/12/02 07	2265	381	SSE
3	2010/12/02 06	2225	381	SSE
4	2012/01/28 00	1724	381	SSE
5	2011/06/06 00	1713	335	SSE
6	2010/12/02 04	1706	316	SSE
7	2011/05/26 03	1627	447	SSE
8	2012/07/18 03	1593	269	SSE
9	2010/12/02 05	1581	381	SSE
10	2012/01/27 23	1530	335	SSE
11	2011/06/07 03	1479	269	SSE
12	2012/04/25 21	1439	316	SSE
13	2011/06/06 02	1422	316	SSE
14	2010/01/05 02	1404	100	W
15	2013/02/17 05	1397	364	SSE
16	2012/01/13 13	1387	100	W
17	2012/12/22 22	1384	100	W
18	2010/12/06 19	1382	112	WNW
19	2012/12/09 11	1376	100	W
20	2010/12/02 03	1371	200	S
21	2013/03/22 22	1368	112	WNW
22	2012/04/25 20	1366	316	SSE
23	2010/12/16 22	1361	100	W
24	2010/04/10 09	1356	206	SSE
25	2012/01/13 12	1352	100	W

Rank	Date/Hour (yyyy/mm/dd hh)	Concentration (µg/m³)	Distance (m)	Direction
26	2012/01/24 11	1342	150	S
27	2010/01/05 03	1341	100	W
28	2012/06/26 01	1331	316	SSE
29	2011/06/05 23	1318	269	SSE
30	2013/12/18 08	1313	806	ESE
31	2010/12/06 15	1305	100	W
32	2010/07/23 00	1290	269	SSE
33	2013/02/04 16	1286	112	WNW
34	2010/02/17 22	1285	112	WSW
35	2010/12/15 17	1281	112	WSW
36	2010/02/18 01	1280	112	WSW
37	2010/12/06 14	1274	100	W
38	2010/02/18 03	1274	112	WSW
39	2010/02/18 00	1271	112	WSW
40	2012/12/09 13	1265	100	W
41	2010/12/16 23	1263	112	WSW
42	2010/12/20 05	1261	112	WSW
43	2012/12/09 10	1261	100	W
44	2010/02/17 23	1261	112	WSW
45	2010/12/20 04	1261	112	WSW
46	2010/01/02 02	1260	112	WSW
47	2010/12/20 06	1260	112	WSW
48	2010/02/18 02	1256	112	WSW
49	2013/12/21 09	1255	763	ESE
50	2010/02/17 21	1254	112	WSW

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 30 Top 50 Events for Daily NO_2 predicted Concentrations for Scenario E (2010-2013)

Rank	Date (yyyy/mm/dd)	Concentration (µg/m³)	Distance (m)	Direction
1	2010/12/19	936	112	WSW
2	2010/01/02	922	112	WSW
3	2010/12/20	894	112	WSW
4	2010/12/14	823	158	WSW
5	2010/02/20	823	112	WSW
6	2010/12/15	809	158	WSW
7	2010/12/23	781	158	SSW
8	2010/01/03	779	112	WSW
9	2010/12/21	721	142	SW
10	2010/02/21	717	112	WSW
11	2010/02/14	673	112	WSW
12	2013/03/04	670	71	SW
13	2010/04/19	669	142	SW
14	2010/02/17	663	181	WSW
15	2011/01/04	663	112	WSW
16	2010/12/25	623	150	S
17	2013/03/03	619	71	SW
18	2010/03/03	619	150	S
19	2010/12/05	609	158	WSW
20	2013/03/26	601	112	SSW
21	2010/02/18	601	112	WSW
22	2010/12/03	590	181	WSW
23	2010/02/13	586	71	SW
24	2013/03/20	572	112	WSW
25	2010/05/17	570	100	S

Rank	Date (yyyy/mm/dd)	Concentration (µg/m³)	Distance (m)	Direction
26	2010/02/22	544	112	WSW
27	2013/02/21	543	158	SSW
28	2013/03/01	542	158	SSW
29	2010/02/06	542	150	S
30	2011/02/21	542	158	SSE
31	2012/12/05	541	42	NE
32	2011/10/21	539	112	WSW
33	2010/12/24	537	206	SSW
34	2013/03/02	531	112	SSW
35	2010/01/22	530	112	SSE
36	2013/02/12	530	112	WSW
37	2010/04/18	526	181	WSW
38	2010/01/04	524	71	SW
39	2010/12/16	524	112	WSW
40	2012/04/08	523	112	WSW
41	2010/12/26	522	206	SSE
42	2010/03/04	522	150	S
43	2010/12/06	519	100	W
44	2010/12/22	512	71	SW
45	2011/06/19	512	112	WSW
46	2010/01/13	508	158	SSE
47	2012/06/05	503	112	SSW
48	2013/09/07	501	42	NE
49	2012/04/04	500	206	SSW
50	2011/05/24	500	42	NE

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 31 Top 50 Events for Daily $PM_{2.5}$ predicted Concentrations for Scenario E (2010-2013)

Rank	Date (yyyy/mm/dd)	Concentration (µg/m³)	Distance (m)	Direction
1	2012/12/05	37	42	NE
2	2013/09/07	35	42	NE
3	2011/05/24	34	42	NE
4	2012/07/09	33	42	NE
5	2012/04/29	33	42	NE
6	2012/08/06	33	42	NE
7	2011/08/25	32	42	NE
8	2010/07/29	32	42	NE
9	2013/09/22	31	42	NE
10	2013/03/11	30	42	NE
11	2012/11/13	30	42	NE
12	2012/09/26	29	42	NE
13	2012/12/24	29	42	NE
14	2012/11/23	29	42	NE
15	2010/06/08	28	42	NE
16	2011/09/03	28	42	NE
17	2011/04/18	28	42	NE
18	2010/11/06	28	42	NE
19	2011/03/06	28	42	NE
20	2013/08/22	28	42	NE
21	2013/09/05	28	42	NE
22	2013/11/24	27	42	NE
23	2012/03/09	27	42	NE
24	2011/05/23	27	42	NE
25	2011/04/11	27	42	NE
26	2010/01/02	26	112	WSW
27	2011/08/14	26	42	NE
28	2013/03/04	26	71	SW
29	2010/12/09	26	42	NE
30	2012/07/23	26	42	NE
31	2012/09/13	25	42	NE
32	2010/08/07	25	42	NE
33	2010/12/19	25	112	WSW
34	2010/04/11	25	42	NE
35	2013/02/01	25	42	NE
36	2013/03/03	25	71	SW
37	2011/12/04	24	42	NE
38	2012/07/08	24	42	NE
39	2013/08/11	24	42	NE
40	2011/03/17	24	42	NE
41	2010/12/20	24	112	WSW
42	2013/07/03	23	42	NE
43	2010/12/14	23	158	WSW
44	2010/06/14	23	42	NE
45	2010/12/21	23	71	SW
46	2012/07/12	23	42	NE
47	2010/08/29	23	42	NE
48	2012/08/28	23	42	NE
49	2012/03/08	23	42	NE
50	2010/05/17	23	50	S

Note: The distance and direction for the maximum concentration for the event is taken from the plant center.

Table 32 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario A (current condition)

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	2.9	2.8	2.9	2.8	2.9	900
	3h	2.4	2.5	2.7	2.5	2.7	600
	24 h	1.8	1.8	2.1	1.9	2.1	300
	Annual	0.25	0.26	0.33	0.30	0.33	60
CO	1h	781	784	790	787	790	35,000
	8 h	704	699	726	683	726	15,000
PM_t	1 h	98	98	102	98	102	n/a
	24 h	66	70	79	71	79	120
	Annual	9.5	10	13	12	13	60
PM_{10}	1h	79	78	81	79	81	n/a
	24 h	53	56	63	57	63	50
	Annual	7.6	8.2	10	9.4	10	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

Table 33 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario A (with replacement)

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	3.1	3.0	3.2	3.0	3.2	900
	3h	2.6	2.7	3.0	2.7	3.0	600
	24 h	1.9	1.9	2.1	2.0	2.1	300
	Annual	0.24	0.27	0.33	0.31	0.33	60
CO	1h	749	746	749	745	749	35,000
	8 h	658	654	685	658	685	15,000
PM_t	1 h	120	123	125	120	125	n/a
	24 h	80	86	95	85	95	120
	Annual	10.6	12	14	13.5	14	60
PM_{10}	1h	96	98	100	96	100	n/a
	24 h	64	69	76	68	76	50
	Annual	8.5	9.4	12	10.8	12	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

Table 34 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario B

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	1.5	1.6	1.6	1.5	1.6	900
	3h	1.3	1.4	1.5	1.4	1.5	600
	24 h	1.0	1.0	1.1	1.0	1.1	300
	Annual	0.10	0.12	0.15	0.14	0.15	60
CO	1h	406	411	408	412	412	35,000
	8 h	350	371	360	362	371	15,000
PM_t	1 h	62	65	66	65	66	n/a
	24 h	40	45	50	43	50	120
	Annual	4.7	5.5	6.8	6.3	6.8	60
PM_{10}	1h	49	52	53	52	53	n/a
	24 h	32	36	40	35	40	50
	Annual	3.8	4.4	5.4	5.1	5.4	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

Table 35 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario C

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	0.62	0.66	0.68	0.61	0.68	900
	3h	0.54	0.62	0.61	0.57	0.62	600
	24 h	0.38	0.43	0.44	0.44	0.44	300
	Annual	0.03	0.04	0.05	0.05	0.05	60
CO	1h	128	171	173	151	173	35,000
	8 h	121	145	135	128	145	15,000
PM_t	1 h	25	33	32	29	33	n/a
	24 h	18	18	19	23	23	120
	Annual	1.2	1.5	1.8	1.7	1.8	60
PM_{10}	1h	20	27	26	23	27	n/a
	24 h	15	14	15	19	19	50
	Annual	1.0	1.2	1.5	1.3	1.5	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

Table 36 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario D

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	1.5	1.6	1.6	1.5	1.6	900
	3h	1.3	1.4	1.5	1.4	1.5	600
	24 h	1.0	1.0	1.1	1.0	1.1	300
	Annual	0.10	0.12	0.15	0.14	0.15	60
CO	1h	395	397	395	396	397	35,000
	8 h	338	349	347	353	353	15,000
PM_t	1 h	57	58	59	58	59	n/a
	24 h	37	42	43	40	43	120
	Annual	4.5	5.2	6.4	6.0	6.4	60
PM_{10}	1h	46	46	47	46	47	n/a
	24 h	30	34	35	32	35	50
	Annual	3.6	4.1	5.1	4.8	5.1	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

Table 37 Summary of Maximum Predicted Concentrations of other Contaminants over all Receptors for the LAL DGS – Scenario E

Pollutant	Period	2010 (µg/m³)	2011 (µg/m³)	2012 (µg/m³)	2013 (µg/m³)	Maximum (µg/m³)	AAQS (µg/m³)
SO_2	1 h	1.5	1.6	1.6	1.5	1.6	900
	3h	1.3	1.4	1.5	1.4	1.5	600
	24 h	1.0	1.0	1.1	1.0	1.1	300
	Annual	0.10	0.12	0.15	0.14	0.15	60
CO	1h	388	390	387	388	390	35,000
	8 h	331	341	340	344	344	15,000
PMt	1 h	56	57	58	57	58	n/a
	24 h	37	42	43	40	43	120
	Annual	4.5	5.1	6.3	5.9	6.3	60
PM_{10}	1h	45	46	47	46	47	n/a
	24 h	29	33	34	32	34	50
	Annual	3.6	4.1	5.1	4.7	5.1	n/a

Notes: Compliance to AAQS is based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums per receptor on an annual basis. Maximums do not necessarily occur at the same time or at the same receptor.

5 CONCLUSIONS

As part of the registration and approval process, air dispersion modelling using the CALPUFF modelling system was performed for several air contaminants (SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$) resulting from the operation of the LAL DGS under various plant configurations and power production scenarios (with and without transmission from Hydro-Quebec), to evaluate the impacts on local air quality in relation with NL Ambient Air Quality Standards (AAQS). A total of six air dispersion modelling scenarios were evaluated in this study, identified as A (current condition), A (replacement condition), B, C, D and E, for the four year period between 2010 and 2013 inclusively. Only Scenario C considered power transmission from Hydro-Quebec.

The most significant impacts on local air quality are from NO_2 and $PM_{2.5}$. The main findings are:

- Under both Scenario A (current condition) and A (replacing unit 247 with 2091), significant exceedances of all AAQS for NO_2 and $PM_{2.5}$ are predicted for all periods.
- Whether stack heights are raised (Scenario B) and a more environmentally efficient model of engine is also installed (Scenarios D and E), the short-term ground level concentrations for NO_2 and $PM_{2.5}$ still exceed AAQS, but annual NO_2 would be met.
- By considering Hydro-Quebec transmission in Scenario C (normal production with raised stacks), maximum predicted ground level concentrations decrease significantly and $PM_{2.5}$ AAQS would be met. However, for NO_2, exceedances are still predicted for hourly and daily concentrations, despite being significantly lower than with the other scenarios. Non-compliance with the hourly NO_2 AAQS is predicted between 0.18% and 0.73% of the time on an annual basis (16 to 64 hours) and non compliance with the daily NO_2 AAQS is predicted three out of four years, with an exceedance frequency of up to 2.2% (8 days per year). The non-compliance area ranges from the plant boundary up to 400 m away under the worst case meteorological conditions.
- For the worst case production scenario, without Hydro-Quebec power transmission, with raised stacks and new engine with a DFP (Scenario E), the LAL DGS would not be compliant with the daily $PM_{2.5}$ AAQS 1.1 % to 2.7% of the time (4 to 10 days per year). Non-compliance with the hourly and daily NO_2 AAQS frequencies would be in the 49% to 55% range somewhere in the modelling domain. The non-compliance area ranges from the plant boundary up to 1.5 km away under the worst case meteorological conditions.

Finally, Table 38 presents a summary of maximum predicted concentrations for the current plant configuration (Scenario A – current condition) and the proposed upgrade (Scenario E) under worst case operating conditions. With the proposed upgrade, maximum predicted concentrations are about 50% lower than for the current configuration for SO_2, CO and particulates of various sizes. For NO_2, the reduction varies between 10% and 50% depending on the averaging period.

Finally, to achieve the most meaningful reduction to air quality impacts, following the plant upgrade, it would be preferable to use the most modern units (units 2082 and 2091) as a priority and restrict the use of older units when possible.

Table 38 Summary of Air Dispersion Modelling Results - Existing Plant Configuration versus Proposed Upgrade

Pollutant	Period	Scenario A: Current Configuration (µg/m^3)	Scenario E: Exhaust Gas Treatment (µg/m^3)	Total Decrease in Ground Level Concentration (µg/m^3)	Percent Reduction
NO_2	1 Hour	1,601	1,262	339	21%
	24 Hour	1035	923	112	11%
	Annual	149	71	78	52%
SO_2	1 Hour	2.9	1.6	1.3	45%
	3 Hour	2.7	1.5	1.2	44%
	24 Hour	2.1	1.1	1.0	48%
	Annual	0.33	0.15	0.18	55%
CO	1 Hour	790	390	400	51%
	8 Hour	726	344	382	53%
PM_t	24 Hour	79	43	36	46%
	Annual	13	6.3	6.7	52%
PM_{10}	24 Hour	63	34	29	46%
$PM_{2.5}$	24 Hour	61	33	28	46%
	Annual	9.7	4.9	4.8	49%

Note: the values represented in Table 30 represent all generating units running under worst case operating conditions

6 REFERENCES

DOEC, 2012a, *Guideline for Plume Dispersion Modelling,* GD-PPD-019.2, Newfoundland & Labrador Department of Environment & Conservation.

DOEC, 2012b, *Determination of Compliance with the Ambient Air Quality Standards,* GD-PPD-009.4*,* Newfoundland & Labrador Department of Environment & Conservation.

EarthTech, 2000a, *A User's Guide for the CALMET Meteorological Model*, EarthTech, January 2000.

EarthTech, 2000b, *A User's Guide for the CALPUFF Dispersion Model*, EarthTech, January 2000.

Environment Canada, 2011. *Sea Ice Climatic Atlas for the East Coast 1981-2010*. Canadian Ice Service, http://ec.gc.ca/Publications/default.asp?lang=En&xml=8DFED3F9-4BD6-49F3-9ACA-F9AA9F52A96D

Newfoundland & Labrador Regulation. *Air Pollution Control Regulations, 2004.* St. John's, NL.

US-EPA, 1995, *AP-42 - Compilation of Air Pollutant Emission Factors, Section 3.4: Large Stationary Diesel and All Stationary Dual-fuel Engines,* Office of Air Quality Planning and Standards.

SNC·LAVALIN

1133 Topsail Road
Mount Pearl, NL A1N 5G2
(709) 368-0118 - (709) 368-0158
www.snclavalin.com