NAT3 GP Inc.
JENNER 20MW POWER FACILITY
EPEA APPLICATION

DISPERSION MODELLING SUMMARY REPORT

LSD 09-19-020-08 W4M

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APPENDICES

1. Introduction

NAT3 GP Inc. (NAT3) will own and operate the proposed 20MW Jenner Power Plant (Power Plant) located at LSD 09-19-020-08 W4 near Jenner, AB. An application under *Environmental Protection and Enhancement Act* (EPEA) and Alberta Utilities Commission (AUC) License Rule 007 are being submitted for approval of the proposed power plant.

Air Dispersion Modelling was performed, considering all equipment operating on site which emits nitrogen dioxide (NO_2) to determine the effect of the facility's operations on the environment and public health.

1.1 Process Description

The facility is a power generating station using natural gas to fire internal-combustion generator sets (gensets). Natural gas from a high pressure pipeline is depressured and distributed to 10 gensets, each generating 2 MW. The gas from the pipeline is heated to combustion temperature in a glycol line heater. The number of gensets and the individual load are controlled based on the desired power to be generated and sent to the local power grid. Normal capacity is 10 MW and maximum capacity is 20 MW. Lube oil is stored in bulk containers for operation and additional oil will be brought in at the time of servicing the equipment to minimize bulk storage. Aerial coolers will manage heat rejection from the gensets. The gensets are "lean-burn" and NO_x is managed through the use of selective catalytic reduction (SCR) units. The SCR units use a urea solution (32.5% solution dissolved within deionized water) as a reductant, converting residual NO_x into N_2 to meet the Alberta Ambient Air Quality Objectives (AAAQO). The urea solution is stored on-site within the facility and injected into the exhaust streams. The possibility of an upset during normal operation is highly unlikely.

2. Methodology

An air dispersion modeling study of NO_X was conducted in accordance with the most recent edition of Alberta Environment and Sustainable Resource Development's (AESRD) "*Air Quality Model Guideline*" (AQMG) (AESRD, October 2013). AERMOD, the United States Environmental Protection Agency's (US EPA) air dispersion model (ISC-AERMOD View Version 8.8.9), which is also the model recommended by AEP (AESRD, 2013), was used to assess the impact of the Power Plant on the environment and public health through the determination of ground level concentrations (AESRD, 2013).

There are ten (10) sources of mono-nitrogen oxides (NO_X emissions) on site, which consists of ten (10) 2MW electric generators for main power generation, all supplied by Cummins. NO_x emissions are subsequently converted to NO_2 emissions.

NO_2 emissions are regulated by Alberta Environment and Parks (AEP) and must comply with the Alberta Ambient Air Quality Objectives (AAAQOs) (AESRD, 2013).

The maximum predicted ground level concentrations of NO_2 at the Power Plant were compared to the AAAQOs to ensure compliance as well as protection of the environment and public health.

3. NO_x to NO_2 Conversion

Nitrogen oxides are composed of nitric oxide (NO) and nitrogen dioxide (NO_2), where the majority is usually NO. Once released to the atmosphere, the NO can react with ozone (O_3) to produce NO_2 as seen in the following formula:

$$NO + O_3 \rightarrow NO_2 + O_2$$

NO_2 is more toxic than NO and can react with water to form nitric acid (HNO_3) which contributes to acid rain. Therefore, AEP has strict regulations on NO_2 ground level concentrations. AERMOD provides results for NO_x ground concentrations and not NO_2 concentrations. The NO_2 concentration can be calculated from the NO_x concentration using the following methods in a tiered approach:

1. Total Conversion Method
2. Ozone Limiting Method
3. Plume Volume Molar Ratio Method
4. Ambient Ratio Method

These method are described in more detail below.

The total conversion method assumes that 100% of NO_x is converted into NO_2 and the model results can be directly compared to the AEP air guidelines.

Total Conversion Method was used to run this model.

The ozone limiting method is based on the above chemical formula which converts nitrogen oxide to nitrogen dioxide. For the ozone limiting method, if the ozone concentration is greater than 90% of the NO_x concentration, then it is assumed that all of the NO_x is converted into NO_2. Otherwise, the concentration of NO_2 is determined by assuming 100% ozone conversion and 10% of the emitted NO_x is NO_2. The following formula is used to calculate the NO_2 concentration:

$$[NO_2] = [O_3] + 0.1 * [NO_X]$$

AEP provides an ozone time-series that can be inputted into AERMOD when on-site ozone data is unavailable. This time-series is provided in Appendix E of the AQMG (AESRD, 2013) and was used in this model.
AEP recommends using the Total Conversion Method first and then applying the Ozone Limiting Method only where the calculated NO_2 concentrations exceed the AAAQOs.

PVMRM limits the conversion of NO to NO_2 based on the amount of ozone available within the volume of the plume. The NO_2 to NOx conversion ratio is therefore linked with the dispersion of the plume. PVMRM also incorporates a technique for merging plumes from nearby sources when calculating the NO_2 to NOx ratios (Hanrahan, 1999 a, b) (Alaska Department of Environmental Conservation, 2005).

4. Alberta Ambient Air Quality Objectives (AAAQO)

The Alberta Ambient Air Quality Objectives for NO_2 are shown in Table 1

Table 1: Alberta Ambient Air Quality Objective for NO_2

Averaging Period	Maximum Ground Concentration ($\mu g/m^3$)
1 hour	300
Annual	45

5. Emission Sources and Parameters

5.1. NO_X Emissions – Normal Operation

Table 2 shows the continuous NO_X emission sources and the dispersion parameters identified in the dispersion modeling study.

Table 2: Site Source Parameters (NO_x)

Source IDs	G01-G10
Source Description	Main Power Generator Units
Make/Model	Cummins - C2000 N6C
X Coordinates (m E)	G01 – 493508.64 G02 – 493513.64 G03 – 493518.64 G04 – 493523.64 G05 – 493528.64 G06 – 493533.64 G07 – 493538.64 G08 – 493543.64 G09 – 493548.64 G10 – 493553.64
Y Coordinates (m N)	G01-10 - 5617817.18
Base Elevation (m)	G01 – 733.7 G02 – 733.66 G03 – 733.62 G04 – 733.58 G05 – 733.56 G06 – 733.65 G07 – 733.73 G08 – 733.82 G09 – 733.9 G10 – 733.99
Stack Height (m)	8.5
Stack Diameter (m)	0.438
Emission Rate (g/s)	0.07
Exit Temperature (K)	731.5
Exit Velocity (m/s)	44.8

6. AERMOD Model

AERMOD is a multi-source Gaussian model capable of predicting long term as well as short term concentrations arising from a point, area and/or volume source. In line with recommended practice by AEP, Gemini utilized the US EPA model AERMOD (The American Meteorological Society (AMS)/EPA Regulatory Model) to predict the impacts of the applicable pollutant release i.e. NO_2 emissions. AERMOD dispersion modeling provides a means of calculating the maximum predicted ground level concentrations of an emitting substance given the emission rate and the local atmospheric and topographic conditions.

6.1. Selected Options

6.1.1. Terrain and Receptor Placing

The plant is located at LSD 09-19-020-8 W4M. The Universal Transverse Mercator (UTM) coordinate system was used to specify model object sources, buildings and receptors. All coordinates were defined in the North American Datum of 1983 (NAD 83). Digital terrain data was obtained from Shuttle Radar Topography Mission (SRTM3) data set N50W112 was assigned to the receptors.

Receptors were positioned based on recommendations provided in Section 3.5 of the AQMG (October, 2013). Specifically, a multi-tier receptor grid with the grid origin centered at the centre of the sources polygon (UTM 4953531.14 E, 5617809.01 N) was spaced as follows to ensure the maximum concentrations have been identified in the area of influence:

- 20-m receptor spacing in the general area of maximum impact and the property boundary,
- 50-m receptor spacing within 0.5 km from the source,
- 250-m receptor spacing within 2 km from the sources of interest,
- 500-m spacing within 5 km from the sources of interest, and
- 1000-m spacing beyond 5 km.

6.1.2. Meteorological Data

Meteorological data for a 5 year period from 2002-2006 was obtained for use in AERMET using the Multi-Model Extraction Utility (MMEU) extraction software. See Appendix A for Cumulative 5-Year Wind Rose 2002-2006. Surface characteristics based on land use were determined for a 3 km radius of the site. Based on the land use a representative value for surface roughness, Bowen ration and Albedo was chosen for each season using the tables in Section 3.3 of the AQMG (October, 2013).

6.1.3. On-Site Buildings

When air flows over buildings and other structures, such as tanks, turbulent eddies are formed on the downwind side of the building or structure, potentially forcing emission plumes down to the ground. There is 1 building included in the model within the facility's plant boundary. Building wake effects were considered in this assessment using the US EPA's Building Profile Input Program (BPIP-PRIME), a pre-processor to AERMOD. The inputs into this pre-processor include the coordinates and heights of the buildings and stacks. The output data from BPIP is used in the AERMOD building wake effect calculations. Table 3 lists the dimensions of all applicable buildings and other significant structures.

A detailed plot plant is presented in Appendix B.

Table 3: Building Heights

Building Name	Building Height (m)
Process Building	8

6.2. Modeling Scenarios

These scenario run for the Power Plant is described below

Scenario 1: Maximum Operating Conditions – during this scenario, continuous NO_x emissions from all applicable sources were considered in the model. However, a normal operating scenario for this facility will be 5 units 24 hours a day, 7 days a week 365 days a year. All 10 units will only be running 75% of the time.

7. Background Concentrations

7.1. Natural Background

Natural background pollutant values are were added to the dispersion model and are described below. AEMERA provides hourly data of the concentrations of NO_x at various monitoring stations throughout Alberta (AEMERA, 2015). The Crescent Heights monitoring station is the closest continuous monitoring station to the site that monitors NO_2. Table 4 summarizes the background concentrations for NO_2 obtained from the Crescent Heights station. These values were incorporated into the dispersion model to produce the final results.

Table 4: Background Continuous Concentration for NO_2 from Crescent Heights Station

Pollutant	Period		99th % Concentrations (ppm)	99th % Concentrations ($\mu g/m^3$)
	From	To		
NO_2	January 1, 2015	November 30, 2015	0.004993	9.39

7.2. Industrial Background

A search was performed for any background industrial sources within 5 km of the Power Plant using AbaData. There were a number of facilities identified within this radius. However, the NOx sources associated with the majority of these facilities have not been included in the air model as they do not meet the 16 kg/hr threshold set out by AEP to require NOx reporting. One facility identified triggered the requirement to be included in the model. Details of the equipment included for the TransCanada Compressor station located at 15-18-020-08 W4 can be referenced in Table 5 below. Information from the data sheet on file at AEP for this facility was referenced to determine the parameters used in this model as shown in Table 5 below.

Table 5: Industrial Background – TransCanada Compressor Station

Source ID	Stack Height (m)	Stack ID (m)	Exit Velocity (m/s)	Emission Rate (g/s)	Exit Temperature (K)
19MWCMP	18.3	3.125	54.4	17.2	729.15

At this facility there are also two small gas-fired boilers. Although these would be sources of NOx, the boilers have not been included in the model or overall results as they were deemed to be insignificant. Although requested, there was no equipment specific information from authorizations (AEP) or the operator available prior to running this model. EPA guidelines were referenced to make assumptions in determining that the NOx emissions of these units are

insignificant (~0.004 g/s emission rate) in relation to the equipment noted above and overall emissions from this facility.

8. Dispersion Modeling Results

8.1. Maximum Operation – Scenario 1

Table 5 summarizes the AERMOD results for the maximum predicted ground level concentration of NO_2 using the Total Conversion Method. Conversion of NO_x to NO_2 concentrations was performed according to the AQMG (AESRD, October 2013) and is explained in more detail in Section 3. Due to extreme and rare weather conditions, AESRD advises disregarding the eight highest 1-hour predicted concentrations for each year (AESRD, 2013). For this reason, the 99.9th percentile 1-hour concentration results are presented in Table 6.

Table 6: AERMOD Model Results for NO_2 with Background

NO_X, NO_2	**AERMOD Results**	**AAAQO**
99.9th Percentile Hourly NO_2 (µg/m^3) – Total Conversion	**137**	**300**
Maximum Annual NO_2 (µg/m^3) – Total Conversion	**22**	**45**

The predicted ground level NO_2 concentration for the 1-hr and annual averaging times under normal operating conditions are presented in the contour plots attached as Appendix C. Based on the above information, it can be stated with confidence that under normal operating conditions the predicted 1-hour and annual NO_2 concentrations outside the plant boundary meet the AAAQO.

9. Conclusion

Based on the results from the AERMOD study, the NAT3 Power Plant complies with the AEP guidelines for NO_2 during *Maximum* Operation and therefore will be compliant during other operational scenarios while fewer units are running as described in 6.2 above.

10. References

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