MODIFIED OPERATION OF DIESEL GENERATORS AT THE HOLYROOD THERMAL GENERATING STATION

Environmental Assessment Registration
Pursuant to the Newfoundland and Labrador *Environmental Protection Act*

Submitted by Newfoundland and Labrador Hydro
May 2017

newfoundland labrador hydro
a nalcor energy company

Modified Operation of Diesel Generators at the Holyrood Thermal Generating Station

Environmental Assessment Registration

Pursuant to the Newfoundland & Labrador *Environmental Protection Act* (Part X)

Submitted by:

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May 2017

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1.0 INTRODUCTION

PROJECT NAME: Modified Operation of Diesel Generators at the Holyrood Thermal Generating Station

1.1 Nature of the Undertaking

Newfoundland and Labrador Hydro – A Nalcor Energy Company (NL Hydro) is proposing to modify the operation of six – 1.825 megawatt (MW) diesel generators that are presently in service at the Holyrood Thermal Generating Station (HTGS), in Holyrood, NL, Figure 1.1. These generators were originally installed in January 2014 for the purpose of providing black start power for the HTGS. Black start power refers to that required to start the HTGS in a power outage situation, when the HTGS is out of service and the transmission line grid connection is not available with sufficient capacity to provide the necessary energy to start the HTGS to a point where it can operate independently. These generators were subsequently used in helping alleviate power availability issues on the Avalon Peninsula during the winter of 2016. This Project will improve the capability to operate these diesel generators as part of the Island Interconnected System (IIS), if required to meet load requirements during peak demand and possible contingency situations, in addition to continued use for HTGS black start capability.

The six diesel generators are each housed within individual mobile trailer enclosures on the HTGS site, Figure 1.2. As the diesel generator units are already in place and operational for black start requirements at the HTGS, the changes required in order to improve the availability and reliability of this system for IIS production are relatively minor in scope. The specific changes include adding new exhaust stacks on each generator and connecting the generators to a new diesel fuel storage tank to be erected near the generators.

Figure 1.1 Location of Holyrood Thermal Generating Station

Figure 1.2 Photograph of Mobile Trailers Housing Six – 1.825 MW Diesel Generators at the Holyrood Thermal Generating Station

1.2 Purpose of the EA Registration

The proposed Project is subject to Part 10 of the Newfoundland and Labrador *Environmental Protection Act* and the associated *Environmental Assessment Regulations*. This document is intended to initiate the provincial environmental assessment (EA) review, and in doing so it:

- Identifies the Project's proponent and describes its goals, core values, and environmental management approaches and procedures;
- Describes the proposed Project, including its overall purpose and rationale, as well as its key components and planned construction and operational activities;
- Describes Project-related consultation activities undertaken by NL Hydro and the main findings; and

- Provides an overview of the existing environmental setting for the Project, some of the potential environmental considerations that have been identified to date, and NL Hydro's planned approaches for addressing these in moving forward with Project planning and eventual implementation.

This *EA Registration* document has been prepared and submitted by NL Hydro, with assistance from Amec Foster Wheeler Environment and Infrastructure.

1.3 The Proponent

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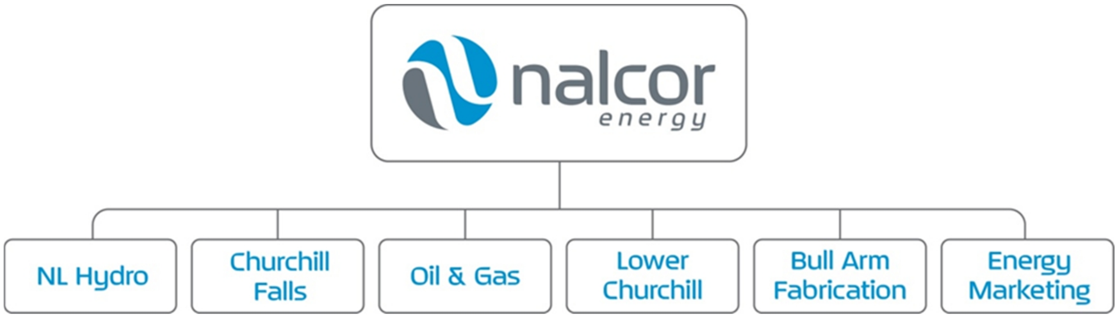
Newfoundland and Labrador has an immense and diverse energy warehouse. In 2007, guided by a long-term *Energy Plan* to manage these energy resources, the Government of Newfoundland and Labrador created a new provincial energy corporation - Nalcor Energy - whose vision is to build a strong economic future for successive generations of Newfoundlanders and Labradorians. The corporation currently has six lines of business (Figure 1.3):

Figure 1.3 Nalcor Energy Organizational Structure



NL Hydro is the Proponent of the proposed Modified Operation of Diesel Generators at the HTGS Project, and is the primary generator of electricity in the province. With an installed generating capacity of 1,769.6 MW, the company generates and transmits over 80 percent of the electrical energy that is used by Newfoundlanders and Labradorians, most of which is comprised of clean, hydroelectric generation.

NL Hydro is committed to delivering safe, reliable, least-cost power to industrial, utility and over 38,000 direct customers in 200 communities in rural Newfoundland and Labrador, and has been doing so for more than 50 years. NL Hydro's regulated assets include nine hydroelectric generating stations (959 MW), one oil-fired plant (490 MW), four combustion turbines (250.5 MW), and 25 diesel plants (70.1 MW), and the company also maintains 54 high-voltage terminal stations, 25 lower-voltage interconnected distribution stations, and thousands of kilometres of transmission and distribution lines throughout the province.

NL Hydro is focused on long-term strategic capital planning to ensure an on-going, reliable source of electricity now and for future generations. Its continuous infrastructure upgrades and use of new technology are some of the ways in which the company commits to providing excellent customer service. The utility is fully dedicated to operational excellence and environmentally sound practices while delivering reliable service at the least cost.

Additional information on NL Hydro, including its overall organization, values, priorities and activities, can be found at: *www.nlhydro.com.*

NL Hydro strives to be a leader in environmental protection and sustainability, and is committed to maintaining a high standard of environmental responsibility and performance. NL Hydro has constructed and currently operates an extensive electricity generation and transmission system throughout Newfoundland and Labrador (Figure 1.4). This includes interconnected electrical power systems on the Island and in Labrador, as well as isolated distribution systems in rural areas of the province.

Environmental protection planning is an integral part of NL Hydro's planning, construction, operations and maintenance programs. The corporation has state-of-the-art and proven policies and procedures related to environmental protection and management which will be implemented throughout this

Project. The corporation has an outstanding record of environmental protection and stewardship, and this objective and experience will be applied to the planning and development of this Project to avoid or reduce potential environmental effects during its various phases.

Figure 1.4 Existing Newfoundland and Labrador Generation and Transmission System

1.4 Environmental Assessment Process and Requirements

The Newfoundland and Labrador *Environmental Protection Act* (*NL EPA*) requires anyone who plans a project that could have a significant effect on the natural, social or economic environment (an "Undertaking") to present it for examination through the provincial EA process.

Section 2. (mm) of the *NL EPA* provides the definition of an Undertaking as follows:

> *2. (mm) "undertaking" includes an enterprise, activity, project, structure, work or proposal and a modification, abandonment, demolition, decommissioning, rehabilitation and an extension of them that may, in the opinion of the minister, have a significant environmental effect;*

The associated *Environmental Assessment Regulations* (Part 3) list those projects (potentially including proposed modifications, rehabilitations and extensions of same) that require registration and review.

Section 34 of the *Environmental Assessment Regulations* state that:

> *34. An undertaking that will be engaged in electric power generation and the provision of structures related to that power generation, including:*
>
> *(e) diesel electric power generating plants with a capacity of more than one megawatt;*
>
> *shall be registered.*

The proposed Project involves modified operation of the existing six-1.825 MW diesel generator installation at the HTGS in order to add an additional capacity to the IIS for peaking and emergency power requirements.

Following public and governmental review of this EA Registration, the Minister of Municipal Affairs and Environment will determine whether the Project may proceed, subject to any terms and conditions and other applicable legislation, or whether further assessment is required.

In addition to approvals under the provincial EA process, the Project may also require a number of other authorizations from relevant regulatory authorities. These are identified and discussed further later in this document and in Appendix A.

2.0 PROJECT DESCRIPTION AND SCOPE

The proposed Project will involve the modified operation of six – 1.825 MW diesel generators, presently in place at the HTGS, in order to secure the availability of a portion of that generation capacity for NL Hydro's IIS, if required, in addition to their present utilization for black start capacity for the HTGS. This will add additional reliable capacity to the IIS for peaking power requirements and for emergency power requirements.

The following sections provide a description of the proposed Project, including an overview of the HTGS and the diesel generation component in particular, as well as the Project rationale, alternatives, and the primary components and activities that will be involved in the planned work.

2.1 HTGS Operations

The electrical energy generation located at the HTGS is comprised of three steam turbine generators with overall 490 MW capacity, six diesel generators with overall 11 MW generation capacity, and one combustion turbine generator with 123.5 MW generation capacity.

The steam turbine component of the HTGS generation capacity was installed in two stages. Stage one consisted of two generating units, Units 1 and 2, each capable of producing 150 MW and was placed in service in April 1971. Stage two consisted of one generating unit, Unit 3, capable of producing 150 MW and was placed in service in December 1979. Units 1 and 2 were modified in 1988 and 1989 to increase their output to 170 MW respectively. The HTGS steam turbines generate between 15 and 25 percent of the IIS annual needs and is an integral component in NL Hydro's generation system, and its ability to provide reliable electricity to the Avalon Peninsula.

Eight diesel generation units were installed at the HTGS in January 2014. Two of the generators were removed in 2016. Each of the remaining six units is a Caterpillar XQ 2000 mobile diesel generator and associated equipment, with a prime power genset rating of 1.825 MW. Each unit connects to a step up transformer that converts the power voltage from 480V to 4160V. A 100 m overhead 3 phase distribution line connects the diesel generators to the HTGS's 4160V plant station service system.

The original 14.6 MW diesel generation capability was constructed to replace an aged 14.1 MW combustion turbine that had provided black start capacity at the HTGS since its original operation in 1971. The 14.1 MW combustion turbine unit was no longer available as a result of equipment damage and an engineering assessment had concluded that it was not practical to repair. The engineering assessment had recommended the installation of the eight - 1.825 MW diesel units within the HTGS yard as the preferred option to meet the requirements for black start power. Black start capability means the capability to start the HTGS when all units are out of service (black), and the transmission line grid connection is not available with a sufficient capacity to provide the necessary energy to start HTGS to a point where it can operate independently. Once the HTGS is started and operating independently the black start capability is no longer operated. Black start capability for the HTGS is essential to the reliability of NL Hydro's Island generation system.

As the installation of the 14.6 MW diesel generation capacity for black start requirements replaced an existing 14.1 MW combustion turbine capacity, Section 34 (1e) of the *Environmental Assessment Regulations* requiring registration of new diesel electric power generation of more than one MW was not exceeded and registration as an undertaking under the *Environmental Protection Act* was not required.

The size of the black start capacity, installed in 2014, was based on an assessment of the requirement for start up of a 3000Hp, 4160V boiler feed pump motor, which is present on the boilers of Units 1 and 2 at the HTGS. Unit 3 has a 2500Hp boiler feed pump motor. The assessment indicated that seven of the 1.825 MW diesel generation units were required for starting a 2500Hp motor, while eight units were required for starting a 3000Hp motor. Subsequent to the installation of the eight 1.825 MW diesel units, testing was carried out that proved that only five of the units were required to start the 3000Hp boiler feed pump in Units 1 and 2. Based on this, the number of 1.825 MW diesel units was reduced in 2016 from eight to six units, five used for black start and one spare for backup.

Subsequent to the installation of the black start diesel generation NL Hydro has also installed a new 123.5 MW combustion turbine at the HTGS which is intended to provide additional generation capacity to meet forecasted load requirements during peak winter demand on the IIS. This new 123.5 MW capacity, installed at the HTGS site, was also originally intended to have the capability and capacity to satisfy black start requirements for the HTGS, and allow the decommissioning of the diesel generating units. However, in May, 2016 the Public Utilities Board of Newfoundland and Labrador approved an application by NL Hydro to leave the six diesel generating units in place for continued use for HTGS black start requirements and to provide additional peaking capacity and voltage support for the Avalon Peninsula, and energy for the IIS.

Given that it is now proposed to operate the diesel generating units as a component of NL Hydro's IIS, and not just as a replacement for the black start capacity at the HTGS, NL Hydro is registering the capacity provided by the diesel units as an undertaking pursuant to the *Environmental Protection Act, Part X*.

2.2 Project Purpose, Rationale and Need

NL Hydro's foundation is built on its core business - the generation and transmission of electrical power – and the corporation has a strong commitment to providing safe, reliable and dependable electricity to its utility, industrial, residential and retail customers.

2.2.1 Requirement for Inclusion of Holyrood Diesel Generation in IIS

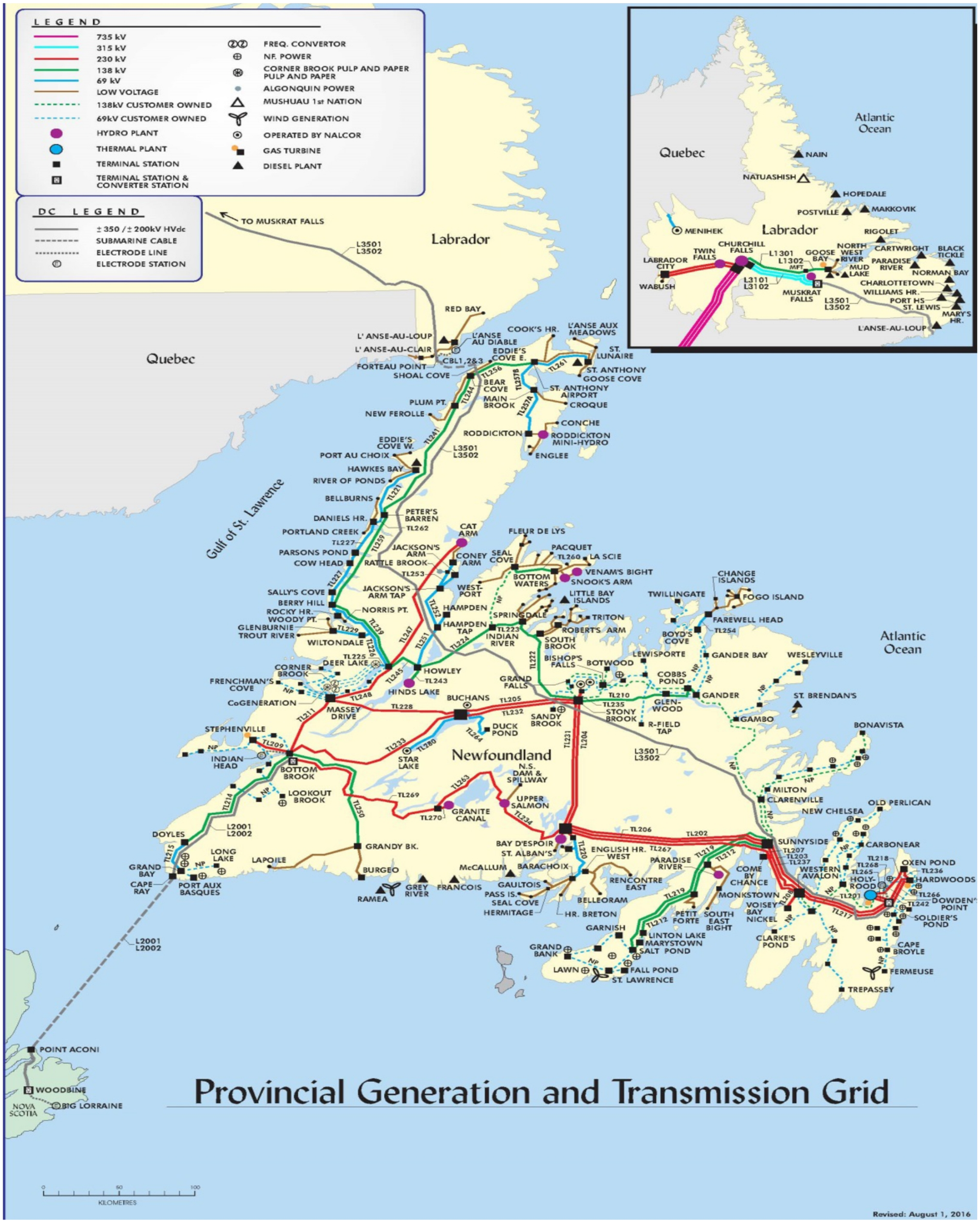
As part of its focus on customer reliability, NL Hydro is continually evaluating its ability to meet peak demand. NL Hydro's *Energy Supply Risk Assessment*, filed with the Public Utilities Board on November 30, 2016 (NL Hydro, 2016), provides a detailed analysis of the likelihood of capacity shortfalls due to average outage rates for generation equipment during periods of extreme cold weather conditions, such as those associated with a P90 forecast. A P90 forecast is one in which the actual peak demand is expected to be below the forecast number 90% of the time and above 10% of the time. A P50 forecast is one in which the actual peak demand is expected to be below the forecast number 50% of the time and above 50% of the time, i.e. the average forecast. NL Hydro bases its generation supply planning decisions on its P90 peak demand forecast in accordance with direction from the Newfoundland and Labrador Public Utilities Board. Due to equipment limitations, a maximum of 10 MW can be transmitted to the IIS from the six-1.825 MW diesel generators at the HTGS. Therefore, 10 MW was included from the Holyrood diesel generators as part of the available IIS generation asset mix during power alert conditions experienced in the winter of 2016, and were included in the *Energy Supply Risk Assessment* analysis (NL Hydro, 2016).

The *Energy Supply Risk Assessment* (NL Hydro, 2016) analysis concluded that, in addition to NL Hydro's installed capacity, which includes the Holyrood diesels, incremental capacity would be required to mitigate expected unserved energy (EUE) in excess of planning criteria for winter 2016-17. As a result, NL Hydro sought and received approval for an additional 10 MW of load curtailment agreements through the winter of 2018. A lack of availability of the Holyrood diesel generators would have further added to the risk of EUE in 2016-17.

The exposure for EUE in excess of planning criteria will be mitigated in future winters by the bringing into service of a new transmission line, TL 267, which is under construction between the Bay d'Espoir Hydroelectric Generating Station and the Western Avalon Terminal Station on the Avalon Peninsula's transmission grid, Figure 2.1. TL 267 is scheduled to be in-service in the fall of 2017 and will significantly increase NL Hydro's capacity to deliver power to the Avalon region. The exposure of EUE will also be subsequently mitigated by the completion of the Labrador Island Link transmission line between Muskrat Falls generating assets, which are under construction, and a new substation under construction at Soldiers Pond, and the Maritime – Island Link between Newfoundland and Nova Scotia, which is also under construction. The changes to NL Hydro's generation and transmission infrastructure resulting from these interconnections are identified in Figure 2.1.

While Holyrood diesel generators have been included as part of the available IIS generation asset mix in the past to supplement Avalon Reserves and generation requirements, the requirement for future operation to support Avalon Reserves will be greatly reduced following TL 267 coming into service. However, the Holyrood diesel generators will continue to play an important role in NL Hydro's fleet by providing operational flexibility and capacity until interconnection is achieved in case of the failure of other generating or transmission assets. While Holyrood diesel generators will help NL Hydro provide reliable service to its customers, NL Hydro does not anticipate having to operate these units continuously. Rather, these units will likely be operated during times of peak demand or equipment failure. Further, given that these are one of NL Hydro's most expensive sources of supply, NL Hydro has no economic incentive to operate these units unless system conditions and customer needs require their operation.

Figure 2.1 NL Hydro's Generation and Transmission Infrastructure After Interconnection with Muskrat Falls



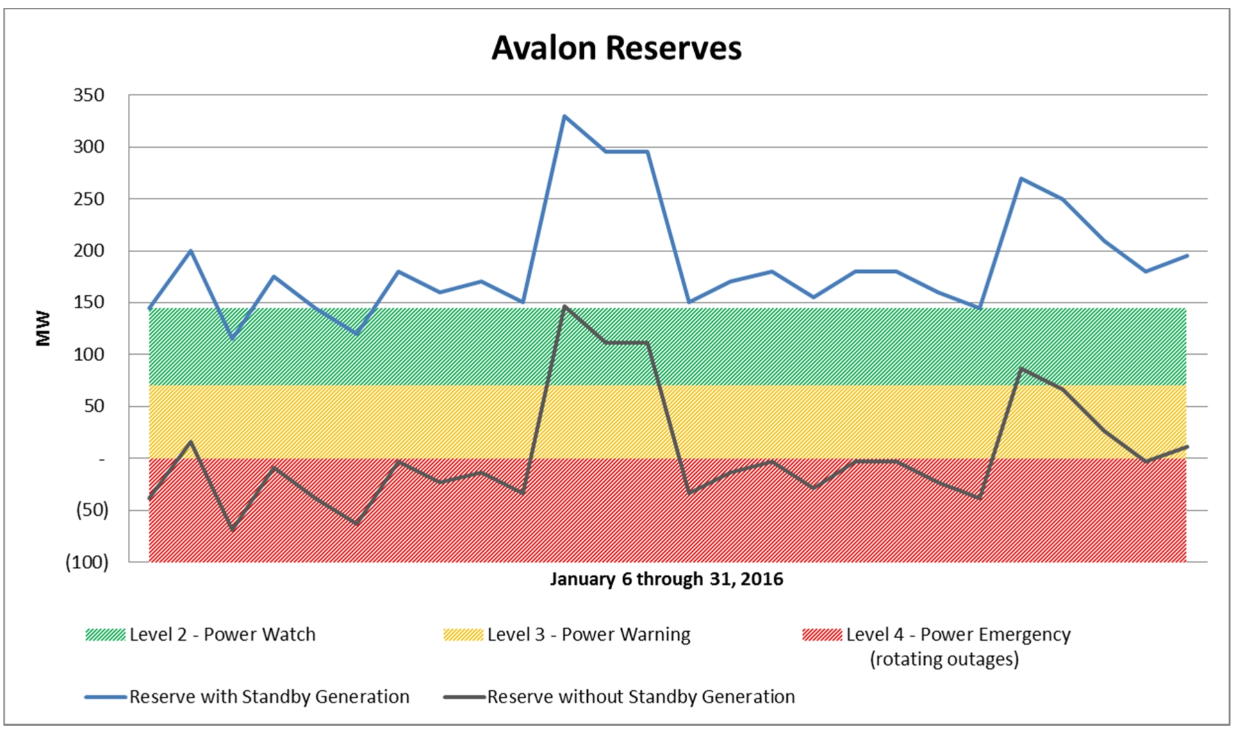
2.2.2 Holyrood Diesel Generation Use for Avalon Energy Reserves

Since system operational upsets in 2015, NL Hydro amended its operational practice regarding the dispatch of standby generation. Specifically, NL Hydro is using increased standby generation and operates its standby generation in the following situations:

1. In advance of single largest contingencies on the Avalon
2. To meet spinning reserves requirements on the Avalon and IIS; and
3. In response to generating unit and transmission line outages.

Standby generating units are placed online to ensure that adequate system capacity is available if needed. A specific example of this occurred in January and February of 2016, when Holyrood Units 1 and 2 were forced out of service, at different times, for urgent boiler tube replacements. During this same timeframe, the Hardwoods Gas Turbine experienced operational issues, including a requirement for an engine replacement. These operational issues increased NL Hydro's requirement to run standby units, including, at times, the Holyrood diesel generators, to ensure energy and reliability for customers. Figure 2.2 illustrates the overall benefit that Avalon Standby Generation provided towards reliable supply on the Avalon Peninsula during January, 2016.

Figure 2.2 Avalon Reserves, January 6-31, 2016



As shown in Figure 2.2**,** if Hydro had not operated NL Hydro's Avalon Standby Generation, which at times included the Holyrood diesel generators, the Avalon Peninsula would have been in a Level 4 Power

Emergency for the majority of January 2016 when there were boiler tube issues at Holyrood and NL Hydro would have worked with Newfoundland Power to institute rolling customer outages on the Avalon Peninsula.

Due to increasing customer demand and equipment issues at the HTGS, there has been a substantial increase in the requirement for standby generation to ensure reliable service for customers on the Avalon. This particularly affected the number of operating hours in which the Holyrood diesel generators were utilized in 2016, resulting in a total of 930 operating hours in that year. This was less the case in 2014, 2015 and 2017, when the total Holyrood diesel generator operating hours were 29, 207, and 272, respectively.

2.2.3 Holyrood Diesel Generation Continued use for HTGS Black Start Requirements

As noted in section 2.1, the HTGS is required to have black start capability in the event of a loss of grid power. The six – 1.825 MW diesel generators were originally intended to provide a black start solution until the new Holyrood Combustion Turbine was fully commissioned, after which it would provide black start, through two connections, a primary and secondary. The secondary connection is the same path used by the diesels to black start the HTGS, and therefore, the diesels would have to be disconnected to test this path. Keeping the diesels in place, there would be no requirement to construct the secondary connection to the Combustion Turbine, resulting in the saving of the cost of that connection. With this proposal, the diesels will remain connected and continue to provide a tested and proven black start solution for the plant.

2.3 Project Planning and Alternatives

The consideration of environmental issues from the earliest stages of project planning and design is an important and integral part of NL Hydro's approach to its development projects and other activities. This approach allows potential environmental interactions to be identified early, so they can be considered and addressed in a proactive manner through appropriate development planning and design. The objective is to attempt to avoid adverse environmental effects where possible and practical, or at least, to put in place appropriate mitigation measures to ensure that these are maintained at acceptable levels.

The six – 1.825 MW diesel generators proposed for utilization for IIS capacity are presently in place at the HTGS and connected to the IIS through the HTGS station service system. As any alternative generation source would require new construction with associated economic and environmental costs, this was not considered a viable alternative. However, consideration has been given to:

- the potential for including additional generation capacity in conjunction with the six – 1.825 MW diesel generators;
- the potential alternatives to utilization of the diesel generators for standby generation requirements; and

- the potential for consumer demand management to reduce or eliminate the peak demand requirements that the diesel generation is intended to satisfy.

2.3.1 Additional Generation Capacity

Eight – 1.825 MW XQ2000 diesel generators were installed at the HTGS in January, 2014 to satisfy black start requirements for the three steam generating units operated at that facility. Testing following initial installation confirmed that black start can be completed with five of the diesel generating units operating. This resulted in a decision to reduce the black start diesel capacity to six units, five for black start requirements plus an additional unit for redundancy and therefore reliability. Six – 1.825 MW diesel generators and associated equipment are presently in place at the HTGS.

The generators provide an on-site black start solution to the plant. While they are capable of sustainably producing up to 11 MW, only 10 MW is available to the IIS due to limitations of the existing station service plant connection. It would require approximately $3 million of modifications at the HTGS to enable any extra supply to the system beyond the existing capability. This was not considered economically viable and is not being pursued by NL Hydro. The use of the Holyrood diesel generators for black start, peaking and emergency back-up will be greatly reduced after construction of TL 267 is completed and the interconnection to Muskrat Falls generation is complete and proven.

2.3.2 Alternatives for Standby Generation

As discussed in Section 2.2.2, NL Hydro currently operates its standby generation to established criteria to help avoid customer outages on the Avalon Peninsula in the event of transmission line or generation contingencies. When the resultant impact of a contingency is expected to be less than 50 MW, NL Hydro operates the Hardwoods Gas Turbine at a minimum loading of 10 MW to be ready to respond to contingencies of up to 50 MW. In the event that the resultant impact of the contingency is expected to be greater than 50 MW, NL Hydro currently operates the Holyrood Combustion Turbine, 123.5 MW capacity, at a minimum output of 40 MW to be able to respond quickly and prevent customer outage in the event of a contingency.

An analysis was completed which indicates that there is a potential fuel savings for the IIS if the black start diesels are part of the dispatch order for Avalon reliability prior to the start-up of the Holyrood Combustion Turbine. This would mean fewer starts for the Combustion Turbine and less run time, as the diesels could be started before the Combustion Turbine. Using the diesels in this capacity could mean a fuel savings. Fuel savings would also result in slightly lower greenhouse gas emissions. Completion of the third line to the Avalon, TL 267, and completion of the interconnection to Labrador will considerably reduce the need for use of the Holyrood diesel generators for standby generation.

2.3.3 Consumer Demand Management (CDM)

In addition to the pursuit of interruptible load arrangements with industrial customers as discussed in section 2.2.1, NL Hydro also reviewed the potential for CDM to meet the capacity.

Capacity and demand reductions are achievable through NL Hydro's existing curtailment programs. Interruptible load arrangements with industrial customers offer an opportunity to reduce system demand by curtailing a customer's load in return for a financial incentive without adversely affecting the customer's operation. However, these arrangements can have limitations in terms of the number of times it can be called upon, the duration of the curtailment, and the time of year it can be called upon. These factors can affect the suitability to NL Hydro in meeting its customers' needs.

CDM also continues to be a component of the supply side equation for NL Hydro. Working through CDM efforts in conjunction with Newfoundland Power, and targeting NL Hydro customers directly, programs have continued to expand and reach new customers with new opportunities to save. The focus to date has been on energy savings and reduction of fuel at the HTGS. The *Newfoundland and Labrador Conservation and Demand Management Potential Study: 2015* (NL Hydro 2015) completed for NL Hydro and Newfoundland Power in 2015, indicated that "demand reduction potential is dominated by the reductions associated with demand response curtailment measure, with much of this potential already in place through existing utility curtailment programs." NL Hydro continues to consult with its industrial customers and Newfoundland Power to determine the potential of securing any incremental load that remains within their systems.

Combined, the CDM and load curtailment programs support both energy and demand reduction, and are considered complementary to the operation of the Holyrood diesel units to better serve and manage the overall system demand. While these options have not been identified as the sole solution, in addition to completion of TL267 and the inclusion of the Holyrood diesels, they continue to be recommended to partially mitigate the risk of EUE.

2.4 Project Components and Lay-out

All electrical components are presently in place to enable utilization of the six – 1.825 MW diesel generating units at the HTGS as part of the IIS in addition to their present utilization for black start capacity. The connection to the IIS will be through the existing connection to the HTGS. Improvements are proposed to exhaust stacks on the diesel units and the fuel storage capacity for this system, as well as the electrical cable housing, as described below, to improve the availability and reliability of the generating units.

The six diesel generators are located wholly on the existing HTGS property. The location of the six diesel generators in relation to other facilities on that property and in relation to the surrounding area is provided in Figure 2.3.

Figure 2.3 Location of the Diesel Generators on the Holyrood Thermal Generating Station Property

The present infrastructure consists of:

- Six Caterpillar XQ 2000 mobile diesel generators;
- Six 2.5 MVA padmount transformers; and
- An overhead distribution line operating at 4,160 V and connecting to the HTGS's station service system through a dedicated breaker.

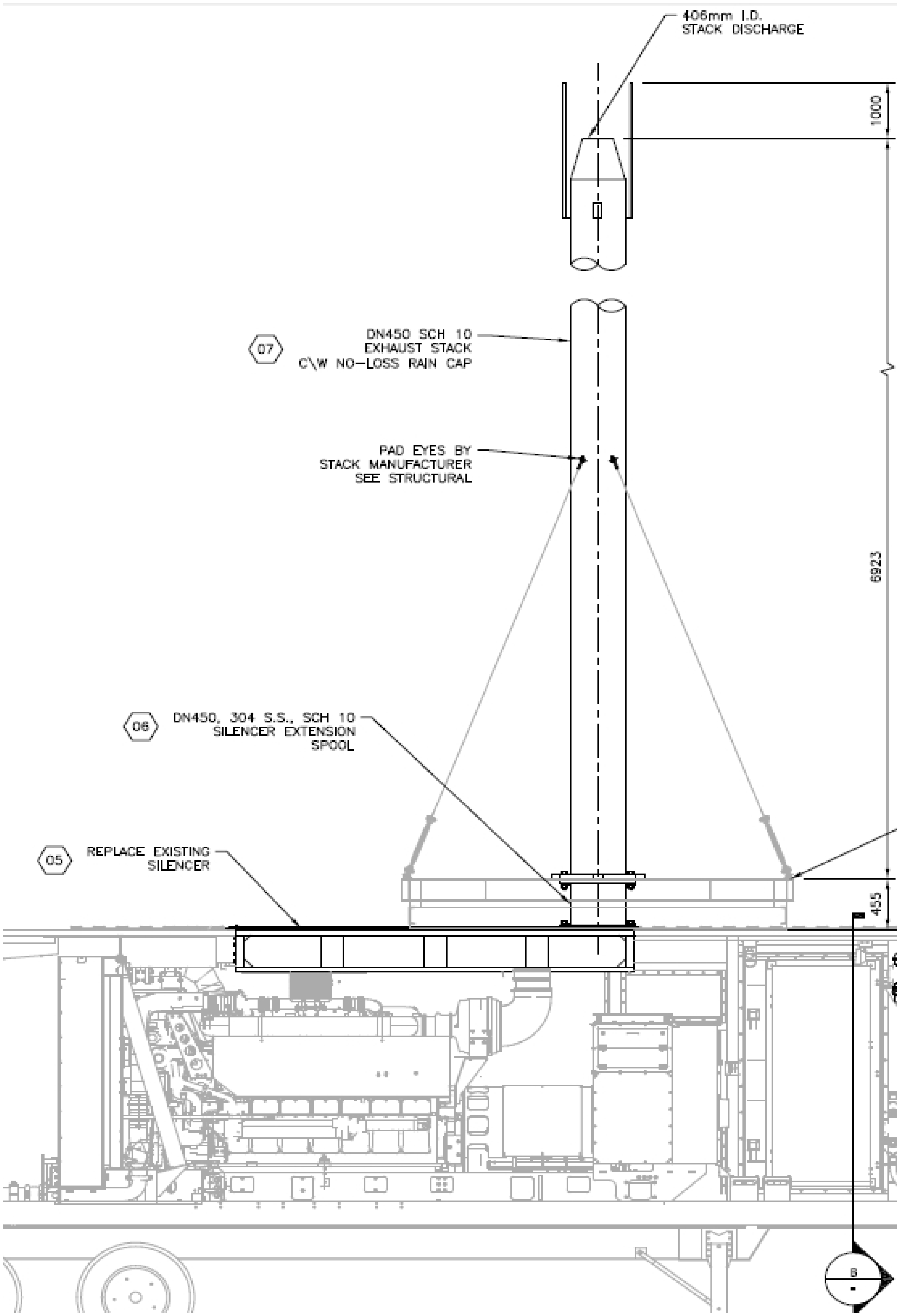
All the generators were manufactured in 2010 and installed at the HTGS in January 2014, but have low operating hours (less than 1500 cumulative for all units to the end of March, 2017). The generators generate at 480 V which is then stepped up to 4,160 V by the six 2.5 MVA padmount transformers

The following changes to the existing infrastructure are proposed as part of this project. These changes address issues that have arisen during the operation of these units that could affect the availability and reliability of the units for inclusion in the IIS capacity.

2.4.1 Exhaust Stacks

The existing engine exhaust discharges to a silencer built into the roof of the mobile trailer, which then discharges to exhaust pipes exiting through a metal grate in the roof of the trailer. This provides for minimal dispersion of exhaust gases during operation of the diesel generators. New stack piping will be connected to add an additional eight meters of stack and enable greater dispersion of exhaust gases released during operation of the diesel units, Figure 2.4. The height of the stack is limited by back pressure in the stack that can affect the efficient operation of the generator. NL Hydro has determined that a maximum stack height of eight meters above the trailer roof can be applied without causing excessive back pressure. The stack will be supported by cables connected to a collar on the stack and to a steel frame to be fabricated and placed on top of the trailer to distribute the load. The existing silencer will also be replaced with a model that has equivalent sound reduction capability, but less back pressure, to allow for maximizing the stack height to eight meters to enhance exhaust gas dispersion.

Figure 2.4 Proposed Exhaust Stack Addition



2.4.2 Fuel Storage

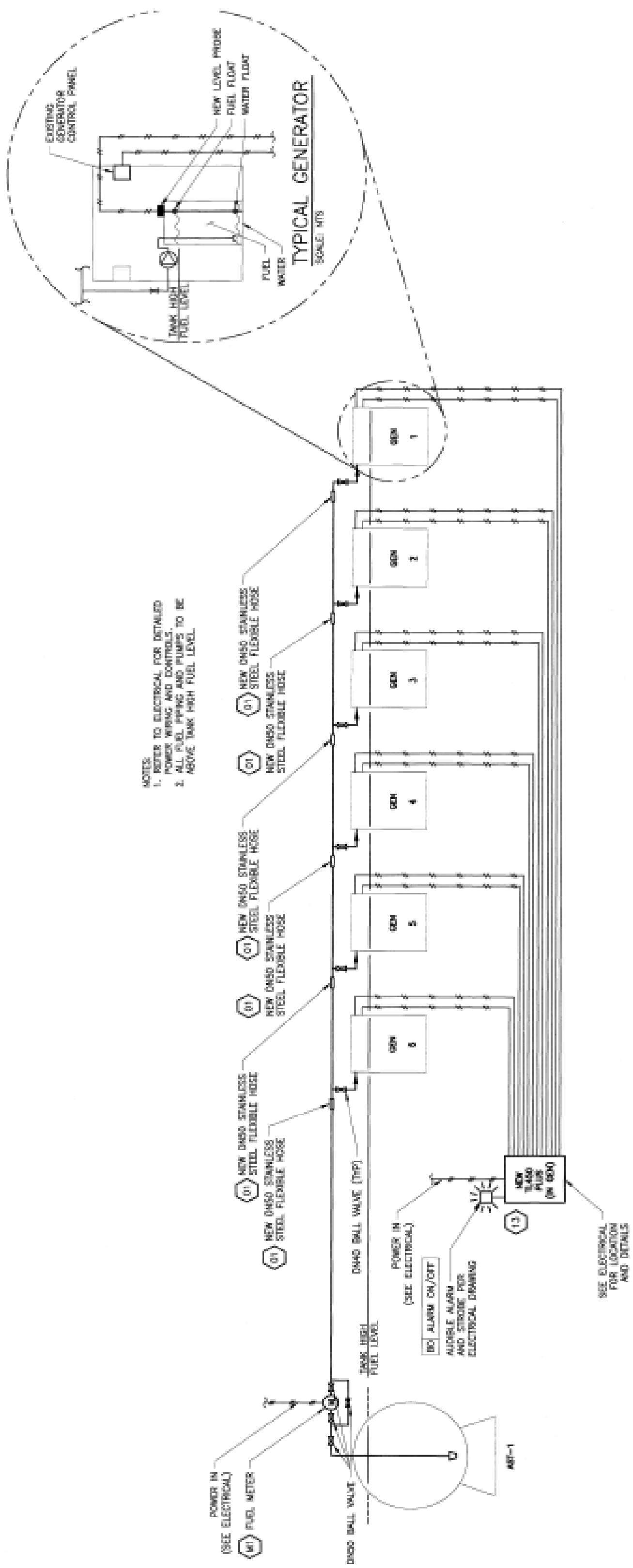
Fuel storage for the current operation of the six diesel generators has utilized fuel storage tanks present in each of the diesel generator mobile trailers that have a capacity of 4,730 litres each. This provides up to 8 hours of fuel consumption before requiring refilling. In order to provide greater reliability of fuel availability for operation of the six diesel generators, NL Hydro has proposed to connect them to a new 90,000 litre aboveground, horizontal, double-walled, steel diesel storage tank to be designed and manufactured in accordance with ULC S601 and erected adjacent to the generator trailers, between the trailers and the electrical substation to the south. The use of this new 90,000 litre fuel storage tank will provide approximately 48 hours of fuel capacity for the six diesel generators.

A new above ground fuel pipeline will be constructed between the new bulk storage tank and the diesel generators. This new pipeline will be equipped with standard valving to prevent accidental siphoning of the tanks in the case of malfunction, and minimize the potential for releases. The new main line will feed a new header with branches connecting to the individual generators. The generator feed lines will connect to existing supply connections on the exterior of the generator bodies which are connected to existing fuel pumps. The main line will be sized to accommodate the flow to the six generator fuel pumps operating simultaneously, 30 litres per minute per generator. Piping will be run above ground to allow visual inspection and leak detection. A schematic illustration of the proposed piping is provided in figure 2.5.

The new tank will be fitted with level probes equipped with both fuel and water level floats to measure both fuel volume and water collection due to condensation. The pipeline to the generating units will be equipped with a flow meter to enable determination of withdrawals from the tank for production purposes. Fuel levels will be recorded prior to and following any deliveries of fuel. Reconciliation of fuel receipts and withdrawls will be undertaken using standard methods on a weekly basis. Any loss indication will trigger a leak investigation.

The fuel supply system will continue to use the 4,730 litre double-walled rectangular aboveground storage tanks, which are built into the generator enclosures, as day tanks to route fuel to the individual generators. Leak detection for these day tanks will be provided by recording the day tank levels immediately before and immediately after the generators are operated. Any loss of fuel indication while the generators are not in operation will trigger a leak investigation. Fuel levels will be checked and recorded using both existing tank gauges and new electronic level probes connected to a central digital console.

Figure 2.5 Proposed Fuel Piping Configuration



2.4.3 Cable Trays

The existing low voltage and high voltage cables are installed on the ground surface. This installation could result in the cables being subject to short circuit forces and physical damage, not suitable for the new requirement. All electrical cables associated with the operation of the diesel generating units will be placed in cable trays supported on treated wood and with cover protection from the corrosive environment.

2.5 Construction

As the diesel generator units have been in place and operational at the HTGS for black start requirements since January 2014, the changes required in order to secure reliable availability of this system for IIS availability are relatively minor in scope. As indicated above, new exhaust stacks, a new diesel fuel storage tank, with associated piping, and cable trays will be put in place to ensure greater availability and reliability of the units for IIS capacity requirements.

Construction of the improvements to the diesel generating system will be undertaken with contract forces, with workers hired at the discretion of the contractor and in accordance with its own hiring practices and policies. Once construction is completed, the facility will continue to be operated using NL Hydro's existing workforce. NL Hydro supports employment and gender equity in its hiring and contracting practices.

An estimate of the Project's construction labor force, by number, occupation and National Occupational Classification (NOC) is provided in Table 2.3.

Table 2.1 Occupations Likely to be Represented in the Construction Work Force

Project Phase	Number (Approximate)	Occupation	National Occupation Classification (NOC)
Construction	1	Supervisor/Foreperson	NOC 7205
	2	Truck Drivers	NOC 7511
	4	Millwrights	NOC 7311
	4	Welders	NOC 7237
	2	Carpenters	NOC 7271
	3	Electricians	NOC 7242

2.6 Operation and Maintenance

In addition to the ongoing HTGS black start requirement, the diesel generator units are proposed to be added to NL Hydro's IIS generation capacity as a reserve for the P90 peak load forecast for the Avalon Peninsula. For this reason, the reliable availability of the units is very important. Each of the diesel units has been run monthly since commissioning in order to test availability. Since commissioning, there have been no occasions when more than one unit was not available when required.

The units have a maintenance schedule including routines such as oil changes and engine overhauls based on manufacturer's recommendations.

2.7 Project Schedule and Cost Estimate

The six diesel units have been in place at the HTGS since January 2014. The registration of these units under the *Environmental Protection Act*, Part X relates to a proposed change in the operational utilization of the generation capacity. The overall price of the proposed upgrades to the system to address availability and reliability issues is estimated at $1.1 M.

The diesel generators and infrastructure associated will continue to provide black start capability for the HTGS. It is planned that the changes to exhaust stacks, fuel storage, and cable trays, to be undertaken to provide greater reliability of Holyrood diesel generator availability for IIS requirements, will be completed by September, 2017.

2.8 Project Documents

Apart from this EA Registration, NL Hydro has conducted air dispersion modelling for the HTGS, including air emissions resulting from operation of the diesel generating units in relation to this Project. A report on the results of this air dispersion modelling is included in Appendix 2.

2.9 Environmental Management and Protection

The number and diversity of environmental challenges facing large companies and their development projects and operations require a structured and consistent management approach. NL Hydro has chosen the ISO 14001 Environmental Management System (EMS) standard developed by the International Organization for Standardization (ISO) to manage environmental aspects. This decision has resulted in continual improvement of environmental performance, while fulfilling the corporation's mandate to provide customers with cost-effective and reliable power. Existing NL Hydro facilities, including the HTGS, have been individually registered by a certified external auditing body (SAI Global) as compliant with the ISO 14001 standard. This Project will be undertaken in accordance with NL Hydro's HTGS EMS.

2.9.1 Safety, Health and Environmental Emergency Response Plan

In the construction, operation and maintenance of any development project, an accidental release or other unplanned event is an unlikely, but unfortunately possible, event. NL Hydro proactively identifies potential emergency situations and develops response procedures, including Safety, Health and Environmental Emergency Response Plans.

The HTGS has put in place Standard Operating Procedures intended to ensure the safety and security of personnel, property and assets associated with all operations at the HTGS, including the operation of the diesel generating units. The HTGS has also put in place a site specific *Emergency Response Manual* which is intended to ensure that the emergency response organization at the HTGS is prepared to:

- Safeguard people, property and the environment;
- Effect the rescue and treatment of casualties;
- Minimize damage to property and environment;
- Contain and control emergency situations;
- Revive operations and effect business continuity; and
- Provide accurate emergency response information to non-essential personnel and community response agencies.

The HTGS *Emergency Response Manual* identifies responsibilities in the event of an unplanned incident, including:

- First aid and medical emergencies;
- Contact with controlled substances and hazardous materials;
- Rescue associated with confined space, high angle , and difficult situations;
- Person overboard rescue during tanker operations;
- Fire;
- Controlled substance spill;
- Natural disaster; and
- Emergency evacuation.

The HTGS *Emergency Response Manual* will continue to provide direction for response to emergency situations involving the six diesel generating units.

2.10 Environmental Permits and Approvals

In addition to approval under the provincial EA process, the Project may also require a number of other provincial and federal permits and authorizations. NL Hydro is committed to obtaining, and complying with the conditions of, these required permits and approvals during Project construction and operations, and will require the same of any and all contractors that are involved in this Project.

A number of key environmental permits and approvals that may be required in relation to the Project include those listed in Appendix A.

3.0 ENVIRONMENTAL SETTING, POTENTIAL INTERACTIONS AND MITIGATION

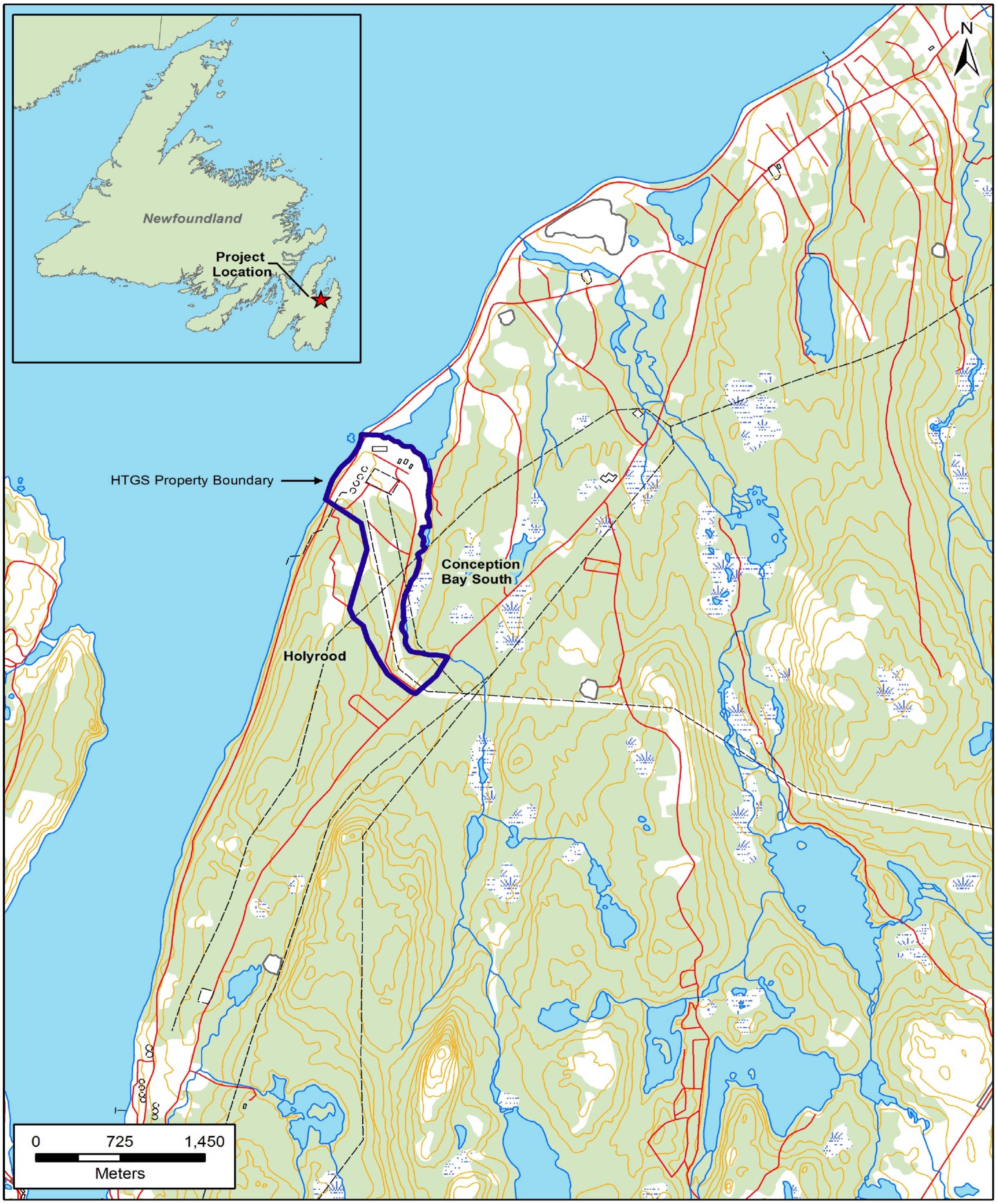
This Chapter provides an overview of the existing environmental setting for the proposed Project, including a description of relevant components of the biophysical and socioeconomic environments. The Project's potential environmental interactions are also analyzed and the mitigation measures which will be put in place to avoid or reduce any such effects are also identified.

3.1 Existing Environment

The six diesel generators are wholly located on the HTGS property, a site that has been utilized for this purpose since 1971. The diesel generators are located approximately 70 m from the Thermal Generating Station and approximately 40 m from the 123.5 MW Combustion Turbine building, Figure 2.3.

The HTGS property is bounded to the west by a section of the linear NL Trailway adjacent to Conception Bay and an area of treed land adjacent to Duff's Road, to the north by Indian Pond, to the east by Quarry Brook and Indian Pond, and to the south by the Conception Bay Highway, Route 60, Figure 3.1. This property is on the boundary of the Town of Conception Bay South on the east and the Town of Holyrood on the west, and the northern and eastern property boundaries follow the boundary between the two Towns. The nearest residences are located in the community of Seal Cove, in the Town of Conception Bay South, approximately 50 m east of the HTGS property and 450 m east of the diesel generators. The nearest residences in the Town of Holyrood are located on Duffs Road approximately 350 m west of the HTGS property and approximately 1000 m from the diesel generators.

Figure 3.1 Holyrood Thermal Generating Station Property Boundary



The diesel generators and associated fuel storage are located on land that has previously be used for purposes associated with operation of the HTGS.

3.2 Potential Environmental Interactions and Planned Mitigation

NL Hydro has well over four decades of experience in planning, designing, building, maintaining and operating electrical generation and transmission infrastructure projects in Newfoundland and Labrador, and currently maintains an extensive electricity transmission and distribution system throughout the province. This, along with the fact that the environmental effects of proposed activities such as those being proposed here are well understood and manageable, means that there is a very good understanding of potential environmental issues and interactions that may be associated with the proposed Project as well as appropriate and effective measures for avoiding or reducing any such effects.

The key environmental aspects of the Project include: air emissions produced as a result of the combustion of distillate fuels, noise produced as a result of operation of the diesel generators, and the security of fuel storage, transport and handling to support the diesel generation.

3.2.1 Atmospheric Environment

The environmental analysis for the Atmospheric Environment includes consideration of any likely implications of the Project on air quality and noise levels within and around the Project area.

3.2.1.1 Air Quality

Construction

The potential interactions between the Project and the Atmospheric Environment relate to the use of equipment during Project construction. The noise, dust and engine emissions that may be associated with these activities will be minimal. The use of heavy equipment will be limited to that required for the placement of stacks on the existing diesel generation units and installation of a new fuel storage tank. In the case of the stacks, this will involve a truck to deliver the preformed stack piping and a boom truck to lift the stack piping into place for attachment to the diesel generator housing. In the case of the fuel storage tank, this will involve an excavator to level the ground in the area on which the tank will be placed, a concrete truck to deliver the concrete to be used to form concrete supports on which the 90,000 litre double-walled tank will be placed, a truck to deliver the manufactured tank, and a boom truck to unload the tank onto the concrete supports. The atmospheric emissions from this equipment will occur within a localized area over a relatively short period. Project-related vehicles and equipment will be maintained in good repair and inspected regularly, and any associated air emissions from equipment and vehicles will conform to applicable regulations and guidelines. Any fugitive dust from construction activities will be controlled as necessary using dust control agents such as water.

Any potential emissions or interactions with the Atmospheric Environment during Project construction are therefore likely to be negligible and within existing regulations or standards, as well as localized and short-term, and intermittent over the construction period.

Operations and Maintenance

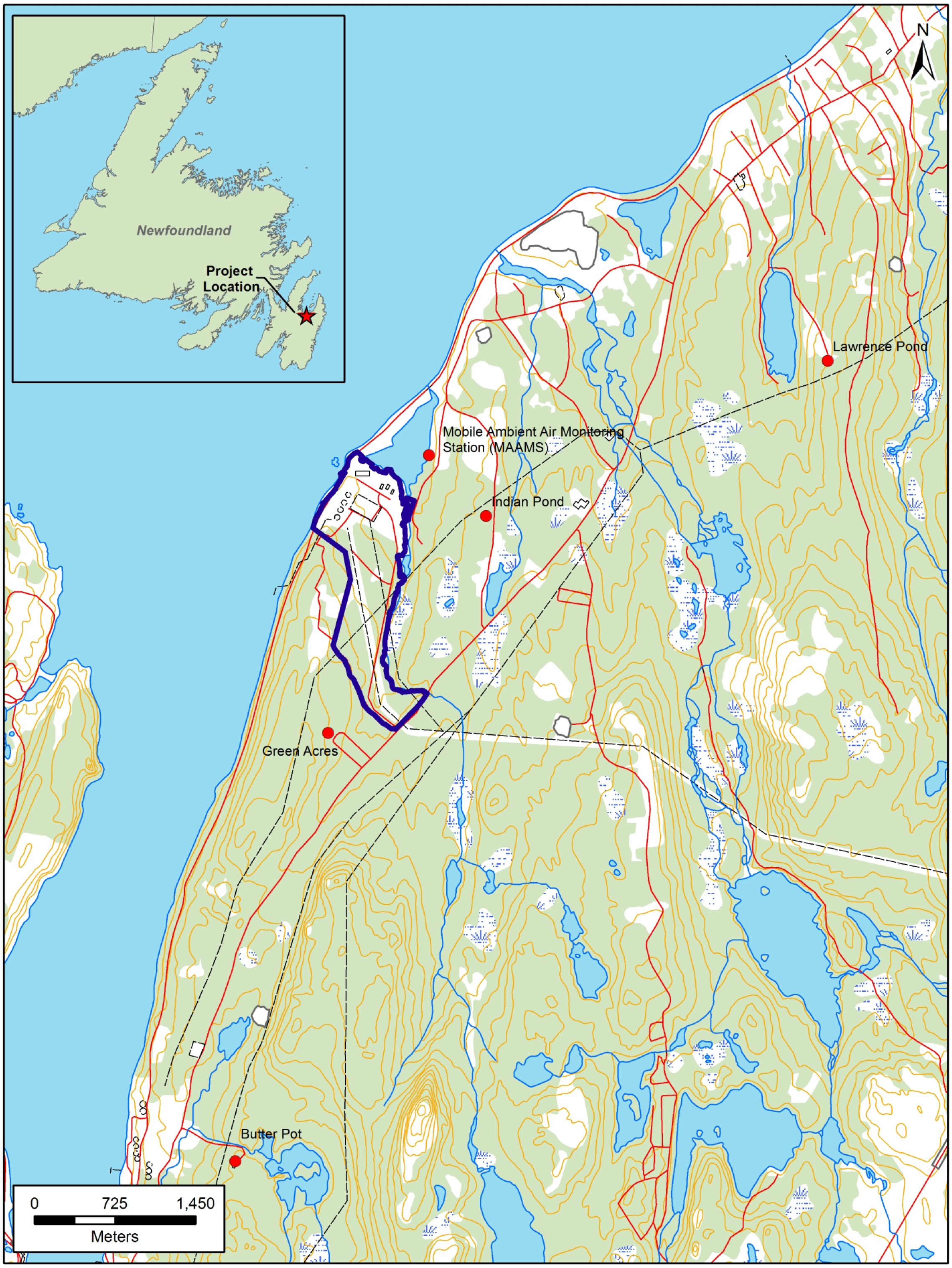
Air emissions tend to be the most significant environmental concern associated with the operation of thermal generation sources such as the HTGS steam generation units, the HTGS combustion turbine generation unit and the HTGS diesel generation units. These thermal generation sources use the combustion of fossil fuel oils, No.6 bunker C in the case of the HTGS steam generation units, and No. 2 diesel fuel in the case of the combustion turbine and diesel generation units, to generate electrical energy. Combustion of fuel oils results in the production of exhaust gasses including sulphur dioxide (SO_2), oxides of nitrogen (NO_X) and particulate matter.

In Newfoundland and Labrador, air emissions from sources such as the HTGS thermal generation units, and the air quality in the surrounding areas, are regulated under the province's *Air Pollution Control Regulations* (the Regulations). NL Hydro has operated an ambient air monitoring program in the area surrounding the HTGS since 1977 to test for air quality relative to requirements of the Regulations. The present ambient air monitoring network consists of monitoring stations at locations identified in Table 3.1 and Figure 3.2 (Independent Environmental Consultants, 2016).

Table 3.1 Holyrood Thermal Generating Station Ambient Air Monitoring Stations

Abient Air Monitoring Site	UTM Easting (m)	UTM Northing (m)	Location Relative to HTGS Diesel Generation
Butter Pot	340783	5251500	Approximately 6,100 m to the Southwest
Green Acres	341617	5255353	Approximately 2,200 m to the South
Indian Pond	343039	5257306	Approximately 1,100 m to the East
Mobile Ambient Air Monitoring Station (MAAMS)	342526	5257852	Approximately 700 m to the Northeast
Lawrence Pond	346116	5258701	Approximately 4,300 m to the East

Figure 3.2 Ambient Air Monitoring Stations



Levels of SO_2, NO_X, nitrogen dioxide (NO_2), and particulate matter 2.5 microns or less ($PM_{2.5}$) are monitored continuously at each of the ambient air monitoring stations using methodologies and equipment conforming to the requirements of the provincial *Guidelines for Ambient Air Monitoring, December 2010*. Total suspended particulate matter (TSP) is also monitored once in every six day cycle at all but the Butter Pot monitoring station.

The objectives of the ambient air monitoring program are to:

- Continuously monitor local air quality within a 6.5 km radius of the HTGS;
- Provide long term ambient air quality data in a database format;
- Provide near real time assessment of SO_2 and NO_X in the surrounding air shed; and,
- Provide data of a quality which follows acceptable guidelines and standard protocol for the parameters measured.

HTGS personnel submit an electronic report to the Department of Municipal Affairs and Environment monthly detailing the results of the monitoring program and any maintenance and quality control items of note. The operation of these ambient air monitoring sites is also subject to auditing by the Department of Municipal Affairs and Environment for quality control purposes.

In addition to monitoring levels of air contaminants of concern relative to emissions from sources at the HTGS, these ambient air monitoring stations provide data on overall air quality in the area surrounding the HTGS, which may also include sources other than those at the HTGS. Appendix C provides a compilation of the ambient air monitoring results for the period January 1, 2015 through March 31, 2017 on a monthly basis.

The highest hourly and daily concentrations of SO_2, NO_X, NO_2, and $PM_{2.5}$ recorded at each of these monitoring stations is provided in Table 3.2. Ambient Air Quality Standards (AAQS) for each averaging period for each contaminant are also identified. AAQS, as prescribed in the Regulations, are concentrations of air contaminants that shall not be exceeded due to all sources and are used to maintain air quality in the province. It should be noted that an AAQS for hourly $PM_{2.5}$ has not been identified in the Regulations, therefore this is not provided in Table 3.2, however, a daily AAQS is prescribed for $PM_{2.5}$ and is provided in Table 3.2 and compared to ambient air quality monitoring results.

Table 3.2 Summary of Maximum Concentrations Recorded at Ambient Air Monitoring Stations During the Period from January, 2015 Through March, 2017

Monitoring Site	Contaminant	Maximum Hourly AAQS	Maximum Hourly Concentration (ug/m^3)	Month Recorded	Maximum Daily AAQS	Maximum Daily Concentration (ug/m^3)	Month Recorded
Butter Pot	SO_2	900	193.74	April, 2016	300	34.72	April 2016
	NO_X	400	64.36	April, 2016	200	13.41	April 2016
	NO_2	400	32.88	April, 2016	200	8.70	April, 2016
	$PM_{2.5}$				25	14.7	July, 2015
Green Acres	SO_2	900	280.43	June, 2016	300	36.68	May, 2015
	NO_X	400	104.85	February, 2015	200	20.38	March, 2016
	NO_2	400	56.41	February, 2015	200	12.14	March, 2016
	$PM_{2.5}$				25	15.7	July, 2015
Indian Pond	SO_2	900	120.47	March, 2015	300	41.34	November 2015
	NO_X	400	72.98	February, 2016	200	35.18	February, 2017
	NO_2	400	36.65	January, 2016	200	18.01	February, 2017
	$PM_{2.5}$				25	23.1	March, 2017
MAMS	SO_2	900	193.77	March, 2016	300	87.40	March, 2017
	NO_X	400	130.25	February, 2015	200	33.82	March, 2016
	NO_2	400	93.81	February, 2015	200	17.22	February, 2015
	$PM_{2.5}$				25	15.3	February, 2015
Lawrence Pond	SO_2	900	180.18	March, 2015	300	26.21	February, 2015
	NO_X	400	79.94	March, 2015	200	13.99	January, 2015
	NO_2	400	47.38	April, 2016	200	11.00	January, 2015
	$PM_{2.5}$				25	12.2	July, 2015

The maximum hourly concentration of SO_2 recorded over the January 2015 to March, 2017 period was 280.43 ug/m^3, which occurred at Green Acres monitoring station in June, 2016. The maximum daily concentration of SO_2 recorded was 87.40 ug/m^3, which occurred at the MAAMS station in March, 2017.

These concentrations were 31 percent and 29 percent of the hourly and daily AAQS for this contaminant, respectively.

The maximum hourly concentration of NO_X recorded over the January, 2015 to March, 2017 period was 130.25 ug/m^3, which occurred at MAAMS monitoring station in February, 2015. The maximum daily concentration of NO_X recorded was 35.18 ug/m^3, which occurred at the Indian Pond station in February, 2017. These concentrations were 32.5 percent and 18 percent of the hourly and daily AAQS for this contaminant, respectively.

The maximum hourly concentration of NO_2 recorded over the January, 2015 to March, 2017 period was 93.81 ug/m^3, which occurred at MAAMS monitoring station in February, 2015. The maximum daily concentration of NO_2 recorded was 18.01 ug/m^3, which occurred at the Indian Pond station in February, 2017. These concentrations were 23.5 percent and 9 percent of the hourly and daily AAQS for this contaminant, respectively.

The maximum daily concentration of $PM_{2.5}$ recorded over the January 2015 to March 2017 period was 23.1 ug/m^3, which occurred at the Indian Pond monitoring station in March, 2017. This concentration was 92.4 percent of the daily AAQS for this contaminant. There is no hourly maximum concentration prescribed for this contaminant.

In order to evaluate potential changes to ambient air quality associated with the greater utilization of the Holyrood diesel generators, NL Hydro contracted Independent Environmental Consultants (IEC), an environmental consulting firm that specializes in air emission dispersion modelling, to undertake air emission modelling of projected emissions from the HTGS operations in combination with possible worst case diesel generator production. This air dispersion modelling projected ground level concentrations of emission from the diesel generators in combination with emissions from the other thermal generation sources at the HTGS when used for IIS peaking production needs and as a separate generating source for emergency power requirements.

IEC completed the air dispersion modelling assessment in conformance with the Newfoundland and Labrador Department of Municipal Affairs and Environment guidelines identified in:

- *Guideline for Plume Dispersion Modelling. GD-PPD-019.2*, (Department of Environment and Conservation, 2012a); and
- *Determination of Compliance with Ambient Air Quality Standards*. GD-PPD-009.4 (Department of Environment and Conversation, 2012b).

The air dispersion modelling undertaken included separate modelling of a peaking production scenario and an emergency production scenario in order to assess differences between the two production requirements that affect the associated air emission characteristics. The peaking and emergency production scenarios outlined below were identified in consultation with the Department of Municipal

Affairs and Environment and define the cases appropriate for modeling the maximum ground level concentrations resulting from operation of the diesel generators following completion of the changes proposed.

The following peaking production scenario was modelled:

- HTGS Units 1, 2 and 3, the HTGS combustion turbine and the HTGS diesel generators were all assumed to operate from January 1 to April 30 and from November 1 to December 31 of each modelled year. There are no operations between May 1 and October 31 as there is sufficient existing reserve capacity to meet the P90 load forecast requirement throughout this period.
- Hourly production data from the 2003 and 2004 operation of HTGS Units 1, 2 and 3 was used to calculate hourly emissions from these sources. These years are considered to be a conservative representation of operations for the HTGS as they were historically high production years for this facility. All three units operate together 24 hours per day, although production levels for each Unit varies by hour.
- The HTGS Combustion Turbine was conservatively assumed to operate 24 hours per day at 100% load.
- The production scenario for the HTGS diesel generators conservatively assumed five generators operating simultaneously at 87% load for 10 hours per day during the periods of 6:00 AM to 11:00 AM and 4:00 PM to 9:00 PM. The 87% (8 MW) load restriction was identified by preliminary air dispersion modelling as a load factor that could result in full compliance with AAQS requirements under this scenario.

Separate modelling was undertaken to assess the dispersion of air emissions from operation of the diesel generators for emergency production requirements using the following scenario:

- Operation of five diesel generators simultaneously at 67% engine load, 24 hours per day, 365 days per year. The 67% (6 MW) load restriction was identified by preliminary air dispersion modelling as a load factor that could result in full compliance with AAQS requirements under this scenario.
- During this emergency scenario no other thermal generation at the HTGS is operational.

In both scenarios it was assumed that the proposed eight meter stack extension above the present exhaust grating on top of the diesel generator housing would be added to maximize the release height of exhaust gasses without causing excessive back pressure on the diesel generators, as discussed in section 2.4.1.

The difference in the period of production modelled between the peaking production scenario, November 1 through April 30 and between the hours of 6:00 AM to 11:00 AM and 4:00 PM to 9:00 PM, and the emergency production scenario, 24 hours per day, 365 days per year, is significant in relation to the engine load factor identified in preliminary modelling that could result in full compliance with AAQS requirements under each respective scenario. This is because the modelling of the emergency scenario incorporates a broader range of meteorological conditions associated with the full year of production potential that must be modelled in this scenario. This is a more significant factor in determining the maximum ground level concentrations than the combination of greater number of emission sources over a more limited production period required in the peaking production scenario.

The CALMET/CALPUFF air dispersion modelling system was used as it is the preferred regulatory model as identified in the Department of Municipal Affairs and Environment guidelines. CALMET is a meteorological model that produces hourly three dimensional gridded wind fields from available meteorological, terrain and land use data. CALPUFF is a non-steady state puff dispersion model that utilizes the CALMET wind fields and accounts for spatial changes in meteorology, variable surface conditions, and plume interactions with terrain (IEC, 2017).

The CALMET model was used to develop four years of hourly meteorological data fields to use in each CALPUFF modelling scenario. The four years of meteorological data were developed for 2012 through 2015 in consultation with the Department of Municipal Affairs and Environment. The CALMET model was run over a 20 km by 20 km modelling domain having a grid spacing of 200 m.

Because the CALMET meteorological data used spans a four year period and the HTGS Units 1, 2 and 3 production data used spans two years, 2003 and 2004, eight CALPUFF model runs were required to model each meteorological year with each year of peaking production. The conservative production scenarios identified above for the Combustion Turbine and the diesel generators were combined with the steam generator production data for each of the peaking production scenario model runs. The same four year meteorological data period was used in combination with the 24 hour per day, 365 days per year operation of the diesel generators identified for the emergency production scenario.

For determination of ground level concentrations, a receptor grid, centered on the HTGS steam generation exhaust stacks was defined within the 20 km by 20 km modelling domain as follows:

- 50 m spacing within 1 km of the site boundary;
- 100 m spacing within all areas located beyond 1 km of the site boundary, but less than 2 km from the site boundary; and
- 200 m spacing within all areas located beyond 2 km of the site boundary.

The modelling undertaken by IEC assessed the maximum predicted concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$, for both the peaking production scenario and the emergency production scenario, following the guidance provided for the determination of compliance with the Regulations as identified in the *Plume Dispersion Modelling Guideline* (Department of Environment and Conservation, 2012a). As indicated in the Guideline, meteorological anomalies may result in over-prediction of modelled concentrations. As a result, compliance for each modelled year, as defined in the Guideline, is 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; and
- 1^{st} highest level at any given receptor for an annual averaging period.

The highest predicted concentrations for determination of compliance with AAQS for each of the air contaminants of concern for the peaking production scenario, as determined by ambient air modelling undertaken by IEC, are provided in Table 3.3. All predicted ground level concentrations are compliant with the AAQS for all of the air contaminants. The predicted ground level concentrations of NO_2 are identified as the highest concentration relative to the specified AAQS and is predicted to occur in combination with the 2013 meteorological year dataset. The highest predicted ground level concentration for SO_2 is also projected to occur in combination with the 2013 meteorological year dataset. Graphical representations of the areas on which these maximum concentrations are projected to occur are provided in Figures 3.3, and 3.4 (IEC, 2017).

Table 3.3 Air Dispersion Modelling Projected Highest Concentration of Air Contaminants of Concern

Pollutant	Period	AAQS (µg/m³)	Concentration (µg/m³)			
			2012	2013	2014	2015
NO_2	1hr	400	331.4	389.1	295.7	338.3
	24hr	200	68.3	120.0	93.6	99.5
	Annual	100	2.5	3.8	4.5	3.6
SO_2	1hr	900	430.5	754.9	488.3	516.6
	3hr	600	327.7	472.6	388.7	440.9
	24hr	300	167.3	250.5	213.5	223.1
	Annual	60	5.2	5.4	8.8	8.3
CO	1hr	35000	37.2	47.3	34.8	39.1
	8hr	15000	14.5	24.8	16.7	19.4
TSP	1hr	N/A	16.7	24.1	26.9	26.7
	24hr	120	4.5	8.0	8.7	7.2
	Annual	60	0.2	0.2	0.3	0.3
PM_{10}	1hr	N/A	16.7	24.1	26.9	26.7
	24hr	50	4.5	8.0	8.7	7.2
	Annual	N/A	0.2	0.2	0.3	0.3
$PM_{2.5}$	1hr	N/A	16.7	24.1	26.9	26.7
	24hr	25	4.3	8.0	8.7	7.2
	Annual	8.8	0.2	0.2	0.3	0.3

Figure 3.3 Overlay of Isopleth Projections of Ground Level Concentrations of NO2 Resulting from Peaking Production Scenario Air Dispersion Modelling

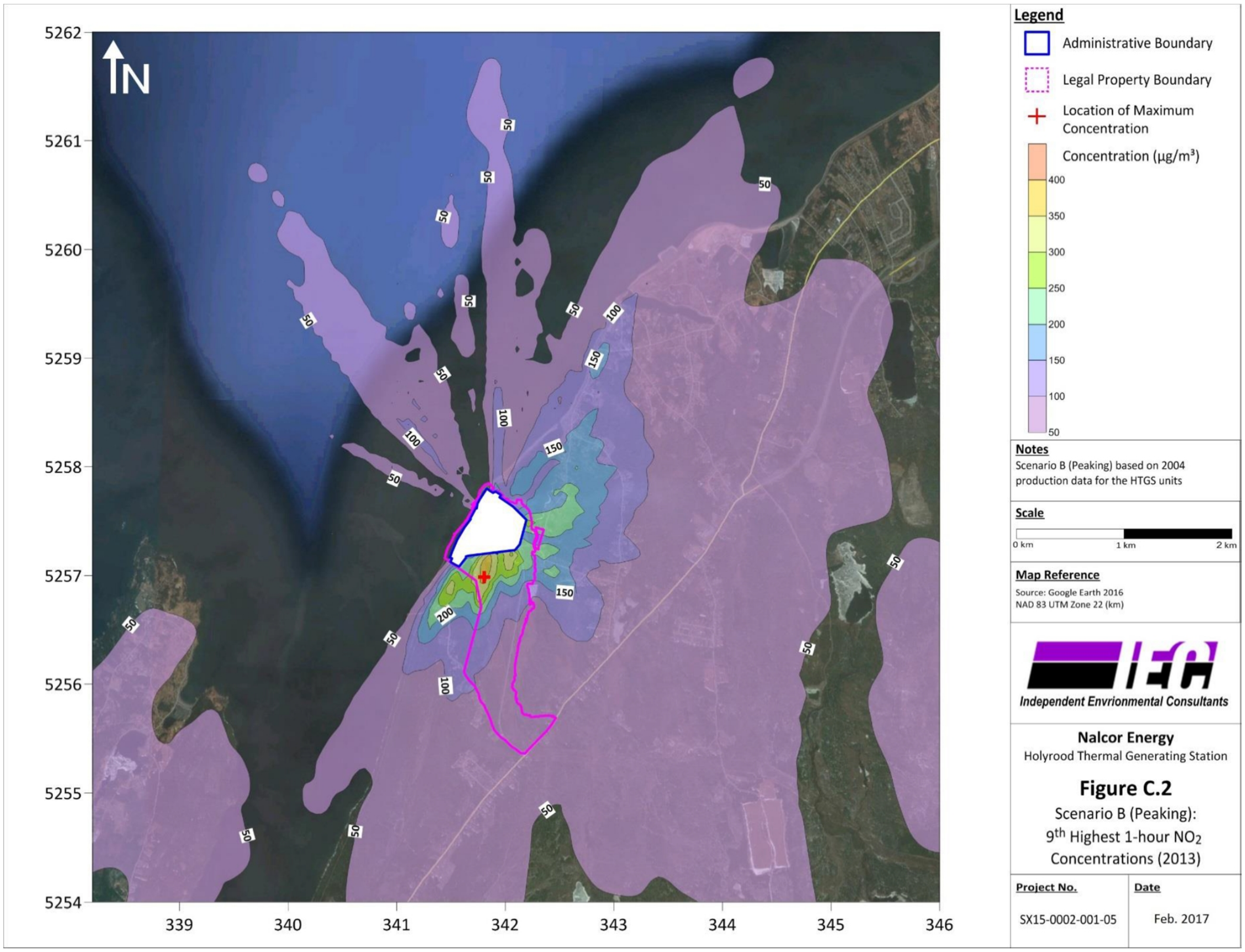
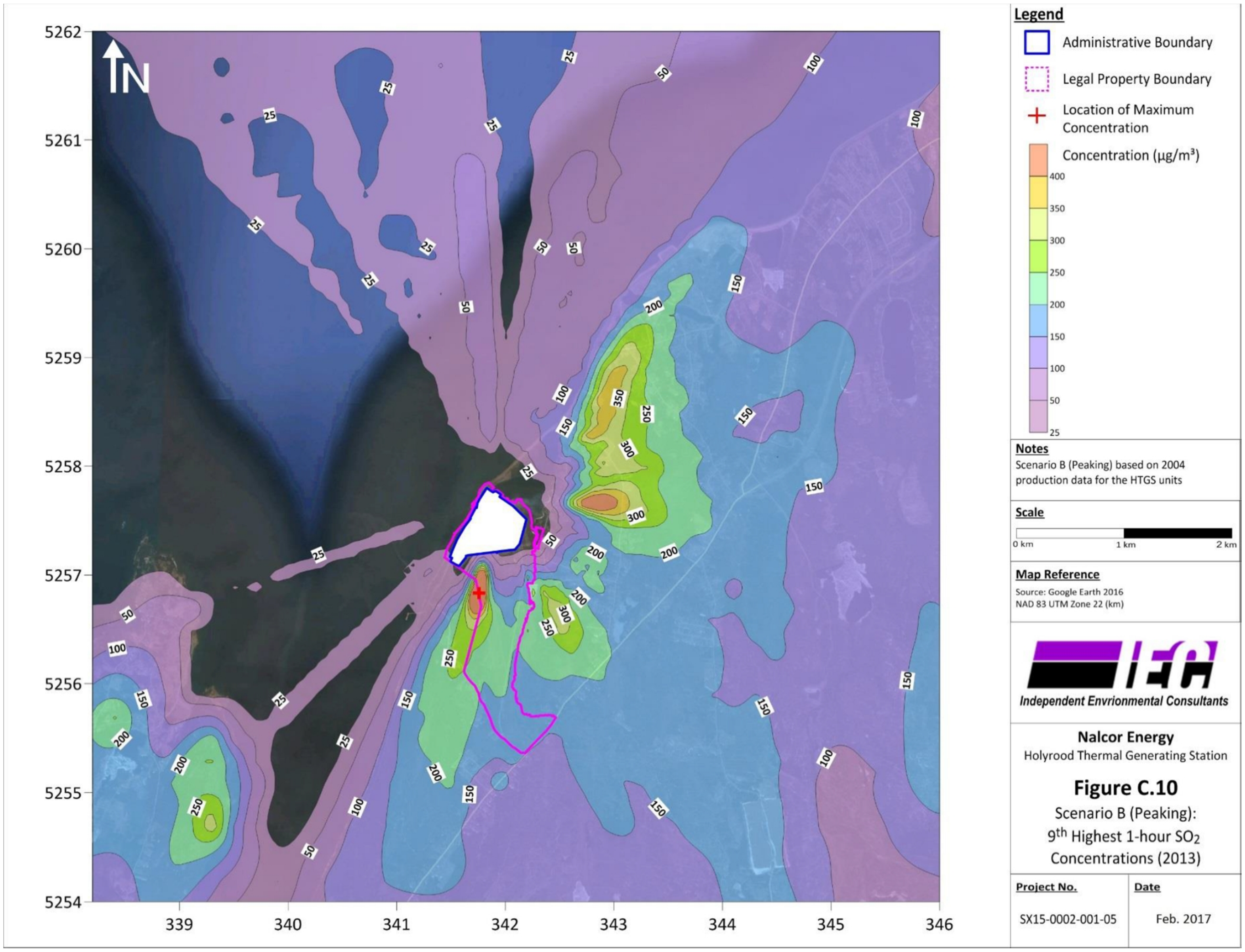


Figure 3.4 Overlay of Isopleth Projections of Ground Level Concentrations of SO2 Resulting from Peaking Production Scenario Air Dispersion Modelling



IEC provide the following general conclusions relating to the results of modelling of the peaking production scenario:

- The maximum concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ are predicted to be compliant with applicable AAQS for all averaging periods and modelling years.
- NO_2 concentrations are primarily influenced by the diesel generators. The maximum 1-hour NO_2 concentrations is predicted to be 389.1 ug/m^3 (or 97.3% of the AAQS) and the maximum 24-hour NO_2 concentration is predicted to be 120 ug/m^3 (or 60% of the AAQS).
- SO_2 concentrations are primarily influenced by the main HTGS stacks. The maximum 1-hour SO_2 concentration is predicted to be 754.9 ug/m^3 (or 83.9% of the AAQS). The maximum 3-hour SO_2 concentration is predicted to be 472.6 ug/m^3 (or 78.8% of the AAQS). The maximum 24-hour SO_2 concentration is predicted to be 250.5 ug/m^3 (or 83.5% of the AAQS).

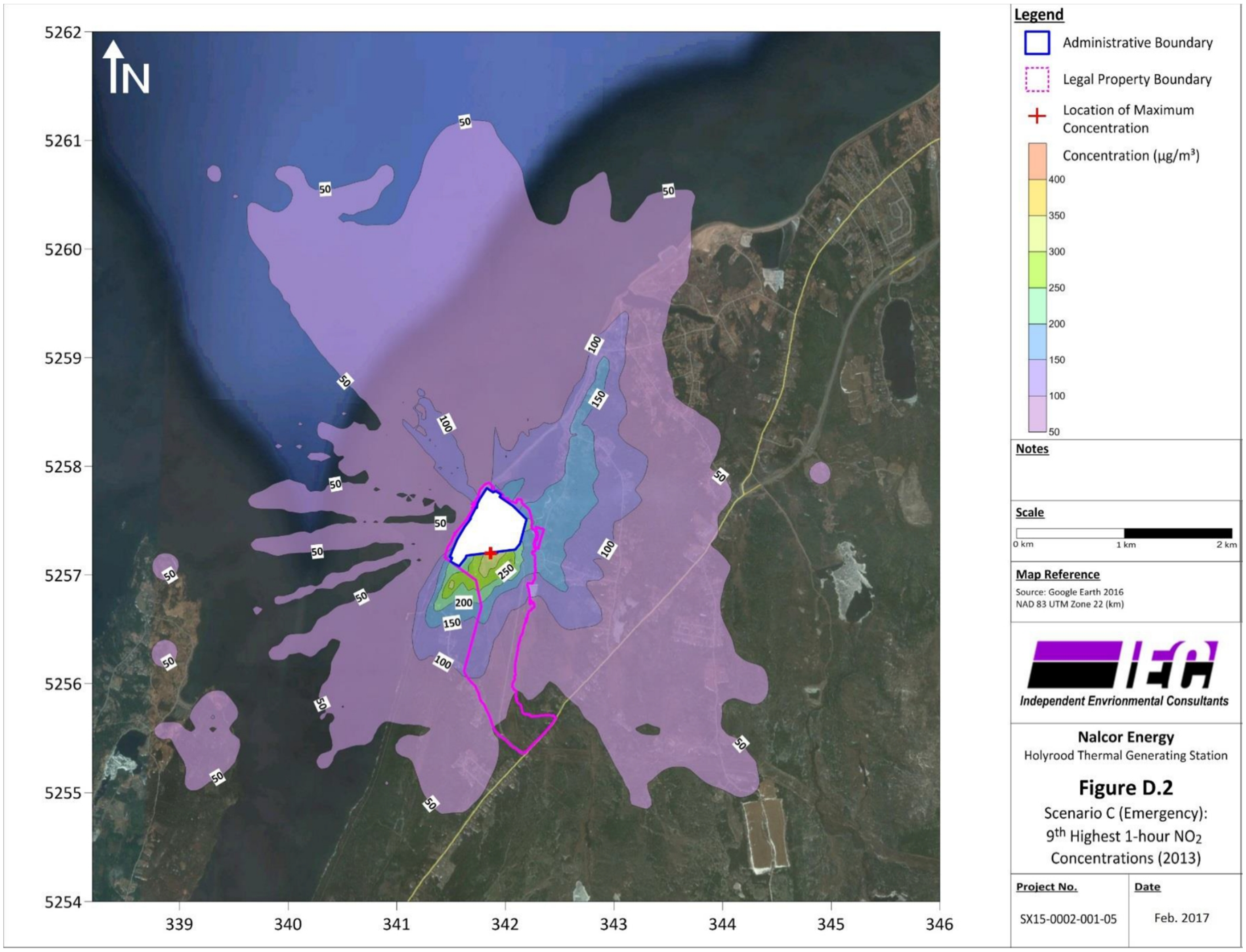
- The maximum predicted particulate matter concentrations are less than 35% of the AAQS for the peaking production scenario.
- Maximum predicted CO concentrations are below 0.5% of the AAQS for the peaking production scenario.

The highest predicted concentrations for determination of compliance with AAQS for of each of the air contaminants of concern for the emergency production scenario, as determined by ambient air modelling undertaken by IEC, are provided in Table 3.4. All predicted ground level concentrations are compliant with the AAQS for all of the air contaminants. The predicted ground level concentrations of NO_2 are identified as the highest concentration relative to the specified AAQS and is predicted to occur in combination with the 2013 meteorological year dataset. Graphical representations of the areas on which this maximum concentration is projected to occur are provided in Figures 3.5 (IEC, 2017).

Table 3.4 Air Dispersion Modelling Projected Highest Concentration of Air Contaminants of Concern

Pollutant	Period	AAQS (µg/m³)	Concentration (µg/m³)			
			2012	2013	2014	2015
NO2	1hr	400	318.3	345.4	313.3	323.5
	24hr	200	153.4	199.4	141.2	193.3
	Annual	100	9.3	11.2	11.2	11.0
SO2	1hr	900	0.5	0.5	0.5	0.5
	3hr	600	0.4	0.3	0.2	0.3
	24hr	300	0.2	0.3	0.2	0.3
	Annual	60	0.01	0.02	0.02	0.017
CO	1hr	35000	44.2	45.5	43.8	44.0
	8hr	15000	29.6	35.2	29.9	34.4
TSP	1hr	N/A	5.7	5.9	5.7	5.7
	24hr	120	2.8	3.5	2.6	3.6
	Annual	60	0.2	0.2	0.2	0.2
PM10	1hr	N/A	5.7	5.9	5.7	5.7
	24hr	50	2.8	3.5	2.6	3.6
	Annual	N/A	0.2	0.2	0.2	0.2
PM25	1hr	N/A	5.7	5.9	5.7	5.7
	24hr	25	2.8	3.5	2.6	3.6
	Annual	8.8	0.2	0.2	0.2	0.2

Figure 3.5 Overlay of Isopleth Projections of Ground Level Concentrations of NO2 Resulting from Emergency Production Scenario Air Dispersion Modelling



IEC provide the following general conclusions relating to the results of modelling of the emergency production scenario:

- Maximum concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ are predicted to be compliant with applicable AAQS for all averaging periods and modelling years.
- NO_2 is the pollutant with the highest predicted concentrations relative to its AAQS. The maximum 1-hour NO_2 concentration is 345.4 ug/m^3 (or 86.4% of the AAQS), and the maximum 24-hour NO_2 concentration is 199.4 ug/m^3 (or 99.7% of the AAQS).
- The maximum predicted 24-hour $PM_{2.5}$ concentration is 3.6 ug/m^3 (or 14.5% of the AAQS).
- Maximum TSP and PM_{10} concentrations are predicted to be less than 10% of the AAQS.
- At less than 0.5%, SO_2 and CO have the lowest predicted maximum concentrations relative to their respective AAQS.

The results of the air dispersion modelling indicate the need to limit production levels from the Holyrood diesel generators to 8 MW for peaking production requirements and 6 MW for emergency production requirements, to ensure compliance with provincial AAQS. These restrictions will be incorporated into a Standard Operating Procedure (SOP) to provide specific instructions to HTGS Operators when starting the diesel generators. The SOP will provide instruction to ensure that when these units are started for peaking power production requirements, the maximum setting for the combined capacity of all of the units being started must not exceed 8 MW. The procedure will also provide instruction to ensure that when these units are started for emergency power production requirements, the maximum setting for the combined capacity of all of the units being started will not exceed 6 MW.

As these units must be manually started by HTGS personnel, and are not subject to remote operation, a HTGS SOP is an effective mechanism by which to control the production output of the diesel generators. As well, as an environmental control at the HTGS, the implementation of the SOP may be subject to auditing on an annual basis by both internal and external Environmental Management System Auditors as part of NL Hydro's ISO 14001 Environmental Management System certification process.

Although not included in the list of air emissions of concern identified in the provincial AAQS, emissions of greenhouse gasses (GHGs) such as CO_2, CH_4, and N_20, also result from the combustion of fuels during operation of thermal generation sources. The volume of emissions of these GHGs from operations at the HTGS are calculated annually for reporting under the Government of Canada's Facility Greenhouse Gas Emissions Reporting Program. In 2016, emissions of GHGs from HTGS operations totaled approximately 1.5 megatonnes of CO_2 equivalents, and emissions from the diesel generators were less than 0.1% of this total. The level of emissions of GHGs from the diesel generators is not expected to change significantly as a result of this Project.

3.2.1.2 Sound Levels

Another environmental concern relating to the operation of thermal generation sources, especially when operated within community boundaries, is the potential for increases in ambient noise levels associated with the combustion process. As the diesel generators are already operational on the HTGS site as a result of their requirement for black start capability, HTGS personnel were able to conduct sound level measurements with the diesel generators operating to document the ambient sound levels. Sound level measurements were undertaken on September 21, 2016 using an Extech 407736 sound meter at eight locations on the HTGS property. The eight locations are identified on Figure 3.6 below. Sound level measurements were taken at locations close to the diesel generators, sites 3, 5 and 6, and at locations near the HTGS property fence line, sites 1, 2, 4, 7 and 8.

Figure 3.6 Sound Level Monitoring Locations, September 21, 2016

Sound level measurements were taken at each of the eight locations prior to the start up of the diesel generators and again when five of the diesel generators were operating at full output. In both cases Unit 2 of the HTGS was also operating at 70 MW. The sound level measurement results for each location and for each of the two measurement cases are provided in Table 3.5.

Table 3.5 Sound Level Monitoring Results During Operation of the Holyrood Diesel Generators on September 21, 2016.

Sound Level Monitoring Location	1	2	3	4	5	6	7	8
Sound Level Monitoring Result (dBA) Prior to Start Up of Diesel Generators	49.8	43.9	54.9	39.4	54.4	52.8	44.2	39.3
Sound Level Monitoring Result (dBA) Following Start Up of Diesel Generators	53.6	55.3	63.7	48.2	77.0	59.6	46.1	45.2

The sound levels recorded increased at all of the locations monitored when the diesel generators were operating. This increase ranged from a difference of 22.6 dBA at location 5, directly adjacent to the diesel generators, to a difference of 1.9 dBA at location 7, at the HTGS southern fence line. The maximum sound level recorded when the diesel generators were operating, 77.0 dBA, was directly adjacent to the diesel generators and diminished to a range of 45.2 to 55.3 dBA at the property fence line. These levels are less than the 90 dBA eight hour day permissible noise level exposure identified for occupational noise exposure in the American Conference of Governmental Industrial Hygienists and referenced in provincial *Occupational Health and Safety Regulations*. These sound levels are also in the normal range that would be expected to occur in association with present HTGS operations. The modification of the diesel generator operations are not expected to result in any change to the sound levels presently associated with HTGS operations.

Environmental Effects Summary and Evaluation

Continuous ambient air monitoring results at five sites in the communities surrounding the HTGS indicate that operation of the diesel generators to date has not resulted in ambient air concentrations of concern relative to provincial AAQS at these locations.

Air dispersion modelling of projected peaking production and emergency production utilization of the diesel generators for potential IIS requirements indicates full compliance with provincial AAQS for all emissions of concern when stack heights on each of the generating units are raised to eight meters above the top of the generator housing, and the load on the generators is limited to 8 MW for peaking production and 6 MW for emergency production.

NL Hydro has incorporated installation of an eight meter high exhaust stack on each diesel generator in the project design, and will implement operational controls, including appropriate SOPs, to ensure that the load on the generators is restricted as required to achieve full compliance.

Sound levels generated as a result of the operation of the diesel generators is not expected to result in changes to the sound levels presently associated with HTGS operations.

3.2.2 Terrestrial Environment

The terrestrial environment is comprised of relevant components of the "on-land" biophysical environment which may interact with the Project, including vegetation, soils, landforms and wildlife.

Construction

The proposed Project site occurs within an already developed area and the six diesel generation units are already in place, having been used for HTGS black start requirements in 2015 and 2016. Project construction will involve very limited vegetation clearing, grubbing, excavation or other on-land site preparation activities as the only new footprint will be that associated with a new fuel storage tank to be installed in the area of the diesel generators. As well, the areas to be used for construction related activities will be limited to those that have been previously disturbed. No listed (protected) plant species are known, or likely to occur within or near the proposed Project area.

Adverse interactions with wildlife are not likely to occur during the Project's construction phase. There are no *SARA* and/or *NL ESA* listed species that are known to occur within or near the proposed Project area. The potential for interactions between the Project and wildlife is very limited.

NL Hydro will apply standard waste management practices to the construction and operations phases of the proposed Project. Waste materials generated through construction activities will be removed from the area and disposed of at an existing, approved site. Non-hazardous construction refuse will be stored in covered metal receptacles, and will be disposed of on an as-needed basis at an approved landfill site, as per Nalcor Energy's on-going operations and practices. Waste materials will be reused / recycled where possible.

Any hazardous wastes will be stored in sealed, labeled containers and disposed of according to applicable regulations and NL Hydro practice. These include procedures for the characterization / identification, storage, inspection, labeling and transportation of hazardous wastes produced at the facility, as well as emergency preparedness / prevention and training. There will therefore be no adverse interaction between construction waste materials and the environment.

Operations and Maintenance

During the operations phase of the Project there will be no additional soil or vegetation disturbance, and therefore, little or no potential for effects to these aspects of the terrestrial environment.

Operation of the diesel generators will include periodic maintenance based on manufacturer's specifications, which will include generation of waste materials such as waste oil and glycol. Hydrocarbon based wastes will continue to be handled, used and disposed of properly throughout the life of the Project. Operational controls at the HTGS include a *Waste Management Plan* and SOPs related to the proper handling and disposal of waste products generated as a result of operations.

Operation of the new fuel storage tank will include daily inspections and weekly fuel reconciliation of receipts and withdrawals to ensure early detection of leaks or spills as required by HTGS SOPs and in compliance with provincial *Storage and Handling of Gasoline and Associated Products Regulations*. The detection of leaks or spills will result in implementation of emergency response procedures as identified in the HTGS *Emergency Response Manual*.

The daily inspection and weekly fuel reconciliation processes are standard industry practice and are an effective mechanism to ensure early detection of leaks and spills from fuel handling systems. As well, as environmental controls at the HTGS, the implementation of these programs may be subject to auditing on an annual basis by both internal and external Environmental Management System Auditors as part of NL Hydro's ISO 14001 Environmental Management System certification process.

No additional interactions with or adverse effects on the Terrestrial Environment are anticipated during the operation phase of the Project.

Environmental Effects Summary and Evaluation

The proposed Project is not likely to result in significant adverse environmental effects on the terrestrial environment.

3.2.3 Freshwater Environment

The freshwater environment includes surface water (quantity and quality) and fish and fish habitat which may interact with the Project.

Construction

The diesel generators are located approximately 150 m from the nearest surface water, Indian Pond, and no construction activities are proposed between the generators and this pond. Any incidents involving accidental release of potential contaminants such as fuel, oils and grease will be managed through standard contingency planning in order to reduce potential contamination of surface or groundwater resulting from the minimal construction requirements associated with this project.

Operations and Maintenance

During planned operations activities there will be no direct interactions with the freshwater environment. Any incidents involving accidental release of potential contaminants such as fuel, oils and grease will be managed through implementation of the HTGS *Emergency Response Manual* in order to reduce potential contamination of surface or groundwater resulting from the operation of the six diesel generators.

No additional interactions or adverse effects to the Freshwater Environment are therefore anticipated during this phase of the Project.

Environmental Effects Summary and Evaluation

The proposed Project is not likely to result in significant adverse environmental effects on the Freshwater Environment.

3.2.4 Socioeconomic Environment

The HTGS property is bounded to the west by a section of the linear NL Trailway adjacent to Conception Bay and an area of treed land adjacent to Duff's Road, to the north by Indian Pond, to the east by Quarry Brook and Indian Pond, and to the south by the Conception Bay Highway, Route 60, Figure 3-1. This property is on the boundary of the Town of Conception Bay South on the east and the Town of Holyrood on the west and the northern and eastern property boundaries follow the boundary between the two towns. The nearest residences are located in the community of Seal Cove, in the Town of Conception Bay South, approximately 50 m east of the HTGS property and 450 east of the diesel generators. The nearest residences in the Town of Holyrood are located on Duffs Road approximately 700 m south of the HTGS property and approximately 1000 m from the diesel generators.

The HTGS has been in operation since 1971 and the HTGS Management strives to promote open and clear communication between HTGS and area residents and organizations. To facilitate this, HTGS Management, in cooperation with local municipalities and provincial government agencies, established a Community Liaison Committee (CLC) in 1998 whose purpose is to provide open communication with area stakeholders and provide them with an avenue to bring forward concerns on environmental or other issues relating to operation of the plant.

The objectives of the HTGS CLC are:

1. To facilitate a high level of communication between the HTGS and area residents, municipal representatives and Holyrood plant staff.

2. To create a mechanism whereby issues of concern to any of the CLC members can freely and objectively be discussed.

3. To enhance public confidence in the day-to-day operations of the HTGS.

4. To serve as a vehicle to seek and provide accurate information to the community in order to foster a greater understanding of the activities of the HTGS.

5. To provide a forum through which representatives of the energy corporation, and various provincial and federal government departments, as members of the CLC, or invited guests, can address the CLC on specific topics of community concern.

The CLC is comprised of a balanced representation consisting of at least eight and no more than 14 participants. The CLC consists of a membership structured as follows:

1. Two representatives from the Town Councils of Holyrood and Conception Bay South, unless any of these Towns should choose to be represented by one person only. These representatives shall be appointed by the respective Town Councils.

2. One community representative each from Conception Bay South and the Town of Holyrood. These representatives shall be appointed by the CLC.

3. One representative from each of the following Provincial Government Departments: Health & Community Services and, Municipal Affairs and Environment. These representatives shall be appointed by the Provincial Government.

4. The HTGS Plant Manager, Manager Safety, Health and Environment, Manager Communication – NL Hydro, and IBEW representative, or their designate. These representatives shall be appointed by the HTGS Plant Manager.

NL Hydro has consulted with the CLC as part of planning for this Project. A summary of the proposed Project including the Project description and need, the environmental approval requirements, and the key environmental considerations, as identified in this environmental assessment registration, were presented at a scheduled CLC meeting on May 24, 2017. Comments and discussion points were recorded as minutes of the meeting. The comments received related to:

- The project rationale/need (section 2);
- The height of the exhaust stacks relative to the visual landscape (section 2.4.1 and section 3.2.4);
- Noise levels resulting from operation of the diesel generators (section 3.2.1.3); and
- Potential effects of exhaust emissions on ambient air quality (section 3.2.1).

These comments were considered when finalizing this Project EA registration document.

Construction and Operations

Project construction will be characterized by fairly standard and non-intrusive activities and practices which will occur within a small and localized area over a relatively short period. The proposed Project site is located within an existing and long-standing industrial area on the boundary of the communities of Holyrood and Conception Bay South, and is not expected to interact negatively with the communities or their residents. The proposed Project site is currently within the boundaries of the fenced and gated HTGS property with no public access. Although the Project will result in the addition of eight meter high stacks on each of the six diesel generator enclosures, these will be surrounded by existing buildings, tanks and other structures on the HTGS property and are not expected to result in any significant change in the visual landscape for residents and other users of land and waterways in the area. As well, as discussed in section 3.2.1.3, sound levels both on the HTGS property and in adjacent areas are not expected to change significantly as a result of operation of the diesel generators, and are not be expected to result in any change to the enjoyment and use of adjacent properties.

Some development projects can result in increased demands on local services and infrastructure. Given the relatively small size and duration of the Project's construction labour requirements (section 2.5) and because its operations will not increase or otherwise change NL Hydro's current labour force at the HTGS, no adverse effects related to the availability or quality of community services and infrastructure are anticipated.

Project construction will be carried out by a qualified and experienced contractor selected by NL Hydro through a competitive bid process. The project will therefore create business opportunities during its construction phase, and the requirement for labour and for goods and services during Project construction may provide opportunities for local and provincial workers and businesses.

Environmental Effects Summary and Evaluation

The proposed Project is not likely to result in significant adverse environmental effects on the Socioeconomic Environment.

3.3 Environmental Monitoring and Follow-up

Any potential environmental issues which may be associated with the Project can be addressed and mitigated through the use of good construction and operational practices and procedures. These will be further addressed through the specific environmental permitting requirements and compliance standards and guidelines which will apply to Project activities and components.

Once operational, the Project will be subject to regular inspections and maintenance as required. The Proponent is committed to obtaining all required authorizations for the proposed Project, and to complying will all applicable regulations.

NL Hydro is committed to maintaining an effective ambient air monitoring program associated with operations at the HTGS, as detailed in Section 3.2.1. This program will be applied to monitor the impact of air emissions resulting from operation of the diesel generators on the ambient air in communities adjacent to the HTGS.

The HTGS also implements a fuel monitoring program including daily inspections and weekly fuel reconciliation of receipts and withdrawals from all storage tanks in compliance with the requirements of the *Storage and Handling of Gasoline and Associated Products Regulations*. This program will be applied to fuel storage associated with the diesel generator system.

Although HTGS also implements a monitoring program associated with waste water discharges, this is not directly applicable to the diesel generation system as there are no associated waste water discharges.

As part of its ISO 14000 compliant Environmental Management System, NL Hydro strives for continual improvement of its environmental management including its environmental controls and operations. This includes annual audits of its Environmental Management System by independent Environmental Management System Auditors. Any non-conformances or program weaknesses identified by the audits or by internal inspections are reviewed and action plans developed to ensure that corrective actions are implemented in a timely manner.

4.0 SUMMARY AND CONCLUSION

NL Hydro is proposing to modify the operation of six – 1.825 MW diesel generators that are presently providing black start power for the HTGS to also provide reliable generation capability for the IIS, if required to meet load requirements during peak demand and possible contingency situations. The proposed Project involves modified operation of the existing six – 1.825 MW diesel generators at the HTGS in order to add an additional 8 MW of reliable capacity for peaking power requirements and 6 MW of reliable capacity for emergency power requirements. As the Holyrood diesel generation replaced a combustion turbine facility of similar capacity that was no longer suitable for use, their original installation did not require registration for environmental assessment under the NL EPA. However, as the proposed modified use will add additional reliable capacity to the IIS in excess of 1 MW, NL Hydro has registered the project as an undertaking for under Section 49 of the NL EPA.

Use of the Holyrood diesel generators for IIS requirements is projected to only be required for peak demand periods or when other sources of generation are not available due to outages. The availability of these units is identified in NL Hydro's latest *Energy Supply Risk Assessment* to help mitigate potential capacity shortfall during extreme cold weather conditions. The requirement for operation of the Holyrood diesel generators to supplement Avalon Reserves and generation requirements will be greatly reduced following the completion of construction of a new transmission line between the Avalon Peninsula and the Bay d'Espoir Generating Station in late 2017, as well as the completion of a transmission line interconnecting Muskrat Falls power to the Island of Newfoundland. However, the Holyrood diesel generators will continue to play an important role in NL Hydro's fleet by providing operational flexibility and capacity.

All electrical components are presently in place to enable utilization of the six – 1.825 MW diesel generators as part of the IIS, in addition to their use for black start capacity at the HTGS. However, changes are proposed to the exhaust, fuel handling, and electrical cable systems for the diesel units to improve availability and reliability of the units for inclusion in the IIS capacity.

The six diesel generators are wholly located on the HTGS property, which is located on the boundary of the Communities of Holyrood and Conception Bay South, and has been utilized for generation of electrical energy using thermal generation sources since 1971. The diesel generators were installed on the property in 2014.

Key environmental aspects associated with thermal generation operations, such as the diesel generators, include air emissions produced from the combustion of distillate fuels, noise produced as a result of operation of the diesel generators, and the security of fuel handling. NL Hydro has undertaken studies to evaluate the potential environmental effects associated with each of these areas of concern and identify mitigation that will be put in place to manage and minimize the associated risks.

In order to evaluate potential changes to ambient air quality associated with the greater utilization of the Holyrood diesel generators, NL Hydro contracted IEC to undertake air emission modelling of projected emission from HTGS thermal generation sources in combination with the possible diesel generator production scenarios. Both a peaking production scenario and an emergency production scenario were modelled. For the peaking production scenario the maximum concentrations of all air emissions of concern are predicted to be compliant with applicable AAQS for all averaging periods and modelling years when generation capacity on the diesel generators is 8 MW or less. For the emergency production scenario the maximum concentrations of all air emissions of concern are predicted to be compliant with applicable AAQS for all averaging periods and modelling years when generation capacity on the diesel generators is 6 MW or less. NL Hydro will put in place operational controls to limit production from the Holyrood diesel generators to a maximum of 8 MW for peaking production and 6 MW for emergency production uses.

As the diesel generators are already operational on the HTGS site as a result of their requirement for black start capability, HTGS personnel were able to conduct sound level measurements with the diesel generators operating to document the ambient sound levels. Although sound levels increased at all locations monitored when the diesel generators were operating, with higher increases occurring closer to the generators, the level of increase was low. The maximum sound level recorded when the diesel generators were operating, 77.0 dBa, was directly adjacent to the diesel generators and diminished to a range of 45.2 to 55.3 dBa at the property fenceline. All levels recorded were below the permissible noise level for occupational noise exposure.

The fuel handling system is designed to be compliant with all industry standards and the provincial *Storage and Handling of Gasoline and Associated Products Regulations*. Fuel system inspection and fuel reconciliation processes will be instituted to ensure early detection of leaks or spills. Any indication of losses will be investigated and the HTGS *Emergency Response Manual* will be followed for response to any emergency situation involving the diesel generators.

5.0 REFERENCES

Independent Environmental Consultants, 2017. CALPUFF Air Dispersion Modelling Assessment for the Holyrood Generating Station. Prepared for NL Hydro, St. John's, NL. February 2017

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NL Hydro, 2015. Newfoundland and Labrador Conservation and Demand Management Potential Study: 2015. Submitted to The Board of Commissioners of Public Utilities by Newfoundland and Labrador Hydro, May, 2016.

NL Hydro, 2016. Energy Supply Risk Assessment. Submitted to The Board of Commissioners of Public Utilities by Newfoundland and Labrador Hydro, November, 2016.

APPENDIX A

List of Potentially Applicable Permits and Authorizations

APPENDIX A List of Potentially Applicable Permits and Authorizations (Provincial, Federal, Municipal)

Approval Potentially Required	Legislation / Regulation	Project Component / Activity Requiring Approval or Compliance	Department or Agency	Requirements
Government of Newfoundland and Labrador				
Certificate of Approval for Construction Site Drainage	*Water Resources Act*	Any run-off from the project site being discharged to receiving waters	Water Resources Management Division, Department of Municipal Affairs and Environment	Approval is required for any run-off from the project site being discharged to receiving waters.
Policy Directives	*Water Resources Act*	Project activities (as applicable)	Water Resources Management Division, Department of Municipal Affairs and Environment	The Department has a number of potentially applicable policy directives in place for particular types of in or near water work
Quarry Permit	*Quarry Materials Act* and Regulations	Extracting borrow material	Mineral Lands Division, Department of Natural Resources	A permit is required to dig for, excavate, remove and dispose of any Crown quarry material.
Certificate of Approval for Storing and handling Gasoline and Associated Products	*Environmental Protection Act, Storage and Handling of Gasoline and Associated Products Regulations*	Storage and handling of gasoline and associated products	Engineering Services Division, Services NL	A Certificate of Approval is required for storing and handling gasoline and associated products.
Certificate of Approval for Installation of a Sewage System	*Sanitation Regulations,* under the *Health and Community Services Act*	Sewage disposal and treatment at construction camps	Department of Health and Community Services	Sewage disposal systems designed, constructed or installed to service a private dwelling or a commercial or other building with a daily sewage flow less than 4,546 L must be approved by an inspector before installation.
Compliance Standard	*Fire Prevention Act,* and *Fire Prevention Regulations*	On-site structures (temporary or permanent)	Engineering Services Division, Service NL	All structures must comply with fire prevention standards.
Compliance Standard	*Environmental Control Water and Sewage Regulation* under the *Water Resources Act*	Any waters discharged from the Project	Pollution Prevention Division, Department of Municipal Affairs and Environment	A person discharging sewage and other materials into a body of water must comply with the standards, conditions and provisions prescribed in these regulations for the constituents, contents or description of the discharged materials.

Approval Potentially Required	Legislation / Regulation	Project Component / Activity Requiring Approval or Compliance	Department or Agency	Requirements
Compliance Standard	*Occupational Health and Safety Act* and Regulations	Project-related occupations	Service NL	Outlines minimum requirements for workplace health and safety. Workers have the right to refuse dangerous work. Proponents must notify Minister of start of construction for any project greater than 30 days in duration.
Compliance Standard	*Workplace Hazardous Materials Information System (WHMIS) Regulations*, under the *Occupational Health and Safety Act*	Handling and storage of hazardous materials	Operations Division, Service NL	Outlines procedures for handling hazardous materials and provides details on various hazardous materials.
Government of Canada				
Letter of Notification	*Fisheries Act* and *Regulations*	Project activities in or near water	Department of Fisheries and Oceans	Where a potential for harmful effects to fish habitat can be prevented, a Letter of Notification is issued outlining appropriate mitigation procedures or conditions to be followed.
Permit(s) for construction within Navigable Waters	*Navigation Protection Act* Associated *Regulations*	Project activities in or across water	Transport Canada	Permit required only within scheduled waters. There are no scheduled waters involved, however, any “non-scheduled” waters are subject to the Act if the owner wishes to opt-in.
Compliance Standard	*Fisheries Act*, Section 36(3), Deleterious Substances	Any run-off from the project site being discharged to receiving waters	Environment Canada Department of Fisheries and Oceans	Environment Canada is responsible for Section 36(3) of the *Fisheries Act*. However, DFO is responsible for matters dealing with sedimentation. Discharge must not be deleterious and must be acutely non-lethal.
Compliance Standard	*Migratory Birds Convention Act* and *Regulations*	Any activities which could result in the mortality of migratory birds and	Canadian Wildlife Service, Environment Canada	Prohibits disturbing, destroying or taking a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird,

Approval Potentially Required	Legislation / Regulation	Project Component / Activity Requiring Approval or Compliance	Department or Agency	Requirements
		endangered species and any species under federal authority		and possessing a live migratory bird, carcass, skin, nest or egg, except when authorized by a permit. The Canadian Wildlife Service should be notified about the mortality of any migratory bird in the project area.
Compliance standards; permits may be required.	National Fire Code	On-site structures (temporary or permanent)	Service NL	Approval is required for fire prevention systems in all approved buildings.
Compliance standards; permits may be required.	National Building Code	On-site structures (temporary or permanent)	Service NL	Approval is required for all building plans.
Municipalities				
Development or Building Permit	*Urban and Rural Planning Act, 2000,* and Relevant Municipal Plan and Development Regulations	Development within municipal boundary	Community Council	A permit is required for any development or building within municipal boundaries.
Approval for Waste Disposal	*Urban and Rural Planning Act, 2000,* and Relevant Municipal Plan and Development Regulations	Waste disposal	Community Council	The use of a community waste disposal site in Newfoundland and Labrador by proponents/contractors to dispose of waste requires municipal approval. Restrictions may be in place as to what items can be disposed of a municipal disposal site.

APPENDIX B

CALPUFF Air Dispersion Modelling Assessment for the Holyrood Thermalo Generating Station

Independent Environmental Consultants (IEC)

February 2017

CALPUFF AIR DISPERSION MODELLING ASSESSMENT FOR THE HOLYROOD THERMAL GENERATING STATION

Independent Environmental Consultants (IEC)

February 2017

CALPUFF AIR DISPERSION MODELLING FOR THE HOLYROOD GENERATING STATION

Prepared for:

newfoundland labrador hydro
a nalcor energy company

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Executive Summary

Newfoundland and Labrador Hydro (NL Hydro, a division of Nalcor Energy) operates a 500 megawatt (MW) oil-fired thermal generating station in Holyrood, Newfoundland and Labrador known as the Holyrood Thermal Generating Station (HTGS) (the Facility). The main HTGS plant is comprised of three thermal generators (Units 1, 2, and 3). In addition, the Facility operates a 123 MW diesel-fired combustion turbine generator (the CT) and is seeking approval for six (6) diesel-fired black start generators each having a nominal rating of 2 MW.

Independent Environmental Consultants (IEC) was retained by NL Hydro to undertake dispersion modelling for the years 2012 through 2015 to evaluate the compliance status of the HTGS units, the CT, and the operation of the black start diesel generators. This study is an update to some previous work completed for the Facility by SNC-Lavalin (SNC) in May 2014.

For this assessment, air dispersion modelling was completed using the CALMET/CALPUFF modelling package to predict ground level concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ resulting from the operation of the HTGS, the CT, and the black start diesel generators. The meteorological data set was developed using the mesoscale model WRF-NMM, which in turn was used to generate hourly surface data (wind speed, wind direction, temperature, cloud cover, etc.) and upper air profiles for seventeen (17) “pseudo” station locations within the CALMET domain. The resulting pseudo observations were used to run the CALMET model.

Two types of production scenarios were assessed: peaking demand production and emergency demand production. Two peaking scenarios were evaluated which were based on the concurrent operation of HTGS Units 1, 2 and 3, the CT, and the black start diesel generators. For the emergency scenario, only emissions from the black start generators were assessed as the HTGS units and CT would be non-operational under such circumstances. Only one emergency production scenario was evaluated. The production scenarios assessed can be summarized as follows:

- Scenario A (Peaking Production):
    - Operation of the HTGS based on NL Hydro’s **2003** hourly power production data
    - Operation of the CT at 100% load, 24 hours per day
    - Operation of five black start diesel generators at 87% load during the hours of 6 am to 10 am and 4 pm to 8 pm (inclusive)
    - All units operate from January 1 to April 30 and from November 1 to December 31.
- Scenario B (Peaking Production):
    - Operation of the HTGS based on NL Hydro’s **2004** hourly power production data

    - Operation of the CT at 100% load, 24 hours per day
    - Operation of five black start diesel generators at 87% load during the hours of 6 am to 10 am and 4 pm to 8 pm (inclusive)
    - All units operate from January 1 to April 30 and from November 1 to December 31
- Scenario C (Emergency Emergency):
    - Operation of five black start diesel generators at 67% engine load, 24 hours per day, 365 days per year.

Based on the above production scenarios, pollutant emissions, stack exit temperature, and stack exit velocity were varied on an hourly basis within CALPUFF. Emissions estimates for the HTGS and CT were based on the 2014 SNC work and emissions from the black start diesel generators were based on manufacturers' specifications.

The model results show that the maximum predicted ground level concentrations for all pollutants and averaging periods are below their respective provincial Ambient Air Quality Standards (AAQS) for both the peaking production and emergency production scenarios. For both peaking and emergency demand production, NO_2 is the pollutant with the highest predicted maximum concentration relative to its AAQS. NO_2 concentrations are similar between the two peaking scenarios (i.e. Scenarios A and B) and the overall maximum 1-hour NO_2 concentration is predicted to be 389.1 µg/m³, while the overall maximum 24-hour NO_2 concentration is 120.0 µg/m³. For the emergency scenario, the maximum predicted 1-hour NO_2 concentration is 345.4 µg/m³, and the maximum predicted 24-hour NO_2 concentration is 199.4 µg/m³.

Depending on the modelling year and production scenario, 1-hour, 3-hour, and 24-hour SO_2 concentrations were predicted to be more than 50% of the AAQS. Across the two peaking production scenarios, the overall maximum 1-hour, 3-hour and 24-hour SO_2 concentrations are predicted to be 754.9 µg/m³, 472.6 µg/m³, and 250.5 µg/m³, respectively. For the emergency production scenario, SO_2 concentrations are predicted to be less than 0.5% of the AAQS.

For the remaining pollutants (TSP, PM_{10}, $PM_{2.5}$, and CO), predicted concentrations are well below 50% of the AAQS for both the peaking and emergency demand scenarios. The maximum 24-hour concentration of $PM_{2.5}$ is predicted to be less than 35% of the AAQS for peaking production, and less than 10% of the AAQS for emergency production. For both peaking and emergency demand production, CO concentrations are predicted to be less than 0.5% of the applicable AAQS.

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1.0 INTRODUCTION

Newfoundland and Labrador Hydro (NL Hydro, a division of Nalcor Energy) operates a fossil-fuel fired thermal generating station in Holyrood, Newfoundland and Labrador known as the Holyrood Thermal Generating Station (HTGS) (the Facility). The main HTGS plant is comprised of three oil-fired thermal generators (Units 1, 2, and 3) having a total power output of 500 megawatts (MW). In January 2015, a diesel-fired combustion turbine generator (the CT) was commissioned, adding 123 MW of generating capacity to the site. The Facility is currently seeking approval for six (6) diesel-fired black start generators each having a nominal generating capacity of 2 MW. Figure 1 shows the general location of the Facility and Figure 2, Figure 3, and Figure 4 provide photographs of the HTGS units, the CT, and the black start generators, respectively.

Independent Environmental Consultants (IEC) was retained NL Hydro to undertake air dispersion modelling to evaluate the compliance status of the HTGS (Units 1, 2 and 3), the CT, and the operation of the black start diesel generators. Modelling was performed using the CALMET/CALPUFF package to predict ground-level concentrations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particulate (TSP), particulate matter less than 10 microns (PM_{10}) and particulate matter less than 2.5 microns ($PM_{2.5}$). This current study is an update to a previous compliance report completed by SNC-Lavalin (SNC) in May 2014 (SNC, 2014). Both this study and the SNC study used the CALPUFF/CALMET air dispersion modelling system; however, there are some key differences to note between the methodologies employed by IEC and SNC:

- In this current study, modelling was performed using meteorology for the years 2012-2015, whereas the SNC study considered the period 2009-2012 (SNC, 2014). The meteorological data set used is this study has also been refined by using outputs from the WRF-NMM weather model and by employing a refined CALMET processing method using a 100 m by 100 m meteorological grid to better resolve the land use and terrain around Indian Pond. This approach was developed by IEC staff members with input from staff at the Department of Environment and Climate Change[1] (DOECC), and was used historically for this Facility.
- The SNC model considered two groups of emissions sources: three oil-fired units in the main HTGS plant; and the CT, which was new at the time of the SNC study (SNC, 2014). The production and emissions data for these two groups of sources have not been

[1] Formerly known as the department of Environment and Conservation (DOEC)

updated for this current study. The exception is SO_2 from the CT – this emission rate was refined based on a sulphur content of 15 mg/kg instead of 500 mg/kg in order to be consistent with the *Sulphur in Diesel Fuel Regulations* (CAN/CGSB-3.517-2007). In addition, some minor refinements were made to the location of the CT source based on revised site drawings.

- This current study considers the addition of six (6) diesel-fired black start generating units, each rated at 2 MW and exhausting to the atmosphere via their own stack.

To evaluate the air quality impacts of the Facility's emissions, maximum modelled ground-level concentrations of NO_2, SO_2, CO, TSP, PM_{10} and $PM_{2.5}$ were compared to the ambient air quality standards (AAQS) outlined in Schedule A of the Air Pollution Control Regulation, 2004 (NLR 39/04). The applicable AAQS are provided in Table 1 for reference.

Table 1: Newfoundland and Labrador Ambient Air Quality Standards

Pollutant	Ambient Air Quality Standard (µg/m³)				
	1-hour	3-hour	8-hour	24-hour	Annual
SO_2	900	600		300	60 [1]
NO_2	400			200	100 [1]
CO	35,000		15,000		
TSP				120	60 [2]
PM_{10}				50	
$PM_{2.5}$				25	8.8 [3]

Source: AAQS from Schedule A of the *Air Pollution Control Regulation, 2004 (NLR 39/04)*
Notes:
All AAQS at standard reference conditions
[1] Arithmetic mean
[2] Geometric mean
[3] The three-year average of the annual average concentrations

1.1 REPORT STRUCTURE

The air dispersion modelling assessment and this report were completed to conform to guidance published by the Newfoundland and Labrador Department of Environment and Climate Change (DOECC), formerly known as the Department of Environment and Conservation (DOEC):

- *Guideline for Plume Dispersion Modelling*. GD-PPD-019.2, Newfoundland and Labrador Department of Environment and Conservation (DOEC, 2012a); and
- *Determination of Compliance with the Ambient Air Quality Standards*. GD-PPD-009.4, Newfoundland and Labrador Department of Environment and Conservation (DOEC, 2012b).

In addition to this introductory chapter of the report, Section 2 provides a description of the Facility and the production/emissions scenarios that were modelled, and Section 3 outlines the CALMET/CALPUFF methodology that was followed. The results of the modelling assessment are discussed in Section 4, while the overall conclusions of the study are presented in Section 5.

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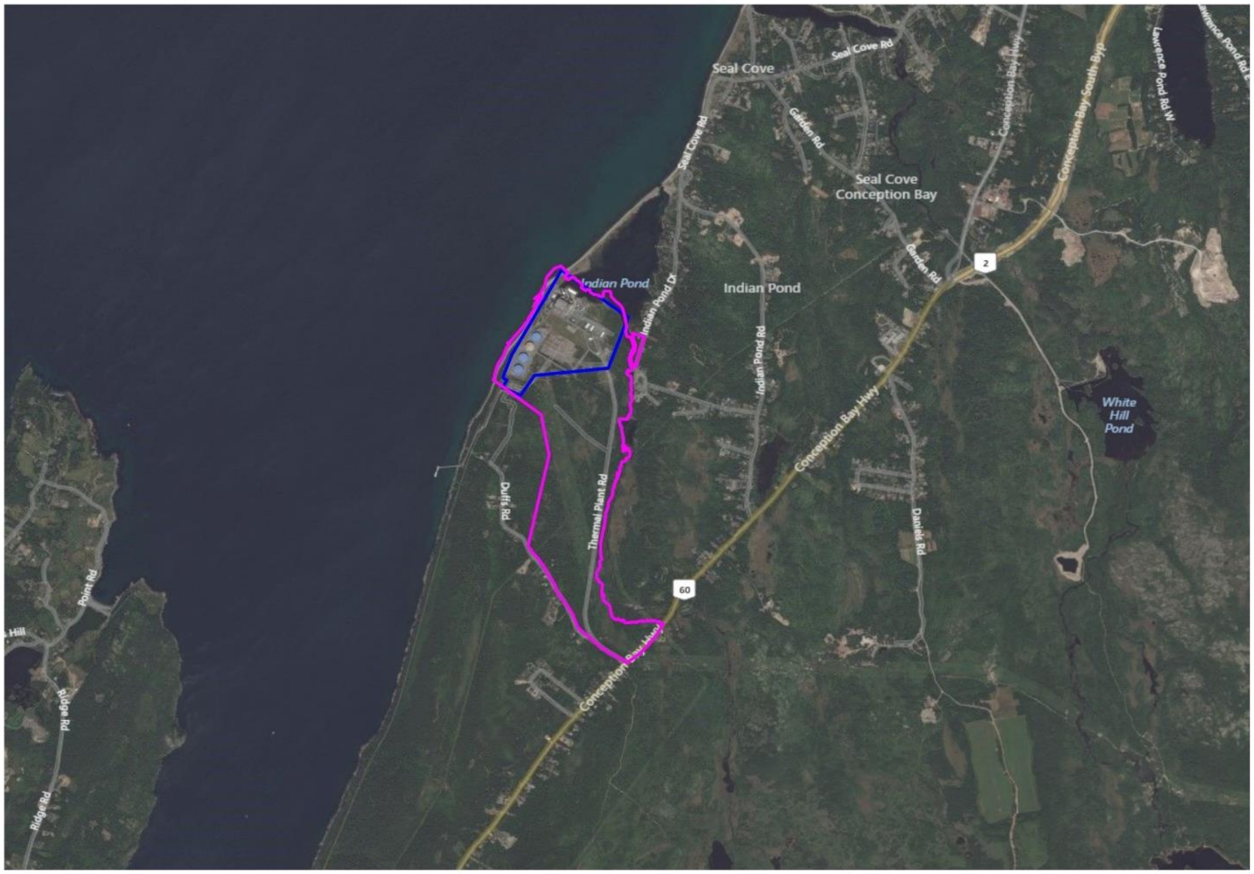


Legend

Administrative Boundary

Legal Property Boundary

Notes

Image Source: Bing Maps 2016

Scale (m)

0 500 1000 1500

Independent Envrionmental Consultants

Nalcor Energy

Holyrood Thermal Generating Station

Figure 1

Site Location Plan

Project	Date
SX15-0002-001-05	Feb. 2017

Figure 2: Site Photograph showing HTGS Units 1, 2 and 3

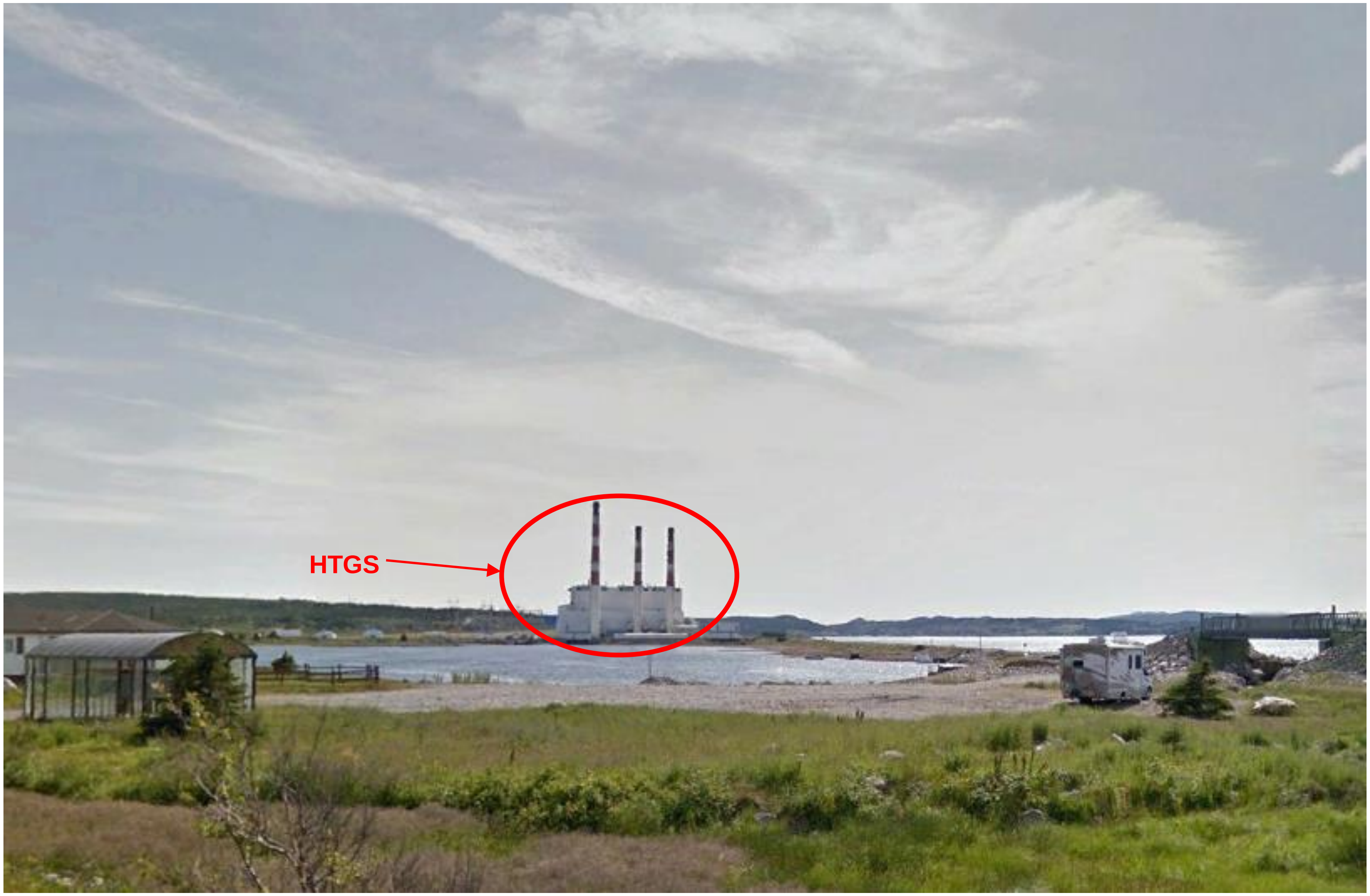


Figure 3: Site Photograph showing the Combustion Turbine Building

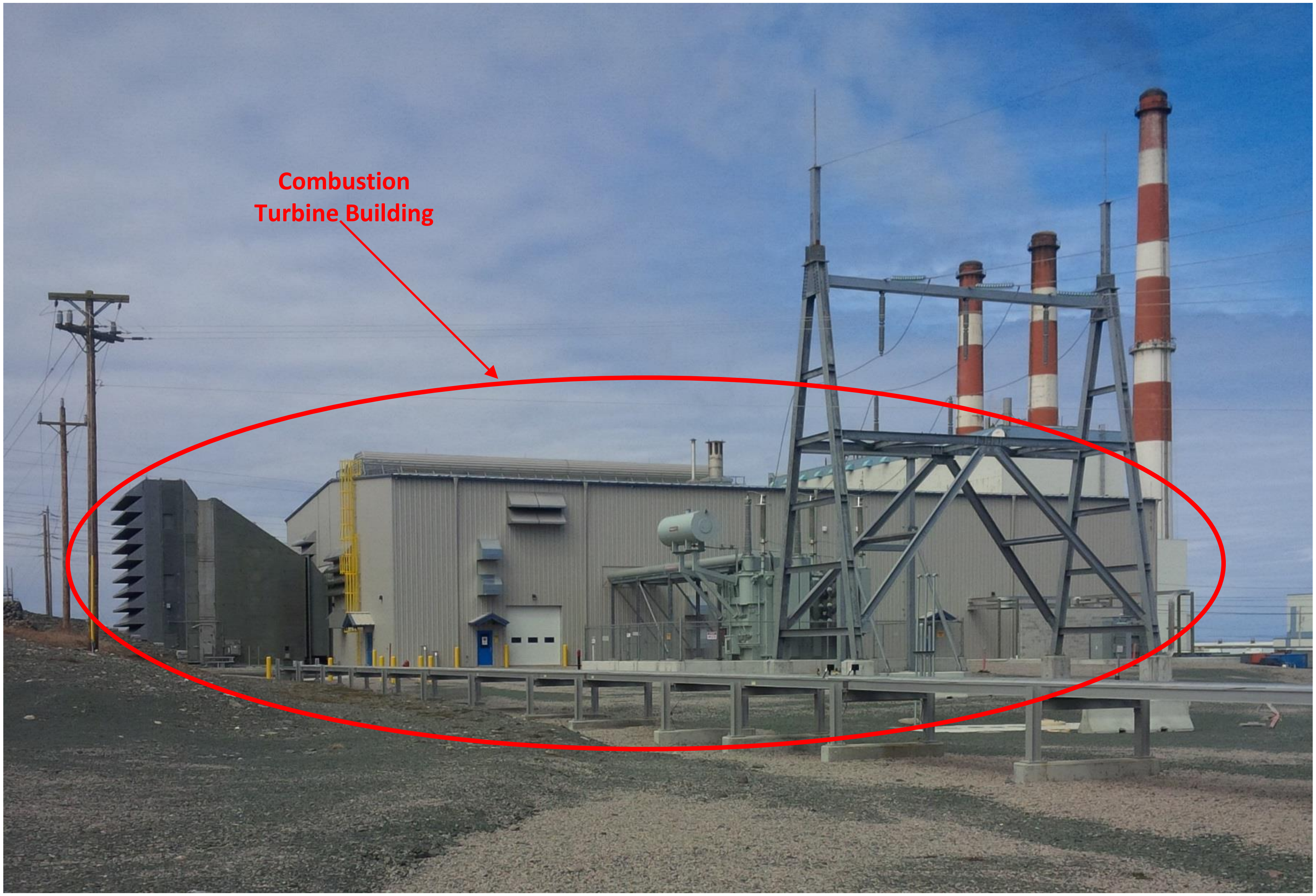


Figure 4: Site Photograph showing the Black Start Diesel Generators

2.0 FACILITY DESCRIPTION

The HTGS facility consists of three types of power generation units:

- The main Holyrood Thermal Generating Station (HTGS) is comprised of two 175 MW units (Units 1 and 2) and one 150 MW unit (Unit 3), each exhausting through their own independent stack. The fuel used in all three units is Bunker C fuel oil.
- The Combustion Turbine (CT) is a 123 MW diesel-fired combustion turbine generator. The CT is located in its own building southeast of the main HTGS units and exhausts through its own stack.
- Six (6) trailer-mounted black start diesel generators rated at 2 MW each, that are located in the yard west of the CT building. Each unit exhausts to the atmosphere through its own stack. Only five (5) out of six (6) units are ever operated simultaneously.

Details about the HTGS facility including building and stack information, production scenarios, and emission rates are outlined below.

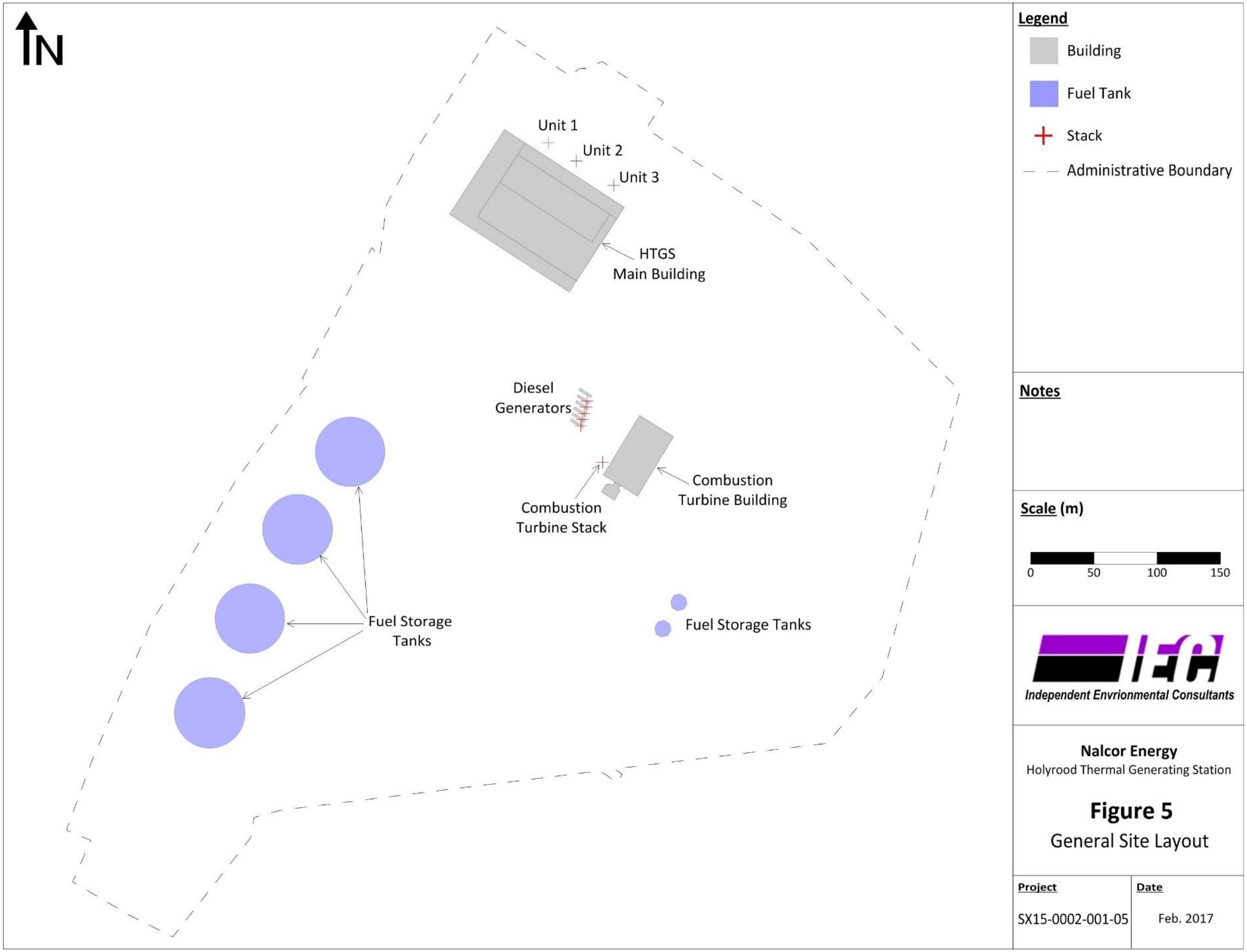
2.1 BUILDING AND STACK INFORMATION

A scaled general site layout is illustrated in Figure 5 which shows the main buildings and structures used in the model, as well as the locations of the modelled exhaust stacks and the administrative property boundary. The main HTGS building, the CT building and fuel tanks were considered in the BPIP Prime building downwash calculations (see section 3.3.2). Other structures also included in BPIP Prime include the diesel generator trailers. Table 2 presents the stack parameters for the various emissions sources.

Table 2: Stack Parameters

Source	Maximum Generating Capacity (MW)	UTM Easting (m)	UTM Northing (m)	Base Elevation (m)	Height Above Grade (m)	Stack Diameter (m)	Exit Temperature (K) [1] [2] [3]	Flow Rate (m^3/min) [1] [2] [3]
HTGS Unit 1	175	341882	5257701	10	91.44	4.115	466 to 479	12,770 to 14,360
HTGS Unit 2	175	341904	5257687	10	91.44	4.115	463 to 473	12,770 to 14,360
HTGS Unit 3	150	341934	5257668	10	109.72	3.048	442 to 449	8,320 to 9,200
CT	123	341929	5257455	13	15.24	7.650	782.0	57,914
Black Start Diesel Generators	2.0	341905	5257468	13	4.26	0.305	642.3 (623.9)	376.6 (326.7)
	2.0	341906	5257473	13	4.26	0.305	642.3 (623.9)	376.6 (326.7)
	2.0	341907	5257478	13	4.26	0.305	642.3 (623.9)	376.6 (326.7)
	2.0	341909	5257483	13	4.26	0.305	642.3 (623.9)	376.6 (326.7)
	2.0	341910	5257488	13	4.26	0.305	642.3 (623.9)	376.6 (326.7)

Notes:
[1] Exhaust temperature and flow rate for Unit 1, 2, and 3 of the main HTGS vary hourly based on production. The typical ranges from the SNC report (SNC, 2014) are reproduced in the table.
[2] CT flow rate and exit temperature based on 100% load.
[3] Black start diesel generator flow rates and exit temperatures based on 87% load (67% load in brackets).



Nalcor Energy
Holyrood Thermal Generating Station

Figure 5
General Site Layout

Project	Date
SX15-0002-001-05	Feb. 2017

2.2 Production Scenarios

For this modelling study, two types of production scenarios were evaluated: peaking demand production and emergency demand production. Two peaking scenarios were evaluated assuming the concurrent operation of HTGS Units 1, 2, and 3, the CT, and the black start diesel generators. The peaking production scenarios were based on NL Hydro's maximum load estimates for the CT and diesel generators and typical maximum operations of the HTGS units, which were developed historically by SNC based on 2003 and 2004 production. Both 2003 and 2004 production were evaluated.

While the diesel generators are reserved to provide black start capability for the Facility, they are sometimes operated to provide supplemental generating capacity during peak load operations. It is also possible for the diesel generators to be used during an emergency situation to provide power. During this situation, only the black start generators would operate. This emergency demand scenario was also evaluated.

The modelled production scenarios can be summarized as follows:

- Scenario A (Peaking Production):
  - Operation of HTGS Units 1, 2, and 3 based on **2003** hourly production data
  - Operation of the CT at 100% load, 24 hours per day
  - Operation of five black start diesel generators at 87% load during the hours of 6 am to 10 am and 4 pm to 8 pm (inclusive)
  - All units operate from January 1 to April 30 and from November 1 to December 31. There are no operations between May 1 and October 31.
- Scenario B (Peaking Production):
  - Operation of HTGS Units 1, 2, and 3 based on **2004** hourly production data
  - Operation of the CT at 100% load, 24 hours per day
  - Operation of five black start diesel generators at 87% load during the hours of 6 am to 10 am and 4 pm to 8 pm (inclusive)
  - All units operate from January 1 to April 30 and from November 1 to December 31. There are no operations between May 1 and October 31.
- Scenario C (Emergency Production):
  - Operation of five black start diesel generators at 67% engine load, 24 hours per day, 365 days per year.

It should be noted that the 2003 and 2004 HTGS production scenarios (i.e. Scenarios A and B) are considered to be a conservative representation of typical operations for the HTGS. In these scenarios, all three units generally operate together 24 hours per day, although the production level for each unit varies by hour. Assuming continuous operation at 100% load for the CT is also conservative.

Peaking production scenarios without the operation of the black start generators were also assessed for the purposes of comparing modelled concentrations from the HTGS units and the CT to available SO_2 and NO_2 monitoring data. These scenarios were not used to assess compliance against applicable AAQS, but rather used to evaluate the performance of the dispersion model.

2.3 AIR EMISSIONS

Air emissions from each stack are related to the combustion of fuel (either Bunker C fuel oil or diesel) and primarily consist of sulphur dioxide (SO_2), oxides of nitrogen (NOx), carbon monoxide (CO) and particulate matter (PM). Hourly emissions rates for HTGS Units 1, 2, and 3 and the CT were developed historically by SNC and used directly in this study without modification. The exception is SO_2 emissions from the CT. The sulphur content was revised to 15 mg/kg from 500 mg/kg to align with the *Sulphur in Diesel Fuel Regulations* (CAN/CGSB-3.517-2007). As noted in Section 2.2, production for the HTGS units varied by hour whereas the production level for the CT was held constant at an assumed load of 100%. Emissions rates for HTGS Units 1, 2, and 3 and the CT are reproduced in Table 3.

Hourly emissions rates for the black start diesel generators were based on manufacturers' specifications provided by NL Hydro and are summarized in Table 3. For the peaking scenarios, emissions were based on 87% load and for the emergency scenario, 67% load. Emission rates for the generators were held constant during each operating hour. Operating hours were outlined previously in Section 2.2.

Emissions of SO_2 for all sources were based on the mass of sulphur in the fuel. HTGS Units 1, 2, and 3 burn low sulphur fuel oil which has a nominal sulphur content of 0.7% by mass (700 mg/kg) whereas the CT and black start diesel generators burn diesel fuel. For the CT and black start diesel generators, SO_2 emissions estimates were based on the assumption that the diesel fuel conforms to the *Sulphur in Diesel Fuel Regulations* (CAN/CGSB-3.517-2007), which specifies that the sulphur content must be less than 15 mg/kg.

Emissions of NO_2 and NO from the black start diesel generators were calculated using an in-stack NO_2/NOx ratio of 10%. This ratio was based on information contained in the U.S. EPA's *NO_2/NOx In-Stack Ratio (ISR) Database* (U.S. EPA, 2016) and confirmed by the DOECC (B. Lawrence, personal communication, 3 February 2017). NO_2 and NO emissions for the CT were conservatively based on a NO_2/NOx ratio of 60% in order to maintain consistency with the emissions estimates for the CT developed by SNC (2014). The procedure for calculating NO_2 and NO emissions from NOx emissions is the following:

$NO_2 = NOx \times NO_2/NOx \text{ ratio } (\%)$

and,

$NO = (NOx – NO_2) \times (\text{MW of NO} \div \text{MW of } NO_2) = (NOx – NO_2) \times (30 \div 46)$

where:

MW = molecular weight in g/mol.

Finally, it should be noted that emissions of particulate matter from the black start diesel generators and CT were assumed to be 100% $PM_{2.5}$ (i.e. TSP = PM_{10} = $PM_{2.5}$) based on the recommendation of the DOECC (B. Lawrence, personal communication, 4 Feb 2016).

Table 3: Emission Rates for HTGS, the Combustion Turbine and the Black Start Diesel Generators

Source	Production Scenario	Emission Rates (g/s)							
		Parameter	SO_2	NO	NO_2	CO	TSP	PM_{10}	$PM_{2.5}$
HTGS Unit #1	2003 Production	Min	34.0	5.5	0.10	0.052	2.0	1.4	1.1
		Max	166.5	26.8	0.48	0.256	10.0	6.8	5.4
		Average	132.1	21.2	0.38	0.203	7.9	5.4	4.2
	2004 Production	Min	27.0	4.3	0.08	0.042	1.6	1.1	0.9
		Max	167.6	26.9	0.48	0.258	10.1	6.8	5.4
		Average	123.3	19.8	0.35	0.190	7.4	5.0	4.0
HTGS Unit #2	2003 Production	Min	37.4	7.1	0.13	0.004	1.0	0.7	0.5
		Max	167.8	31.8	0.60	0.019	4.7	3.2	2.5
		Average	129.3	24.5	0.46	0.015	3.6	2.4	1.9
	2004 Production	Min	28.0	5.3	0.10	0.003	0.8	0.5	0.4
		Max	162.4	30.7	0.58	0.018	4.5	3.1	2.4
		Average	117.3	22.2	0.42	0.013	3.3	2.2	1.7
HTGS Unit #3	2003 Production	Min	48.6	17.5	0.62	0.003	2.0	2.0	1.8
		Max	142.6	51.4	1.83	0.010	5.8	5.8	5.2
		Average	118.6	42.8	1.52	0.008	4.9	4.9	4.3
	2004 Production	Min	36.1	13.0	0.46	0.003	1.5	1.5	1.3
		Max	142.7	51.5	1.83	0.010	5.8	5.8	5.2
		Average	110.2	39.7	1.42	0.008	4.5	4.5	4.0
CT	100% Load	Max	0.291	8.05	18.52	4.03	6.39	6.39	6.39
DG [1]	87% Load [2]	Max	0.0030	1.90	0.32	0.25	0.030	0.030	0.030
	67% Load [3]	Max	0.0025	1.21	0.21	0.22	0.028	0.028	0.028

Notes:
HTGS = Holyrood Thermal Generating Station
CT = Combustion Turbine
DG = Diesel Generator
[1] Emission rates are for each generating unit
[2] Used in the peaking production scenarios A and B described in Section 2.2.
[3] Used in the emergency production scenario C described in Section 2.2.

3.0 MODELLING METHODOLOGY

3.1 MODEL SELECTION

The CALMET/CALPUFF modelling system is the preferred regulatory model in Newfoundland and Labrador. CALMET is a meteorological model that produces hourly, three dimensional gridded wind fields from available meteorological, terrain, and land use data. CALPUFF is a non-steady state puff dispersion model that utilizes the CALMET wind fields and accounts for spatial changes in meteorology, variable surface conditions, and plume interactions with terrain. CALPUFF can handle both simple and complex terrain.

The HTGS facility is located in an area with complex terrain and is near the shoreline of the Conception Bay, Newfoundland, emphasizing the need to use CALPUFF to resolve these features. Version 7.0 of the CALMET and CALPUFF models were used in this assessment.

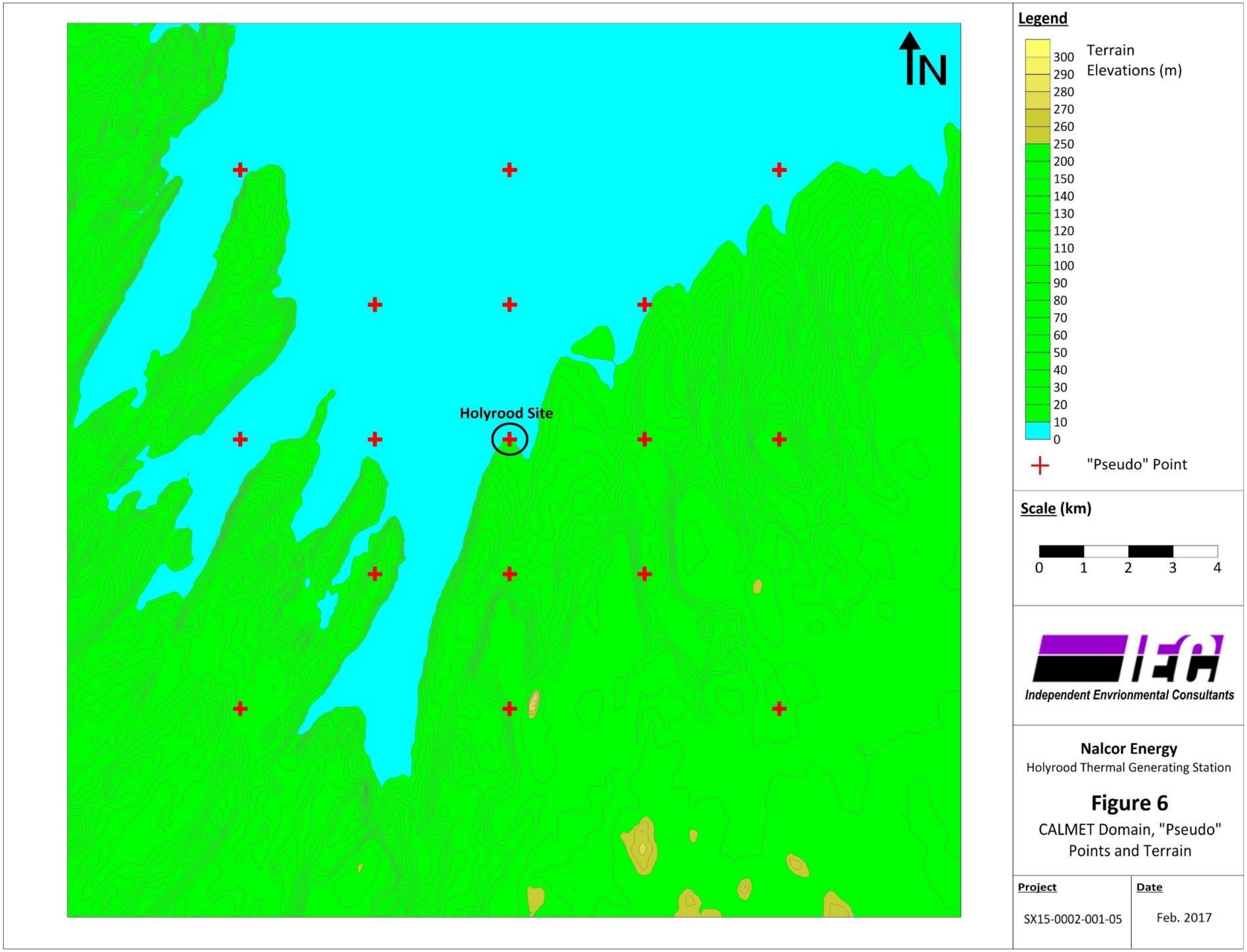
3.2 CALMET

The CALMET model was used to develop four (4) years of hourly meteorological data fields to use in CALPUFF. The most recent four years (2012 to 2015) of meteorological data were developed. The CALMET model was run over a large 20 km by 20 km modeling domain having a grid spacing of 100 m. Figure 6 presents the CALMET modelling domain.

The outputs from the CALMET model were used to capture the regional wind flow pattern and were used as the inputs into CALPUFF's air dispersion calculations. Ten vertical layers were included for the wind field. The layer heights are shown in Table 4.

Table 4: CALMET Wind Field Layer Heights

Vertical Height of Layer (m)	Height of Layer Top (m)	Notes
20	20	10-metre meteorology
20	40	30-metre meteorology
40	80	
80	160	
140	300	
300	600	
400	1000	
500	1500	
700	2200	
800	3000	


N
Holyrood Site
Legend
Terrain Elevations (m)
300
290
280
270
260
250
200
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
"Pseudo" Point
Scale (km)
0
1
2
3
4
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure 6
CALMET Domain, "Pseudo" Points and Terrain
Project
SX15-0002-001-05
Date
Feb. 2017

3.2.1 Meteorology

As outlined in DOECC guidance (DOEC, 2012a), CALMET can accept inputs from mesoscale meteorological models. The mesoscale model outputs can be directly applied to CALMET or used to generate hourly surface and upper air data. The latter approach was used for this assessment. The mesoscale model used was the Weather Research and Forecast (WRF) Non-Hydrostatic Mesoscale Model (WRF-NMM). WRF-NMM was initialized using archived Global Model analysis wind fields produced by the National Center for Environmental Prediction (NCEP). The Global analysis data is generated every 6 hours over a 30 km by 30 km grid and is based on all available surface and upper air observations. The WRF-NMM modelling was used to cover a large area with a horizontal resolution of approximately 3 km by 3 km. Additional details about the WRF-NMM model are provided under separate cover (IEC, 2016).

The output from the WRF-NMM model was used to generate hourly surface data in CD-144 format (wind speed, wind direction, temperature, cloud cover, etc.) as well as upper air profiles. Hourly surface and upper air data was generated for seventeen (17) locations in the CALMET modelling domain. The locations of the 17 “pseudo” stations are shown in Figure 6.

3.2.2 Terrain Data

Terrain data inputs for CALMET were processed through the TERREL program. TERREL is a pre-processor program provided with the CALMET/CALPUFF modelling system which accepts surface elevation data in a variety of formats to produce grid-cell averaged terrain files for use in the MAKEGEO processor. For this modelling assessment, Canadian Digital Elevation Model (CDED) files in 3 arcsecond format were used. CDED files are available online from Natural Resources Canada’s Geo-Gratis database (http://geogratis.gc.ca/).

The resulting gridded terrain file produced by TERREL is presented graphically in Figure 6. The outputs from TERREL were also used to assign ground elevations to the discrete receptors used in CALPUFF (see Section 3.3.1).

3.2.3 Land Use Data

Gridded land use classifications were provided by the DOECC for the CALMET meteorological domain. This land use data was further edited by IEC by recoding small inland water bodies (land use code 51) and large water bodies or (i.e. the ocean or land use code 55) to reflect times of the year when the water bodies are covered in ice. For such periods, the land use classification was changed to 90 (perennial snow or ice). Periods with sea ice were classified using Multisensor

Analyzed Sea Ice Extent (MASIE) data available from the National Ice Data Centre (NIC) (National Ice Center (NIC) and NSIDC, 2010). MASIE products include image files showing sea ice over the entire Northern Hemisphere with 16 separate Arctic regions identified. The input data comes from the 1 km and 4 km Interactive Multisensor Snow and Ice Mapping System (IMS) snow and ice product produced by the National Ice Center (NIC). NIC utilizes visible imagery, passive microwave data, and NIC weekly analysis products to create their data product.

The different time periods used to generate the CALMET land use files are outlined in Table 5 while the surface parameters used in CALMET are provided in the DOECC Plume Dispersion Modelling guidance document (DOEC, 2012a). However, the surface parameters are reproduced in Table 6 for completeness.

The resulting gridded land use file produced by MAKEGEO for the Non-Winter Period is provided in Figure 7. Additional periods are provided in Appendix A.

Table 5: Seasonal Land Use Periods used in CALMET

Season	Julian Days			
	2012[1]	2013	2014	2015
Non-winter	137-305	136-304	136-304	136-304
Winter **without** snow	92-136 and 306-366	91-135 and 305-365	91-135 and 305-365	91-135 and 305-365
Winter **with** snow	1-91	1-90	1-90	1-90
Frozen Ocean	Not frozen	Not frozen	31-47, 62-73 and 87-93	73-79
Frozen Lakes	1-76	1-90 and 345-365	1-90 and 345-365	1-90 and 345-365

Notes:
[1] Leap year with 366 days

Table 6: Seasonal Land Use Characteristics

Input Land Use Category	z0 (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	Output Category ID
Non-Winter[1]							
31 - Herbaceous Rangeland	0.05	0.25	1.0	0.15	0.0	0.5	30
32 - Shrub and Brush Rangeland	0.05	0.25	1.0	0.15	0.0	0.5	30
41 - Deciduous Forest Land	1.0	0.1	1.0	0.15	0.0	7.0	40
42 - Evergreen Forest Land	1.0	0.1	1.0	0.15	0.0	7.0	40
43 - Mixed Forest Land	1.0	0.1	1.0	0.15	0.0	7.0	40
51 - Fresh Water	0.001	0.1	0.0	1.0	0.0	0.0	51
55 - Salt Water	0.001	0.1	0.0	1.0	0.0	0.0	55
62 - Non-forested Wetland	0.2	0.1	0.1	0.25	0.0	1.0	62
74 - Bare Exposed Rock	0.05	0.3	1.0	0.15	0.0	0.05	70
90 - Perennial Snow or Ice	0.05	0.7	0.5	0.15	0.0	0.0	90
Winter with Snow Cover[1]							
31 - Herbaceous Rangeland	0.005	0.7	0.5	0.15	0.0	0.5	30
32 - Shrub and Brush Rangeland	0.005	0.7	0.5	0.15	0.0	0.5	30
41 - Deciduous Forest Land	0.5	0.5	0.5	0.15	0.0	0.0	40
42 - Evergreen Forest Land	1.3	0.35	0.5	0.15	0.0	7.0	40
43 - Mixed Forest Land	0.9	0.42	0.5	0.15	0.0	3.5	40
51 - Fresh Water	0.001	0.7	0.5	0.15	0.0	0.0	51
55 - Salt Water	0.001	0.7	0.5	0.15	0.0	0.0	55
61 - Forested Wetland	0.5	0.3	0.5	0.15	0.0	0.0	61
62 - Non-forested Wetland	0.2	0.6	0.5	0.15	0.0	0.0	62
74 - Bare Exposed Rock	0.002	0.7	0.5	0.15	0.0	0.0	70
77 - Mixed Barren Land	0.002	0.7	0.5	0.15	0.0	0.0	70
90 - Perennial Snow or Ice	0.05	0.7	0.5	0.15	0.0	0.0	90
Winter without Snow Cover[1]							
31 - Herbaceous Rangeland	0.01	0.20	1.0	0.15	0.0	0.5	30
32 - Shrub and Brush Rangeland	0.01	0.20	1.0	0.15	0.0	0.5	30
41 - Deciduous Forest Land	0.6	0.17	1.0	0.15	0.0	7.0	40
42 - Evergreen Forest Land	1.3	0.12	0.8	0.15	0.0	7.0	40
43 - Mixed Forest Land	0.95	0.14	0.9	0.15	0.0	7.0	40
51 - Fresh Water	0.001	0.10	0.0	1.0	0.0	0.0	51
55 - Salt Water	0.001	0.10	0.0	1.0	0.0	0.0	51
61 - Forested Wetland	0.6	0.14	0.3	0.25	0.0	2.0	61
62 - Non-forested Wetland	0.2	0.14	0.1	0.25	0.0	1.0	62
74 - Bare Exposed Rock	0.05	0.20	1.5	0.15	0.0	0.05	70
77 - Mixed Barren Land	0.05	0.20	1.5	0.15	0.0	0.05	70
90 - Perennial Snow or Ice	0.002	0.70	0.50	0.15	0.0	0.0	90

Notes:
[1] For periods used in CALMET see Table 5

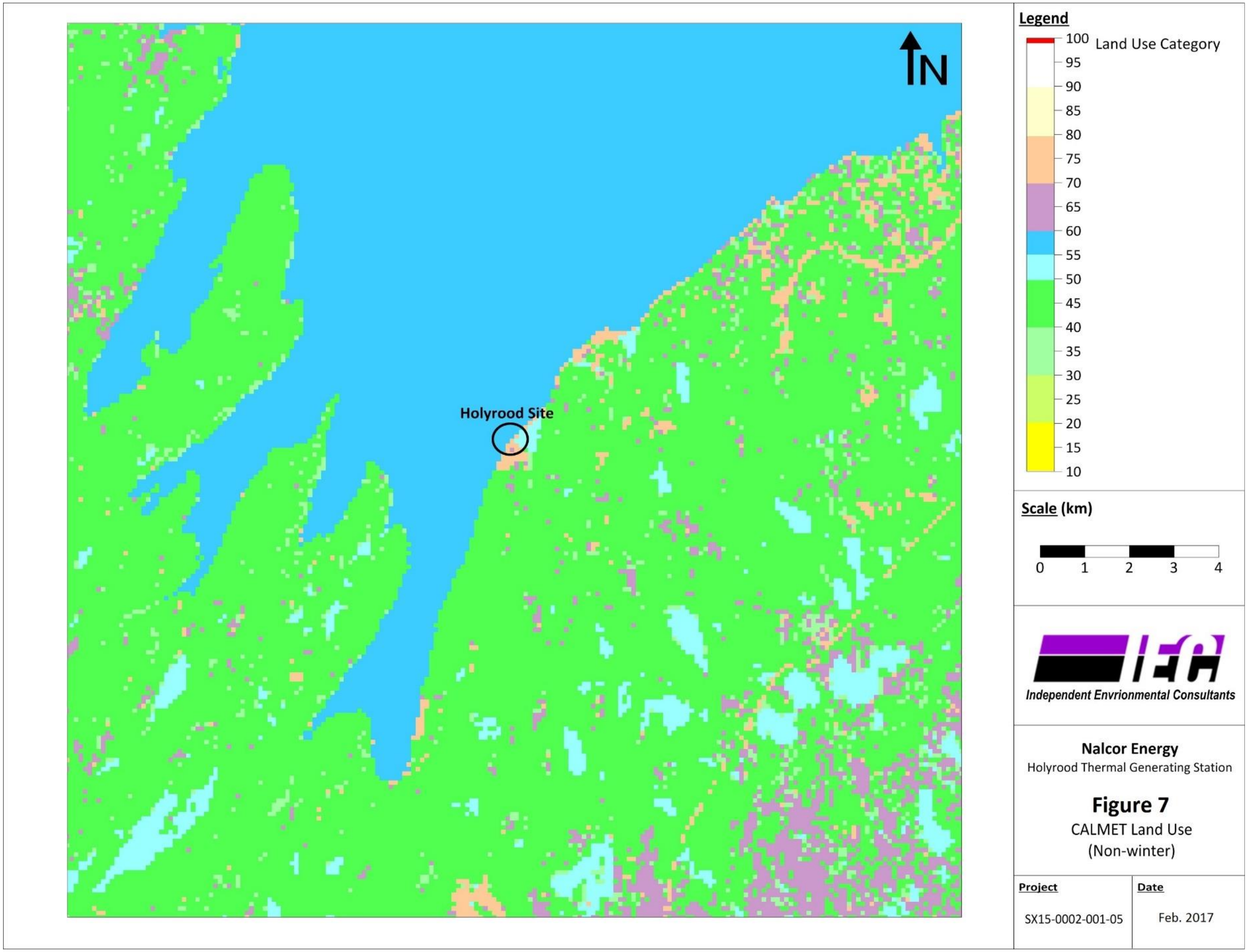


Figure 7
CALMET Land Use
(Non-winter)

3.2.4 CALMET Options

DOECC guidance was followed when selecting the appropriate CALMET options. The main CALMET options used are summarized in Table 7.

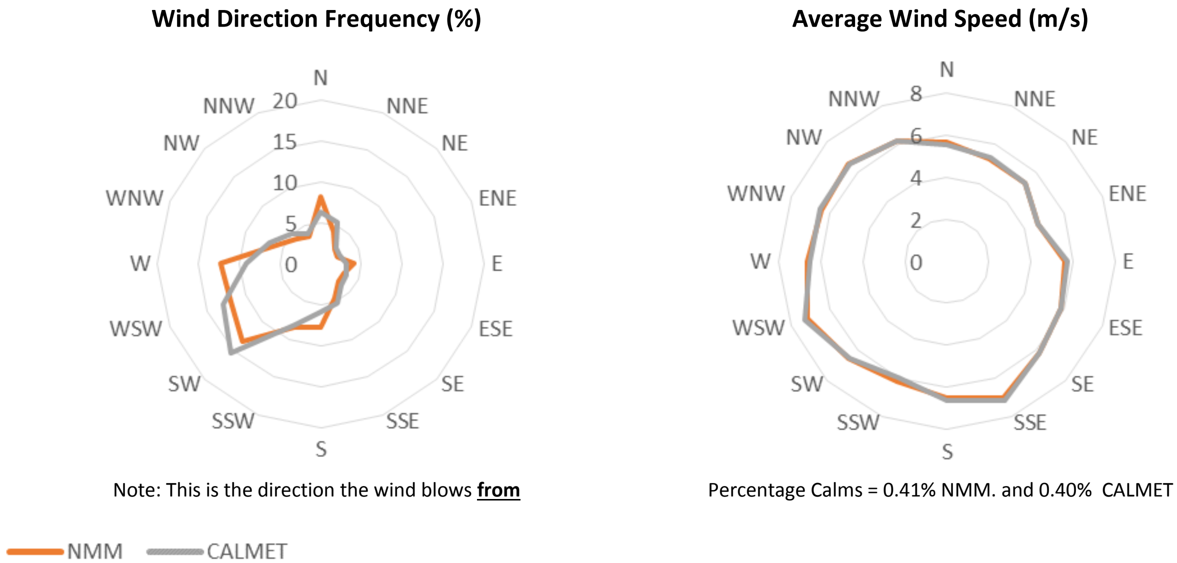
Table 7: CALMET Options

CALMET Option	Selected Option	Explanation
No. of Vertical Layers	NZ = 10	10 vertical layers used: 0, 20, 40, 80, 160, 300, 600, 1000, 1500, 2200, 3000 m
No Observation Mode	NOOBS = 0	Use surface, overwater, or upper air observations
Method to compute cloud fields	ICLOUD = 0	Gridded clouds not used
Use varying radius of influence	LVARY = T	Use varying radius of influence
Maximum radius of influence over land in the surface layer	RMAX1 = 5	Maximum radius of influence of surface stations over land is 5 km
Maximum radius of influence over land in the layer aloft	RMAX2 = 5	Maximum radius of influence of upper air stations over land is 5 km
Maximum radius of influence over water	RMAX3 = 5	Maximum radius of influence of upper air stations over water is 5 km
Minimum radius of influence used in the wind field interpolation	RMIN= 0.1	Minimum radius of influence of stations is 0.1 km
Radius of influence of terrain features (no default)	TERRAD = 1	Terrain effects are considered up to 1 km for each grid point
Relative weighting of the first guess field and observations in the surface layer	R1 = 1	Weighting used for surface layer is 1km
Relative weighting of the first guess field and observations in the layers aloft	R2 = 1	Weighting used for layers aloft is 1 km
Surface met. station to use for the surface temperature	ISURFT = -1	Use 2-D spatially varying surface temperatures
Option for overwater lapse rates used in convective mixing height growth	ITWPROG = 0	Use SEA.DAT lapse rates and deltaT (or assume neutral conditions if missing)
3D relative humidity from observations or from prognostic data	IRHPROG = 0	Use RH from SURF.DAT file
3D temperature from observations or from prognostic data	ITPROG = 0	Use Surface and upper air stations
Land use categories for temperature interpolation over water	JWAT1 = 999 JWAT2 = 999	Temperature interpolation disabled using 999

3.2.5 CALMET Results

Wind direction frequencies and the average wind speed (by direction) generated by CALMET are presented as a wind rose in Figure 7 for a grid point near the HTGS facility. In this Figure, the CALMET results are compared to the inputs from the mesoscale model WRF-NMM as there is no local observation data available for comparison. This wind rose comparison is a QAQC mechanism which shows that CALMET reproduces the WRF-NMM outputs as expected.

Figure 8: CALMET Wind Rose (2012-2015) at HTGS



Although local weather observations were not available for comparison, WRF-NMM has been evaluated at several other airport stations throughout Newfoundland and Labrador (IEC, 2016). Overall, the meteorological model shows good performance at many sites across NL (IEC, 2016), lending confidence to the dispersion modelling assessment.

As a second measure of model performance, Figure 9 and Figure 10 show the daily profile of mixing height and temperature, respectively for a CALMET grid point near the HTGS site. For each modelling year, Figure 9 demonstrates a typical mixing height profile which shows how the mixing height grows after sunrise and collapses after sunset. These profiles provide further confirmation that CALMET is able to correctly reproduce the physical parameters that are important for air dispersion modelling.

Figure 9: Daily Mixing Height Profiles at HTGS from CALMET

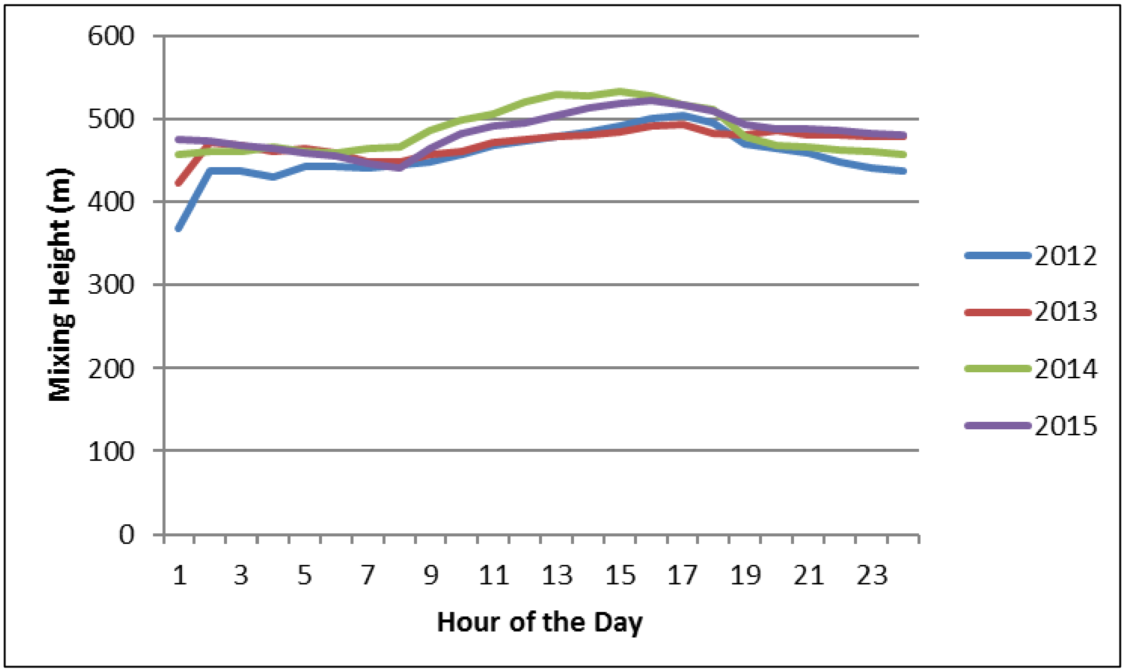
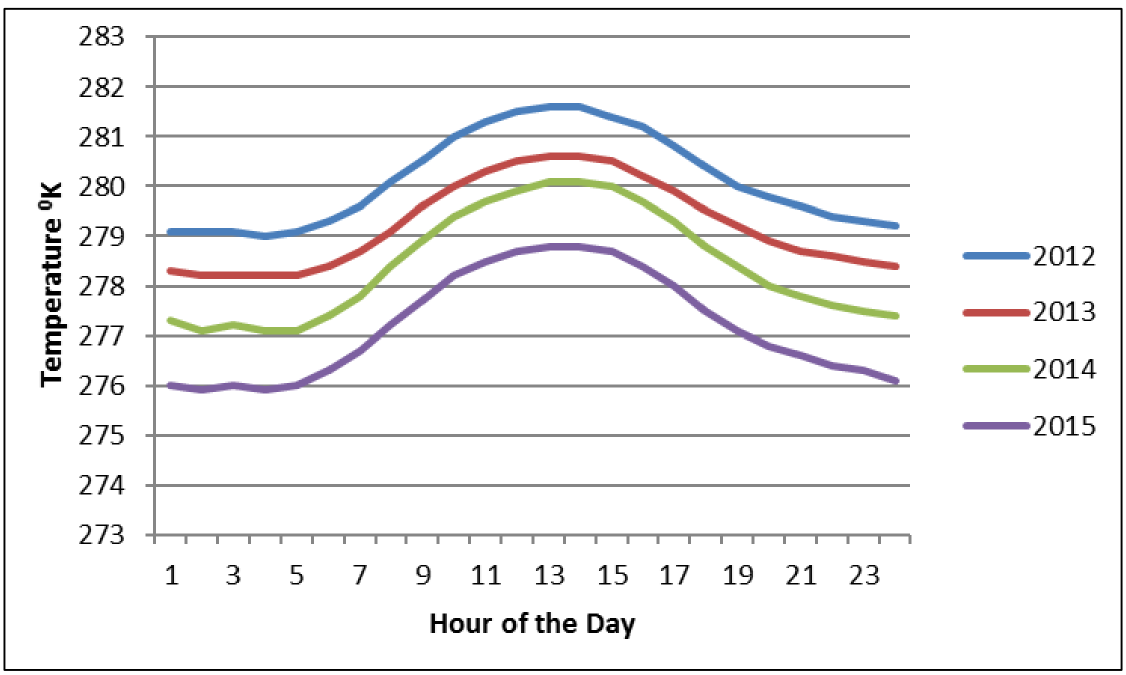


Figure 10: Daily Temperature Profiles at HTGS from CALMET



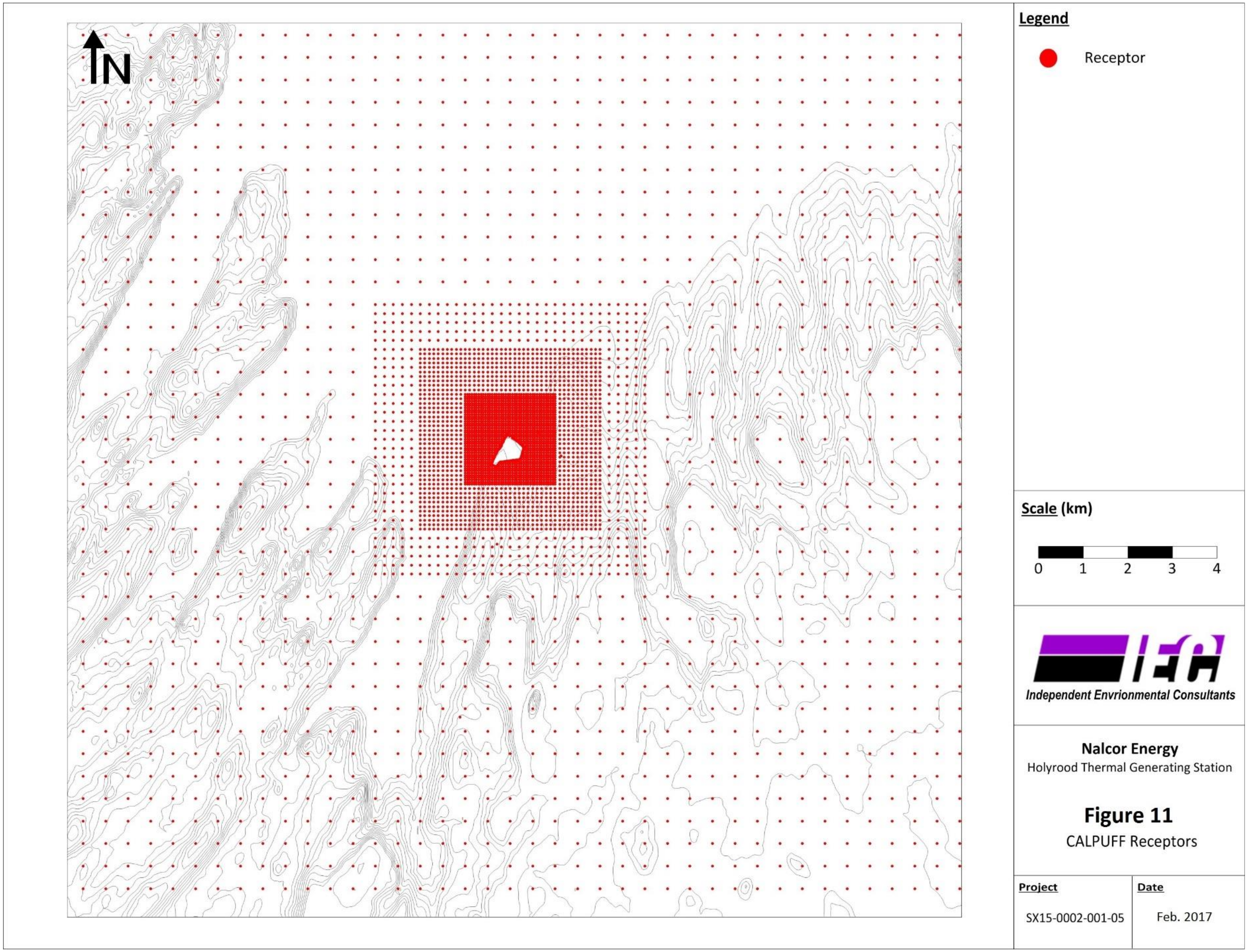
3.3 CALPUFF

3.3.1 Modelling Domain and Receptor Grid

A 20 km by 20 km modelling domain was used in the CALPUFF model run. Receptors were chosen based on recommendations provided in section 2.4 of DOECC guidance (DOEC, 2012a). Specifically, a nested receptor grid, centered on the HTGS site, was placed as follows:

- 50 m spacing within 1 km of the site boundary;
- 100 m spacing within all areas located beyond 1 km from the site boundary, but less than 2 km from the site boundary;
- 200 m spacing within all areas located beyond 2 km from the site boundary, but less than 3 km from the site boundary; and
- 500 m spacing beyond 3 km from the site boundary.

In addition, discrete receptors were placed every 20 m along the property boundary and at five monitoring locations. The full receptor grid contains 4,861 receptors and is illustrated in Figure 11.


N
Legend
Receptor
Scale (km)
0
1
2
3
4
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure 11
CALPUFF Receptors
Project
SX15-0002-001-05
Date
Feb. 2017

3.3.2 Building Downwash

The effects of building wake on plume rise and dispersion were considered in this assessment. Building dimensions and stack heights were processed with the Building Profile Input Program (BPIP) to generate the characteristic dimensions required by CALPUFF's PRIME building wake sub-model. As illustrated in Figure 5, a number of buildings and structures were considered in the PRIME sub-model, including the main HTGS generator building, the diesel generator trailers, the CT building and several fuel storage tanks. The locations and heights of these structures are outlined in Table 8.

Table 8: Building Information for BPIP-Prime

Building Name	Building Tier	Corner	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Height Above Grade (m)
Main Power House	Tier 1	1	341804	5257645	10.0	15.2
		2	341847	5257712		
		3	341942	5257650		
		4	341898	5257584		
	Tier 2	1	341826	5257643	10.0	23.5
		2	341864	5257701		
		3	341942	5257650		
		4	341904	5257592		
	Tier 3	1	341826	5257643	10.0	29.0
		2	341858	5257692		
		3	341936	5257641		
		4	341904	5257592		
	Tier 4	1	341844	5257670	10.0	44.5
		2	341858	5257692		
		3	341930	5257645		
		4	341916	5257623		
Tank 1	n/a	n/a	341726	5257485	16.0	14.6
Tank 2	n/a	n/a	341684	5257424	16.0	14.7
Tank 3	n/a	n/a	341647	5257354	16.0	14.6
Tank 4	n/a	n/a	341615	5257280	16.1	14.6
CT Tank 1	n/a	n/a	341989	5257334	13.0	10.0
CT Tank 2	n/a	n/a	341976	5257313	13.0	10.0
Combustion Turbine Air Intake	n/a	1	341934	5257420	13.0	10.7
		2	341939	5257427		
		3	341937	5257428		
		4	341939	5257431		
		5	341934	5257434		
		6	341932	5257431		
		7	341931	5257432		
		8	341927	5257432		
		9	341924	5257426		
		10	341934	5257420		

Building Name	Building Tier	Corner	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Height Above Grade (m)
Combustion Turbine Main Building	n/a	1	341954	5257486	13.0	10.7
		2	341925	5257440		
		3	341952	5257423		
		4	341980	5257470		
		5	341954	5257486		
Generator Trailer 1	n/a	1	341910	5257478	13.0	4.3
		2	341909	5257476		
		3	341899	5257482		
		4	341900	5257484		
		5	341910	5257478		
Generator Trailer 2	n/a	1	341911	5257483	13.0	4.3
		2	341910	5257481		
		3	341900	5257487		
		4	341901	5257489		
		5	341911	5257483		
Generator Trailer 3	n/a	1	341912	5257487	13.0	4.3
		2	341911	5257485		
		3	341901	5257491		
		4	341903	5257494		
		5	341912	5257487		
Generator Trailer 4	n/a	1	341914	5257492	13.0	4.3
		2	341913	5257490		
		3	341903	5257496		
		4	341904	5257499		
		5	341914	5257492		
Generator Trailer 5	n/a	1	341915	5257497	13.0	4.3
		2	341914	5257495		
		3	341904	5257501		
		4	341905	5257503		
		5	341915	5257497		
Generator Trailer 6	n/a	1	341917	5257502	13.0	4.3
		2	341915	5257500		
		3	341906	5257506		
		4	341907	5257508		
		5	341917	5257502		

3.3.3 CALPUFF Options

DOECC guidance was followed when selecting the appropriate CALPUFF options. The options used in this assessment are presented in Table 9.

Table 9: CALPUFF Options

Parameter	Name of parameter and interpretation	Default value	Selected value	Selected value interpretation
NSE	Number of emitted species	3	7	Emitted species (7)
NSPEC	Number of chemical species	5	10	Emitted species and species implicated in chemical transformations (10)
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	H2O2 data input option	1	0	Monthly background value
NINT	Number of particle size intervals	9	5	Used to evaluate effective particle deposition velocity

3.3.4 Chemical Characteristics of Modelled Species

As required by DOECC guidance (DOEC, 2012a), the RIVAD/ISORROPIA chemical mechanism, inclusive of wet and dry deposition of particles as gases, was modelled. This mechanism requires a special sequence of pollutants: SO_2, SO_4, NO, NO_2, HNO_3 and NO_3. Since the diesel generators do not emit SO_4, HNO_3 or NO_3, their emission rates have been set to zero in the model.

The dry and wet deposition parameters used were based on DOECC guidance (DOEC, 2012a) and are presented in Table 10 (dry deposition parameters for particles), Table 11 (dry deposition parameters for gases) and Table 12 (wet deposition parameters). Background concentrations of ozone (O_3), ammonia (NH_3), and hydrogen peroxide (H_2O_2) are required for the RIVAD/ISORROPIA chemical mechanism. In the absence of local monitoring data, default data from DOECC guidance (DOEC, 2012a) was used which is summarized in Table 13.

Table 10: Dry Deposition Parameters for Particles

Species	Geometric Mass Mean Diameter (µm)	Geometric Standard Deviation (µm)
SO_4	0.48	2
NO_3	0.48	2
P1 (d < 2.5 µm)	1.25	1.242

Table 11: Dry Deposition Parameters for Gases

Species	Diffusivity (cm²/s)	Alpha Star	Reactivity	Mesophyllic Resistance	Henry's Law Coefficient
SO_2	0.1509	1000	8	0	0.04
NO	0.1345	1	2	25	18
NO_2	0.1656	1	8	5	3.5
HNO_3	0.1628	1	18	0	8.0E-08
CO	0.186	1	2	61	44

Table 12: Wet Deposition Parameters for Modelled Species

Species	Scavenging Coefficient	
	Liquid Precipitation	Frozen Precipitation
SO_2	3.0E-05	0
SO_4	1.0E-04	3.0E-05
NO	0	0
NO_2	0	0
HNO_3	6.0E-05	0
NO_3	1.0E-04	3.0E-05
P1 (d < 2.5 µm)	1.0E-04	3.0E-05
CO	0	0

Table 13: Monthly Background Concentrations of O_3, NH_3, and H_2O_2

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

4.0 MODELLING RESULTS

The following sections outline the results of the air dispersion modelling assessment. Section 4.1 provides a comparison of modelled and monitored data based on emissions from the HTGS Units and the CT only. Compliance for the HTGS facility is assessed in Section 4.2, which is based on the emissions from the peaking and emergency production scenarios described in Section 2.2 and the comparison of maximum modelled concentrations to applicable air quality standards beyond the administrative boundary.

4.1 MODELLED VS. OBSERVED SO_2 CONCENTRATIONS

Ambient air concentrations of SO_2 and NO_2 are monitored at five locations surrounding the HTGS facility (see Figure 12). However, the model results were only compared to SO_2 monitoring data since NO_2 is not considered a good indicator of model performance. There are many other sources of NO_2 in the area that impact the monitoring results which make it difficult to evaluate the performance of the model.

In order to compare the model results to SO_2 monitoring data, the emissions data for the HTGS units and CT source groups were combined. As outlined in Section 2.0, the emissions for the HTGS units were developed in the previous SNC study (SNC, 2014) and were based on detailed production data from both the 2003 and 2004 calendar years. The emissions for the CT were also developed by SNC and based on an assumed power demand for the months of November to April. However, SO_2 emission rates in this current study were revised based on a sulphur content of 15 mg/kg instead of 500 mg/kg used by SNC. Comparisons to the monitoring data were made based on both 2003 and 2004 HTGS production data.

The 1- and 24-hour model predicted concentrations of SO_2 at the five nearby monitoring locations are presented in Table 14 for both 2003 and 2004 production data, and are compared to the maximum observed concentrations in 2012, 2013, 2014, and 2015. As can be seen in Table 14, the observed and model-predicted values generally show good agreement. Most of the data agree within factor of two, which is considered to be good performance for an air dispersion model. However, the values are not expected to match exactly since the HTGS production data and monitoring data are based on different years (i.e. 2003 and 2004 production data vs. 2012-2015 observations). In 2003 and 2004, the average Bunker C consumption in the main HTGS units was about 465,000 tonnes per year, while in the 2012 to 2015 period the average consumption was about 33% less at 309,000 tonnes per year. In addition, the sulphur content of

Bunker C in 2003/2004 was about 2.0% while in the period 2012 to 2015 it was only 0.7%, indicating that the fuel characteristics were different. Therefore, it can be expected that the model results would be higher than the observed values. This is true for majority of the model results - about 65% of the results are greater than observed values during the 2012-2015 period.

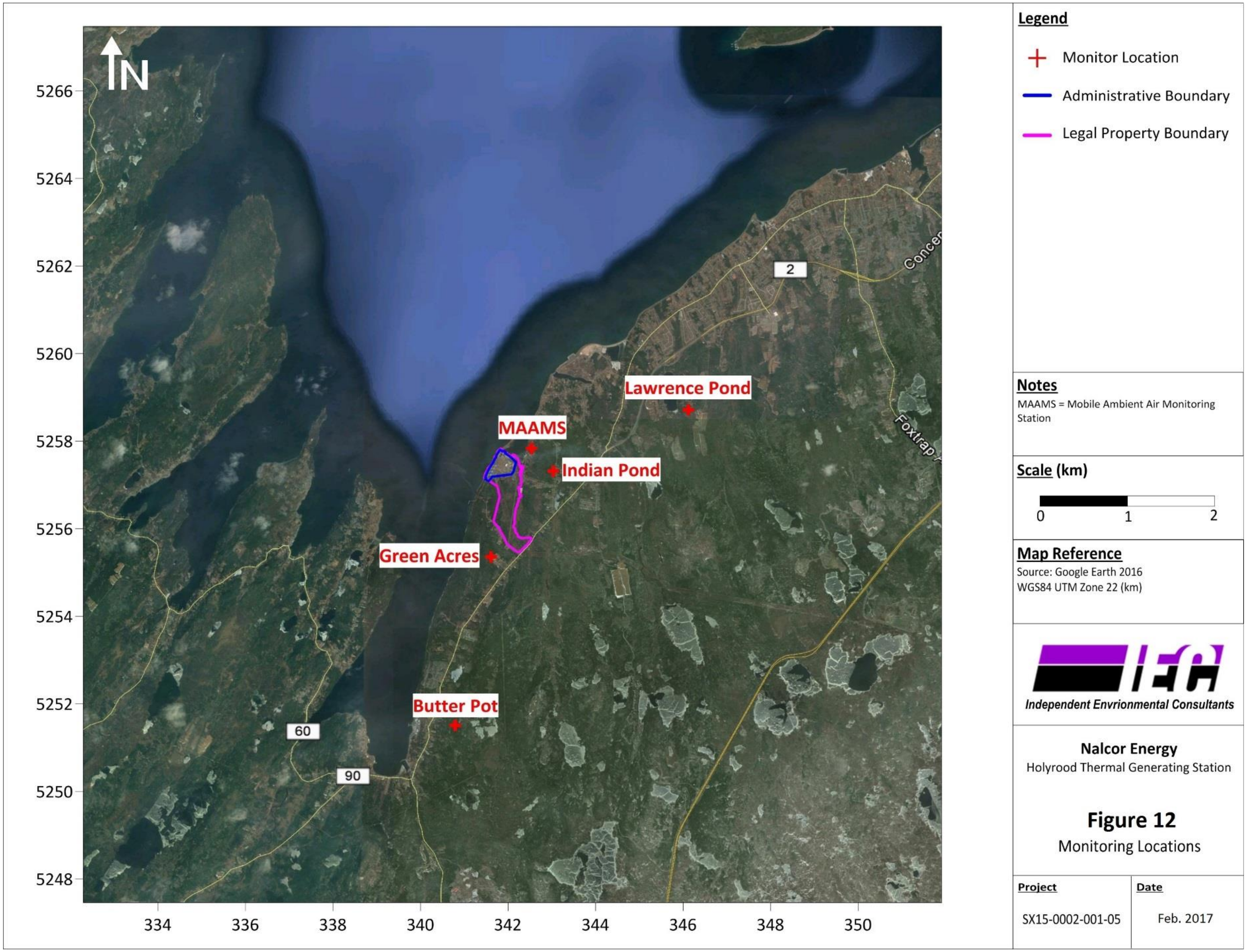

N
5266
5264
5262
5260
5258
5256
5254
5252
5250
5248
334
336
338
340
342
344
346
348
350
Lawrence Pond
MAAMS
Indian Pond
Green Acres
Butter Pot
2
60
90
Foxtrap
Legend
Monitor Location
Administrative Boundary
Legal Property Boundary
Notes
MAAMS = Mobile Ambient Air Monitoring Station
Scale (km)
0
1
2
Map Reference
Source: Google Earth 2016
WGS84 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure 12
Monitoring Locations
Project
SX15-0002-001-05
Date
Feb. 2017

Table 14: Model-Predicted Concentrations of SO_2 vs. Monitoring Data based on 2003 and 2004 Production Emissions

Production Year	Period / Pollutant	Monitor	UTM East (km)	UTM North (km)	2012 Modelled Conc. (µg/m³)	2012 Observed Conc. (µg/m³)	2013 Modelled Conc. (µg/m³)	2013 Observed Conc. (µg/m³)	2014 Modelled Conc. (µg/m³)	2014 Observed Conc. (µg/m³)	2015 Modelled Conc. (µg/m³)	2015 Observed Conc. (µg/m³)
2003	1-hour SO_2	Lawrence Pond	346.122	5258.712	132.0	62.7	147.9	75.0	132.0	135.0	139.3	179.8
		Green Acres	341.608	5255.354	158.3	156.0	196.2	214.1	159.9	305.1	149.8	192.8
		Butter Pot	340.791	5251.506	58.3	47.9	88.4	51.9	59.9	77.9	56.6	75.8
		Indian Pond	343.034	5257.313	148.6	140.2	190.7	112.6	150.1	158.0	186.5	120.8
		MAAMS	342.536	5257.836	89.8	167.0	73.4	106.7	58.9	194.1	219.3	187.1
	24-hour SO_2	Lawrence Pond	346.122	5258.712	35.5	15.9	37.6	16.6	35.5	21.9	48.8	26.0
		Green Acres	341.608	5255.354	24.9	20.5	70.0	23.6	28.1	22.9	52.2	36.5
		Butter Pot	340.791	5251.506	11.6	10.4	22.7	12.4	11.7	18.4	16.0	8.1
		Indian Pond	343.034	5257.313	55.1	44.6	62.6	21.5	62.0	31.1	58.3	42.1
		MAAMS	342.536	5257.836	32.2	43.2	16.3	39.7	14.0	59.5	75.1	73.8
2004	1-hour SO_2	Lawrence Pond	346.122	5258.712	138.9	62.7	137.2	75.0	149.6	135.0	154.3	179.8
		Green Acres	341.608	5255.354	146.6	156.0	201.5	214.1	142.1	305.1	168.3	192.8
		Butter Pot	340.791	5251.506	54.6	47.9	70.1	51.9	59.9	77.9	60.6	75.8
		Indian Pond	343.034	5257.313	201.1	140.2	211.0	112.6	159.7	158.0	188.8	120.8
		MAAMS	342.536	5257.836	85.4	167.0	75.6	106.7	145.1	194.1	222.1	187.1
	24-hour SO_2	Lawrence Pond	346.122	5258.712	35.0	15.9	41.6	16.6	57.1	21.9	42.9	26.0
		Green Acres	341.608	5255.354	28.3	20.5	74.7	23.6	38.5	22.9	57.4	36.5
		Butter Pot	340.791	5251.506	13.8	10.4	23.1	12.4	13.4	18.4	19.1	8.1
		Indian Pond	343.034	5257.313	90.7	44.6	60.8	21.5	63.3	31.1	64.6	42.1
		MAAMS	342.536	5257.836	24.7	43.2	16.4	39.7	32.5	59.5	61.8	73.8

Notes:
1-hour modelled concentrations are based on 9th rank
24-hour modelled concentrations are based on 2nd rank
MAAMS – Mobile Ambient Air Monitoring Station
Conc. - concentration

4.2 MAXIMUM MODELLED CONCENTRATIONS

In accordance with section 5 of the *Plume Dispersion Modelling Guideline* (DOEC, 2012a), the following sections summarize the maximum model predicted concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ for the peaking production scenarios (Section 4.2.1) and the emergency production scenario (Section 4.2.2). As stated in DOECC guidance for the determination of compliance, meteorological anomalies may result in the over-prediction of modelled concentrations (DOEC, 2012a). As a result, compliance for each modelled year is based on the following:

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

Background concentrations were not added to the predicted concentrations, and modelled results were directly compared to air quality standards.

It should be noted that the predicted concentrations presented below are based on conservative emissions estimates and operating hours, and are likely to be lower than the values presented in this report. As discussed in section 2.2, two peaking production scenarios were modelled, which conservatively assumed that all three HTGS units, the combustion turbine, and five diesel generators operate concurrently at their peak loads. In addition, an emergency production scenario was modelled, which assumed that the black start diesel generators operated continuously 24 hours per day, 365 days per year. In reality, peak loads and the number of operating hours may be less than what has been modelled; therefore, actual concentrations are likely to be less than what has been predicted in this assessment.

4.2.1 Peaking Production

The maximum predicted concentrations (meteorological anomalies removed) of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ for each modelled year (2012 to 2015) are presented in Table 15 for Scenario A (2003 HTGS production) and Table 16 for Scenario B (2004 HTGS production). As can be seen in both Tables, the maximum concentrations for all pollutants and averaging periods are predicted to be below their respective ambient air quality standards (AAQS) and are quite similar across both production scenarios. At 97.3% of the applicable AAQS, 1-hour NO_2 has the highest predicted maximum concentration relative to its AAQS. Maximum predicted 1-hour NO_2

concentrations range from 294.4 µg/m³ to 389.1 µg/m³ (or 73.6% to 97.3% of the AAQS) across the two peaking scenarios and 24-hour NO_2 maximum concentrations range from 68.3 µg/m³ to 120.0 µg/m³ (or 34.2% to 60.0% of the AAQS).

The pollutant with the next highest concentration relative to its AAQS is SO_2. Depending on the modelling year and scenario, predicted concentrations of 1-hour, 3-hour, and 24-hour SO_2 are more than 50% of their corresponding AAQS. 1-hour SO_2 concentrations are similar between the two peaking scenarios and range from 407.3 µg/m³ to 754.9 µg/m³ (or 45.3% to 83.9% of the AAQS). Model predicted 3-hour and 24-hour SO_2 concentrations range from 316.3 µg/m³ to 472.6 µg/m³ and 143.3 µg/m³ to 250.5 µg/m³, respectively.

Finally, predicted concentrations of particulate matter (TSP, PM_{10}, and $PM_{2.5}$) and CO are all less than 50% of their applicable AAQS for both peaking scenarios. 24-hour particulate concentrations are all below 35% of their respective AAQS, while predicted CO concentrations are less than 0.5% of the AAQS.

4.2.2 Emergency Production

The maximum predicted concentrations (meteorological anomalies removed) of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ for each modelled year (2012 to 2015) are presented in Table 17 for the emergency production scenario (Scenario C). As can be seen in the Table, the maximum concentrations for all pollutants and averaging periods are predicted to be below their respective AAQS. The pollutant with the highest predicted concentration relative to its AAQS is NO_2. Maximum predicted concentrations of 24-hour NO_2 range from 141.2 µg/m³ to 199.4 µg/m³ (or 70.6% to 99.7% of the AAQS), and the maximum predicted concentrations of 1-hour NO_2 range from 313.3 µg/m³ to 345.4 µg/m³ (or 78.3% to 86.4% of the AAQS).

The pollutant with the next highest concentration relative to its AAQS in the emergency production scenario is $PM_{2.5}$. Maximum predicted concentrations of 24-hour $PM_{2.5}$ range from 2.6 µg/m³ to 3.6 µg/m³ (or 10.3% to 14.5% of the AAQS of 25 µg/m³). As discussed in Section 2.3, it was assumed that all particulate matter emissions from the generators are less than 2.5 microns. As a result, predicted concentrations of TSP and PM_{10} are equal to predicted $PM_{2.5}$ concentrations in this scenario and are less than 10% of their respective AAQS.

Finally, at less than 0.5%, SO_2 and CO have the lowest predicted concentrations relative to their AAQS in the emergency production scenario.

Table 15: Summary of the Maximum Predicted Concentrations for the HTGS Facility: Scenario A (Peaking Production)

Pollutant	Averaging Period	AAQS (µg/m³)	2012		2013		2014		2015	
			Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS
NO_2	1-hour	400	331.4	82.9%	389.1	97.3%	295.7	73.9%	338.3	84.6%
	24-hour	200	68.3	34.2%	120.0	60.0%	93.6	46.8%	98.9	49.5%
	Annual	100	2.5	2.5%	3.8	3.8%	4.5	4.5%	3.6	3.6%
SO_2	1-hour	900	430.5	47.8%	577.3	64.1%	488.3	54.3%	516.6	57.4%
	3-hour	600	316.3	52.7%	472.6	78.8%	388.7	64.8%	401.6	66.9%
	24-hour	300	167.3	55.8%	250.5	83.5%	183.1	61.0%	169.7	56.6%
	Annual	60	4.4	7.4%	4.5	7.5%	8.4	14.0%	7.0	11.7%
CO	1-hour	35,000	37.2	0.1%	47.3	0.1%	34.8	0.1%	39.1	0.1%
	8-hour	15,000	14.5	0.1%	24.8	0.2%	16.7	0.1%	19.4	0.1%
TSP	1-hour	N/A	16.5	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	120	4.5	3.7%	7.4	6.2%	8.7	7.3%	5.9	4.9%
	Annual	60	0.1	0.2%	0.1	0.2%	0.3	0.4%	0.2	0.4%
PM_{10}	1-hour	N/A	16.5	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	50	4.5	8.9%	7.4	14.9%	8.7	17.5%	5.9	11.9%
	Annual	N/A	0.1	N/A	0.1	N/A	0.3	N/A	0.2	N/A
$PM_{2.5}$	1-hour	N/A	16.5	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	25	4.5	17.9%	7.4	29.7%	8.7	35.0%	5.9	23.7%
	Annual	8.8	0.1	1.5%	0.1	1.5%	0.3	2.9%	0.2	2.4%

Notes:

Based on Production Scenario A as described in Section 2.2.

Compliance with AAQS based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums.

N/A – not applicable

Table 16: Summary of the Maximum Predicted Concentrations for the HTGS Facility: Scenario B (Peaking Production)

Pollutant	Averaging Period	AAQS (µg/m³)	2012		2013		2014		2015	
			Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS
NO_2	1-hour	400	331.4	82.9%	389.1	97.3%	294.4	73.6%	338.3	84.6%
	24-hour	200	68.3	34.2%	120.0	60.0%	93.3	46.6%	99.5	49.7%
	Annual	100	2.5	2.5%	3.8	3.8%	4.5	4.5%	3.6	3.6%
SO_2	1-hour	900	407.3	45.3%	754.9	83.9%	441.8	49.1%	514.6	57.2%
	3-hour	600	327.7	54.6%	399.1	66.5%	339.5	56.6%	440.9	73.5%
	24-hour	300	143.3	47.8%	229.7	76.6%	213.5	71.2%	223.1	74.4%
	Annual	60	5.2	8.6%	5.4	8.9%	8.8	14.7%	8.3	13.8%
CO	1-hour	35,000	37.2	0.1%	47.3	0.1%	34.8	0.1%	39.1	0.1%
	8-hour	15,000	14.5	0.1%	24.8	0.2%	16.7	0.1%	19.4	0.1%
TSP	1-hour	N/A	16.7	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	120	4.3	3.6%	8.0	6.7%	8.7	7.3%	7.2	6.0%
	Annual	60	0.2	0.3%	0.2	0.3%	0.3	0.4%	0.3	0.4%
PM_{10}	1-hour	N/A	16.7	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	50	4.3	8.6%	8.0	16.0%	8.7	17.5%	7.2	14.5%
	Annual	N/A	0.2	N/A	0.2	N/A	0.3	N/A	0.3	N/A
$PM_{2.5}$	1-hour	N/A	16.7	N/A	24.1	N/A	26.9	N/A	26.7	N/A
	24-hour	25	4.3	17.2%	8.0	32.1%	8.7	35.0%	7.2	29.0%
	Annual	8.8	0.2	1.7%	0.2	1.9%	0.3	3.0%	0.3	2.9%

Notes:
Based on Production Scenario B as described in Section 2.2.
Compliance with AAQS based on the 9^{th} hourly, 6^{th} 3-hour, 3^{rd} 8-hour and 2^{nd} daily maximums.
N/A – not applicable

Table 17: Summary of the Maximum Predicted Concentrations for the HTGS Facility: Scenario C (Emergency Production)

Pollutant	Averaging Period	AAQS (µg/m³)	2012		2013		2014		2015	
			Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS	Conc. (µg/m³)	% of AAQS
NO_2	1-hour	400	318.3	79.6%	345.4	86.4%	313.3	78.3%	323.5	80.9%
	24-hour	200	153.4	76.7%	199.4	99.7%	141.2	70.6%	193.3	96.7%
	Annual	100	9.3	9.3%	11.2	11.2%	11.2	11.2%	11.0	11.0%
SO_2	1-hour	900	0.5	0.1%	0.5	0.1%	0.5	0.1%	0.5	0.1%
	3-hour	600	0.4	0.1%	0.4	0.1%	0.4	0.1%	0.4	0.1%
	24-hour	300	0.2	0.1%	0.3	0.1%	0.2	0.1%	0.3	0.1%
	Annual	60	0.01	0.02%	0.02	0.03%	0.02	0.03%	0.017	0.03%
CO	1-hour	35,000	44.2	0.1%	45.5	0.1%	43.8	0.1%	44.0	0.1%
	8-hour	15,000	29.6	0.2%	35.2	0.2%	29.9	0.2%	34.4	0.2%
TSP	1-hour	N/A	5.7	N/A	5.9	N/A	5.7	N/A	5.7	N/A
	24-hour	120	2.8	2.3%	3.5	2.9%	2.6	2.1%	3.6	3.0%
	Annual	60	0.2	0.3%	0.2	0.3%	0.2	0.3%	0.2	0.4%
PM_{10}	1-hour	N/A	5.7	N/A	5.9	N/A	5.7	N/A	5.7	N/A
	24-hour	50	2.8	5.5%	3.5	7.0%	2.6	5.2%	3.6	7.2%
	Annual	N/A	0.2	N/A	0.2	N/A	0.2	N/A	0.2	N/A
$PM_{2.5}$	1-hour	N/A	5.7	N/A	5.9	N/A	5.7	N/A	5.7	N/A
	24-hour	25	2.8	11.0%	3.5	14.0%	2.6	10.3%	3.6	14.5%
	Annual	8.8	0.2	2.1%	0.2	2.4%	0.2	2.3%	0.2	2.4%

Notes:
Based on Production Scenario C as described in Section 2.2.
Compliance with AAQS based on the 9th hourly, 6th 3-hour, 3rd 8-hour and 2nd daily maximums.
N/A – not applicable

4.3 Isopleths of Concentrations

DOECC guidance (DOEC, 2012a) requires that isopleths be created for each pollutant and averaging time that has a modelled concentration that is more than 50% of the AAQS. As shown in Tables 15 and 16, maximum 1-hour NO_2 concentrations for both peaking production scenarios were predicted to be more than 50% of the AAQS in all four modelling years. As a result, isopleths of 1-hour NO_2 concentrations have been created for each peaking scenario and for each modelling year. 24-hour NO_2 concentrations as well as 1-hour, 3-hour, and 24-hour SO_2 concentrations were also predicted to be greater than 50% of the AAQS depending on the modelling year and production scenario. As a result, isopleths have been created for these pollutants and averaging periods for both peaking scenarios. For completeness and to aid in the discussion of results, isopleths of NO_2 and SO_2 concentrations have been created for each modelling year even though concentrations are less than 50% of the AAQS in some years.

The model results for the emergency production scenario (Table 17) showed that the maximum 1-hour and 24-hour NO_2 concentrations were predicted to be more than 50% of the AAQS in all four modelling years. As a result, a total of eight contour plots of NO_2 concentrations have been created for this scenario. For all other pollutants and averaging periods, concentrations were predicted to be well below 50% of the AAQS; therefore, isopleths of SO_2, CO, and particulate matter have not been created for the emergency production scenario.

Isopleths for each pollutant and production scenario are discussed separately in the following sections. Note that all isopleths shown only cover a portion of the modelling domain and are representative of concentrations which have meteorological anomalies removed.

4.3.1 Isopleths of NO_2 Concentrations

4.3.1.1 Peaking Production

Isopleths of NO_2 concentrations for the peaking production scenarios are presented in Appendix B for Scenario A (HTGS 2003 production) and Appendix C for Scenario B (HTGS 2004 production). The Figures illustrate that the isopleths and locations of the maximum 1-hour and 24-hour NO_2 concentrations are very similar between the two peaking production scenarios. For each modelled year, the 1-hour NO_2 maximum concentration is predicted to occur at a receptor located south/southwest of the generator stacks, within 225 m of the administrative boundary. The close proximity of the NO_2 maximums to the generator stacks suggests that NO_2 concentrations in the peaking production scenarios are primarily influenced by emissions from the black start diesel generators.

For both of the peaking production scenarios, the location of the 24-hour NO_2 maximum varies depending on the modelling year due to differences in meteorology. In 2012, the 24-hour NO_2 maximum occurs at a receptor located to the east of the Facility, within 50 m of the administrative boundary. In 2013 and 2014, the 24-hour NO_2 maximum concentrations occur at receptors located along the administrative boundary just south of the generators. Finally, in 2015 the 24-hour NO_2 maximum is located south of the generators, about 130 m from the administrative boundary.

4.3.1.2 EMERGENCY PRODUCTION

Isopleths of 1-hour and 24-hour NO_2 concentrations for the emergency production scenario are presented in Appendix D. For each modelled year, the 1-hour NO_2 maximum concentration is predicted to occur at a receptor located south/southwest of the generator stacks along the administrative boundary. In 2012, 2014, and 2015, the maximum 24-hour NO_2 concentrations are also predicted to occur at receptors located along the southern administrative boundary. The exception is 2013, when the 24-hour NO_2 maximum is predicted to occur at a receptor located about 100 m from the administrative boundary, southwest of the generator stacks.

4.3.2 Isopleths of SO_2 Concentrations

Isopleths of SO_2 concentrations for the peaking production scenarios are presented in Appendix B for Scenario A (HTGS 2003 production) and in Appendix C for Scenario B (HTGS 2004 production). Isopleths for the emergency production scenario are not presented since all SO_2 concentrations were predicted to be less than 50% of the AAQS. The Figures show that SO_2 concentrations are below the AAQS throughout the modelling domain. For all averaging periods, the maximum SO_2 concentrations are predicted to occur at receptors located east/northeast of the Facility at distances of 900 m to around 1,600 m from the main HTGS stacks (depending on the modelling year and peaking production scenario). The exception is 2013, when the SO_2 maximums are predicted to occur southwest of the HTGS stacks, within 450 m of the administrative boundary. Unlike NO_2, the isopleths show that SO_2 concentrations are primarily influenced by the main HTGS stacks.

4.4 TOP-50 EVENTS

In addition to isopleths, DOECC guidance requires that Top-50 tables be produced for all pollutants and averaging times exceeding more than 50% of an AAQS (DOEC, 2012a). Top-50 tables do not have meteorological anomalies removed; therefore, they present the overall maximum modelling results. The Top-50 tables are included in Appendices at the end of this report and present the top 50 concentrations out of all four modelling years for each scenario:

- **Appendix E** contains the Top-50 tables for Scenario A (peaking production based on 2003 HTGS emissions), including 1-hour and 24-hour NO_2 concentrations, and 1-hour, 3-hour, and 24-hour SO_2 concentrations.
- **Appendix F** contains the Top-50 tables for Scenario B (peaking production based on 2004 HTGS emissions), including 1-hour and 24-hour NO_2 concentrations, and 1-hour, 3-hour, and 24-hour SO_2 concentrations.
- **Appendix G** contains the Top-50 tables for 1-hour and 24-hour NO_2 concentrations for Scenario C (emergency production).

The tables in Appendices E and F show that for each peaking production scenario, all of the Top-50 1-hour NO_2 concentrations exceed the AAQS of 400 µg/m³. However, there are no events where the 24-hour NO_2 AAQS of 200 µg/m³ is predicted to be exceeded. Out of both peaking scenarios, the overall maximum 1-hour NO_2 concentration (i.e. without anomalies removed) is 593.8 µg/m³, while the overall maximum 24-hour NO_2 concentration is 140.6 µg/m³.

Similarly, the tables in Appendices E and F show that all of the Top-50 concentrations of 1-hour SO_2 exceed the AAQS of 900 µg/m³, but there are no events where the 24-hour SO_2 AAQS of 300 µg/m³ is exceeded. Out of both peaking scenarios, the highest 1-hour SO_2 concentration without meteorological anomalies is 1,427.5 µg/m³, while the highest 24-hour SO_2 concentration is 294.1 µg/m³. For 3-hour SO_2 concentrations, there are 20 events in Scenario A where the AAQS of 600 µg/m³ is predicted to be exceeded, and 38 events predicted for Scenario B. The highest 3-hour SO_2 concentration without meteorological anomalies is predicted to be 824.1 µg/m³ in Scenario A and 841.6 µg/m³ in Scenario B.

The Top-50 1-hour and 24-hour concentrations of NO_2 are presented in Appendix G for the emergency production scenario. There are 31 events across all four modelling years where the 1-hour NO_2 AAQS is predicted to be exceeded, and there are 12 events where the 24-hour NO_2 AAQS is predicted to be exceeded. The highest overall 1-hour NO_2 concentration without meteorological anomalies removed is 452.5 µg/m³ and the highest 24-hour NO_2 concentration is 219.4 µg/m³.

5.0 CONCLUSION

Air dispersion modelling using the CALMET/CALPUFF modelling system was performed to evaluate the impacts of the Holyrood Thermal Generating Station (HTGS) on local air quality. The assessment considered emissions from the main HTGS stacks, as well as the combustion turbine (CT) and the proposed operation of five black start diesel generators each rated at 2 MW. The modelling assessment built upon a previous assessment completed by SNC-Lavalin in 2014 (SNC, 2014), which considered two emissions scenarios for the main HTGS stacks based on 2003 and 2004 production data. In this assessment, two peaking production scenarios were modelled, which considered the concurrent operation of the main HTGS units, the CT at 100% load, and the black start diesel generators at 87% load. The first peaking scenario (Scenario A) was based on 2003 HTGS production data, and the second peaking scenario (Scenario B) was based on 2004 HTGS production data. A third production scenario (Scenario C) was modelled, which was based on the operation of the black start diesel generators only at 67% load during an emergency situation.

For each production scenario, NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ were modelled and predicted concentrations were compared to Newfoundland and Labrador Ambient Air Quality Standards (AAQS) in accordance with DOECC guidance. A four-year modelling period (2012 to 2015) was used.

The main conclusions of this air dispersion modelling assessment are:

Peaking Production:

- For both peaking production scenarios, maximum concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ are predicted to be compliant with the applicable AAQS for all averaging periods and modelling years.
- Results between Scenario A (2003 HTGS production) and Scenario B (2004 HTGS) production scenarios are similar, particularly for NO_2.
- NO_2 concentrations are primarily influenced by the black start diesel generators. The maximum 1-hour NO_2 concentration is predicted to be 389.1 µg/m³ (or 97.3% of the AAQS) and the maximum 24-hour NO_2 concentration is predicted to be 120.0 µg/m³ (or 60% of the AAQS).
- SO_2 concentrations are primarily influenced by the main HTGS stacks and varied slightly across the two peaking production scenarios. The maximum 1-hour SO_2 concentration for Scenario A is predicted to be 577.3 µg/m³ (or 64.1% of the AAQS) and 754.9 µg/m³ (or 83.9% of the AAQS) for Scenario B. The maximum 3-hour SO_2 concentration is

predicted to be 472.6 µg/m³ (or 78.8% of the AAQS) for Scenario A and 440.9 µg/m³ (73.5% of the AAQS) for Scenario B. The maximum 24-hour SO_2 concentration is predicted to be 250.5 µg/m³ (or 83.5% of the AAQS) for Scenario A and 229.7 µg/m³ (or 76.6% of the AAQS) for Scenario B.
- Maximum predicted particulate matter concentrations are less than 35% of the AAQS for both of the peaking production scenarios.
- Maximum predicted CO concentrations are below 0.5% of the AAQS for both peaking production scenarios.

Emergency Production:

- Maximum concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ are predicted to be compliant with the applicable AAQS for all averaging periods and modelling years.
- NO_2 is the pollutant with the highest predicted concentrations relative to its AAQS. The maximum 1-hour NO_2 concentration is 345.4 µg/m³ (or 86.4% of the AAQS), and the maximum 24-hour NO_2 concentrations is 199.4 µg/m³ (or 99.7% of the AAQS).
- The maximum predicted 24-hour $PM_{2.5}$ concentration is 3.6 µg/m³ (or 14.5% of the AAQS).
- Maximum TSP and PM_{10} concentrations are predicted to be less than 10% of the AAQS.
- At less than 0.5%, SO_2 and CO have the lowest predicted maximum concentrations relative to their respective AAQS.

Finally, compared to monitoring data, predicted SO_2 concentrations based on emissions from the main HTGS units and the CT were generally within a factor of two of ambient concentrations measured between 2012 and 2015. An air dispersion model is considered to perform well if modelled concentrations are within a factor of two of monitored values. This lends confidence to the model results presented in this assessment.

6.0 REFERENCES

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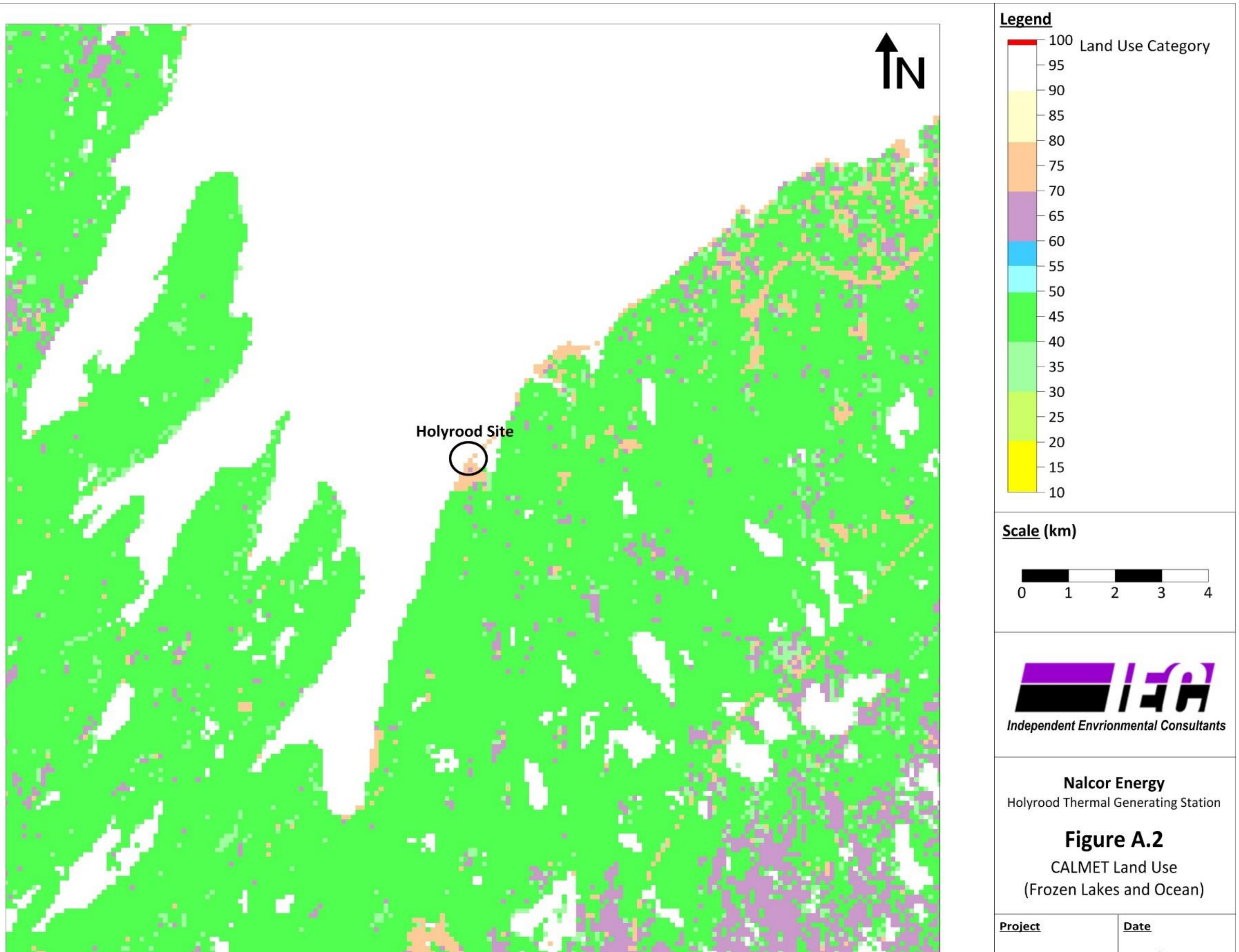
Appendix A:

Additional Land Use Plots

Nalcor Energy
Holyrood Thermal Generating Station

Figure A.1
CALMET Land Use
(Frozen Lakes)

Project	Date
SX15-0002-001-05	Feb. 2017



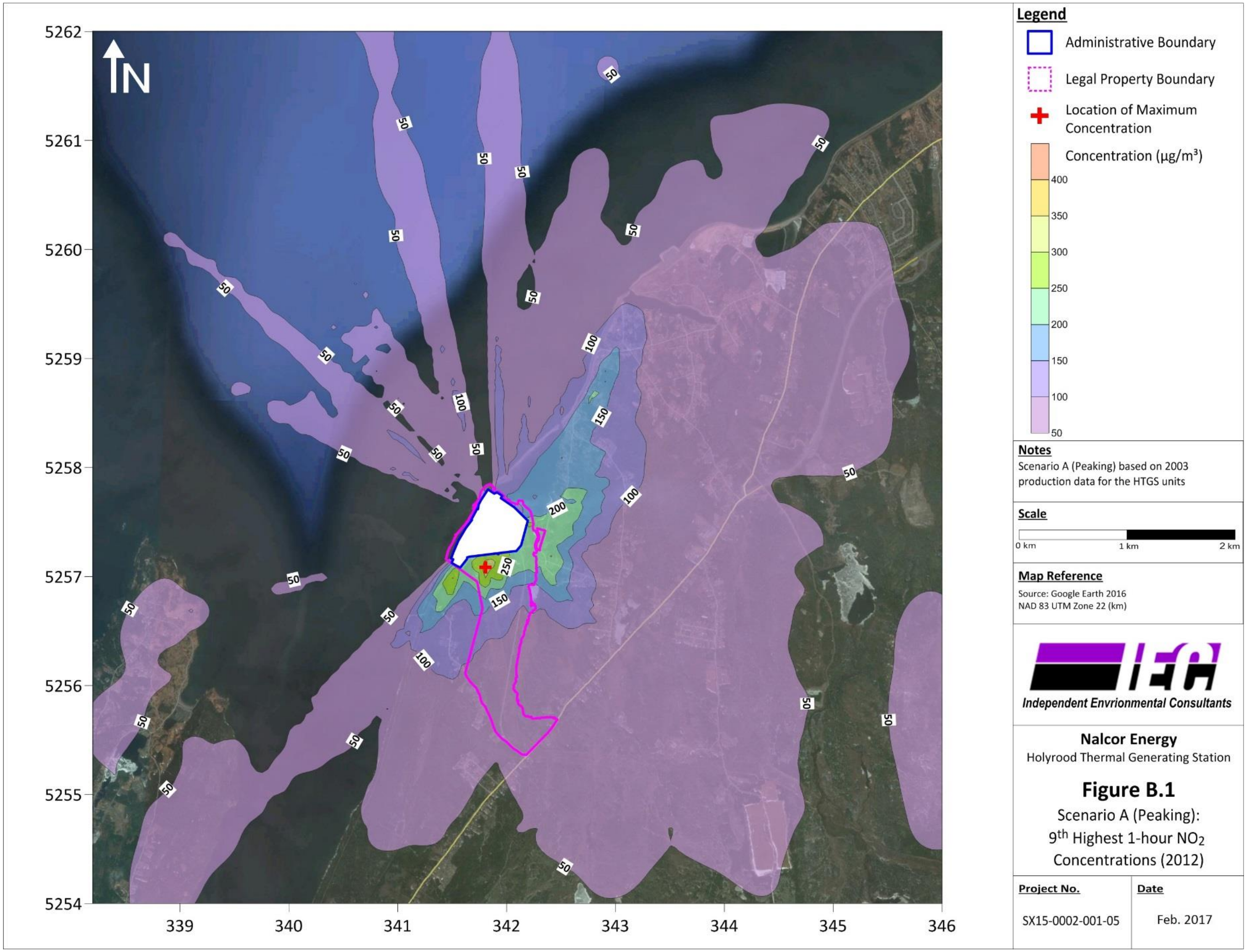
Nalcor Energy
Holyrood Thermal Generating Station

Figure A.2
CALMET Land Use
(Frozen Lakes and Ocean)

Project	Date
SX15-0002-001-05	Feb. 2017

Appendix B:

Scenario A Isopleths



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Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
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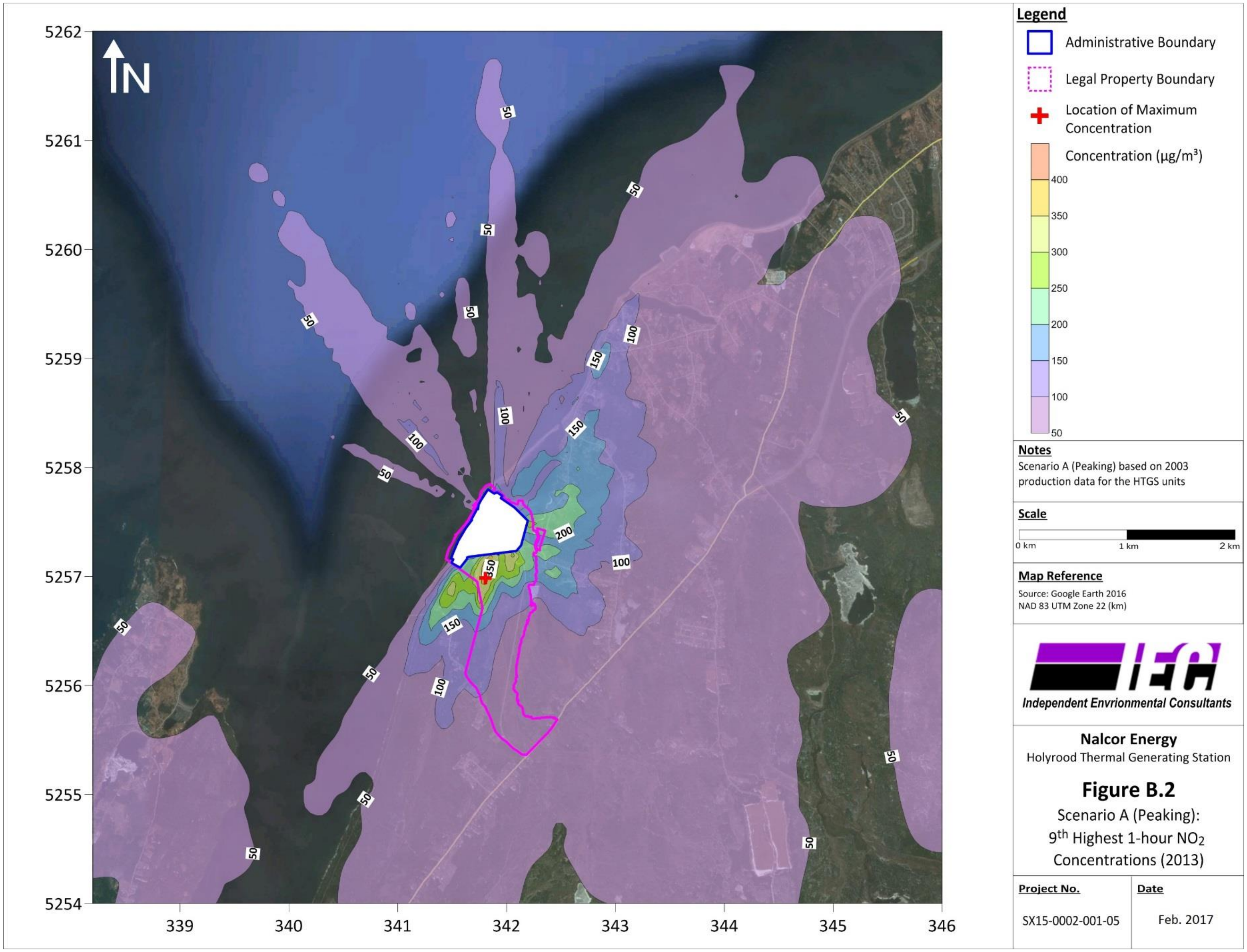
250
200
150
100
50
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.1
Scenario A (Peaking):
9th Highest 1-hour NO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017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Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (μg/m³)
400
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100
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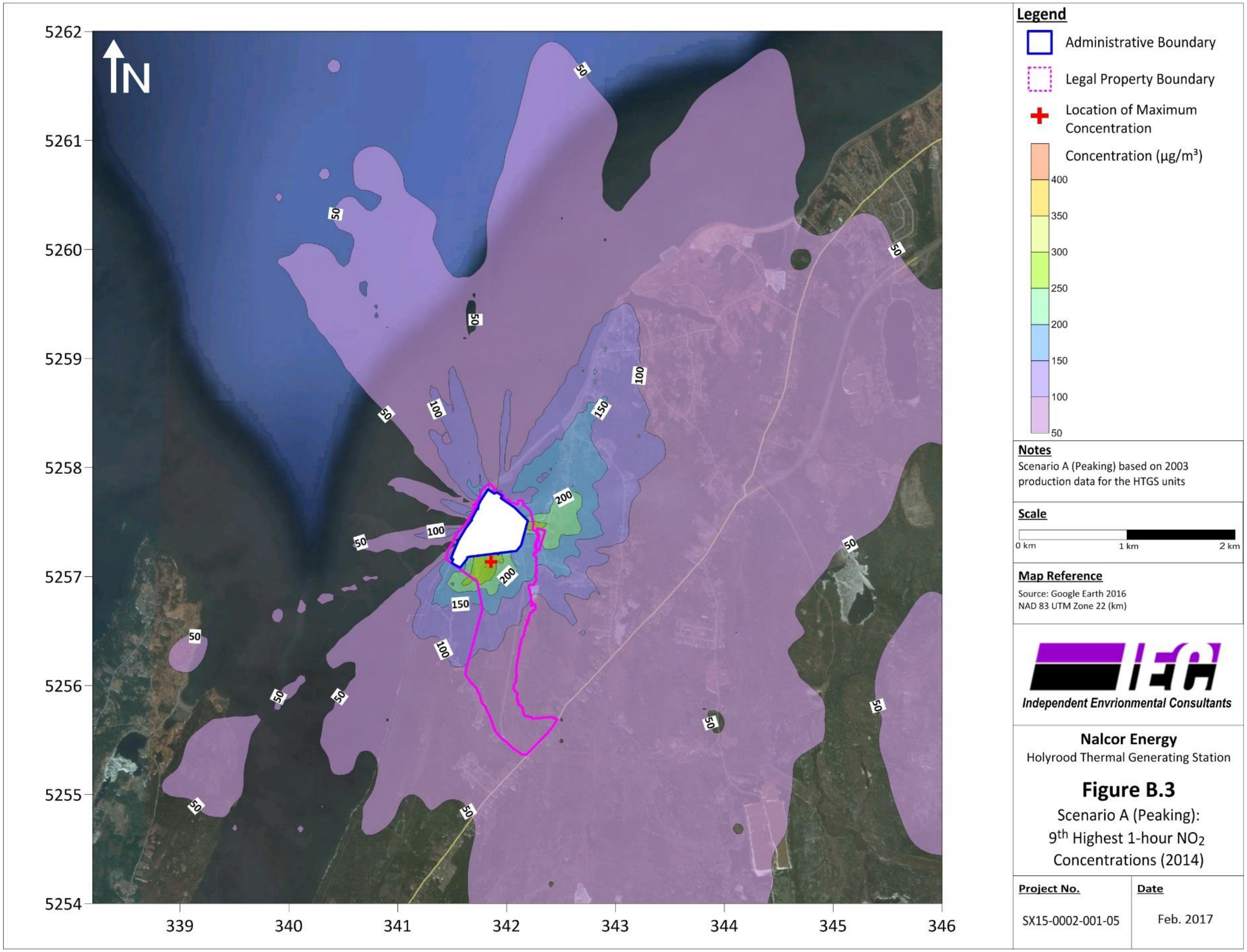
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.2
Scenario A (Peaking):
9th Highest 1-hour NO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017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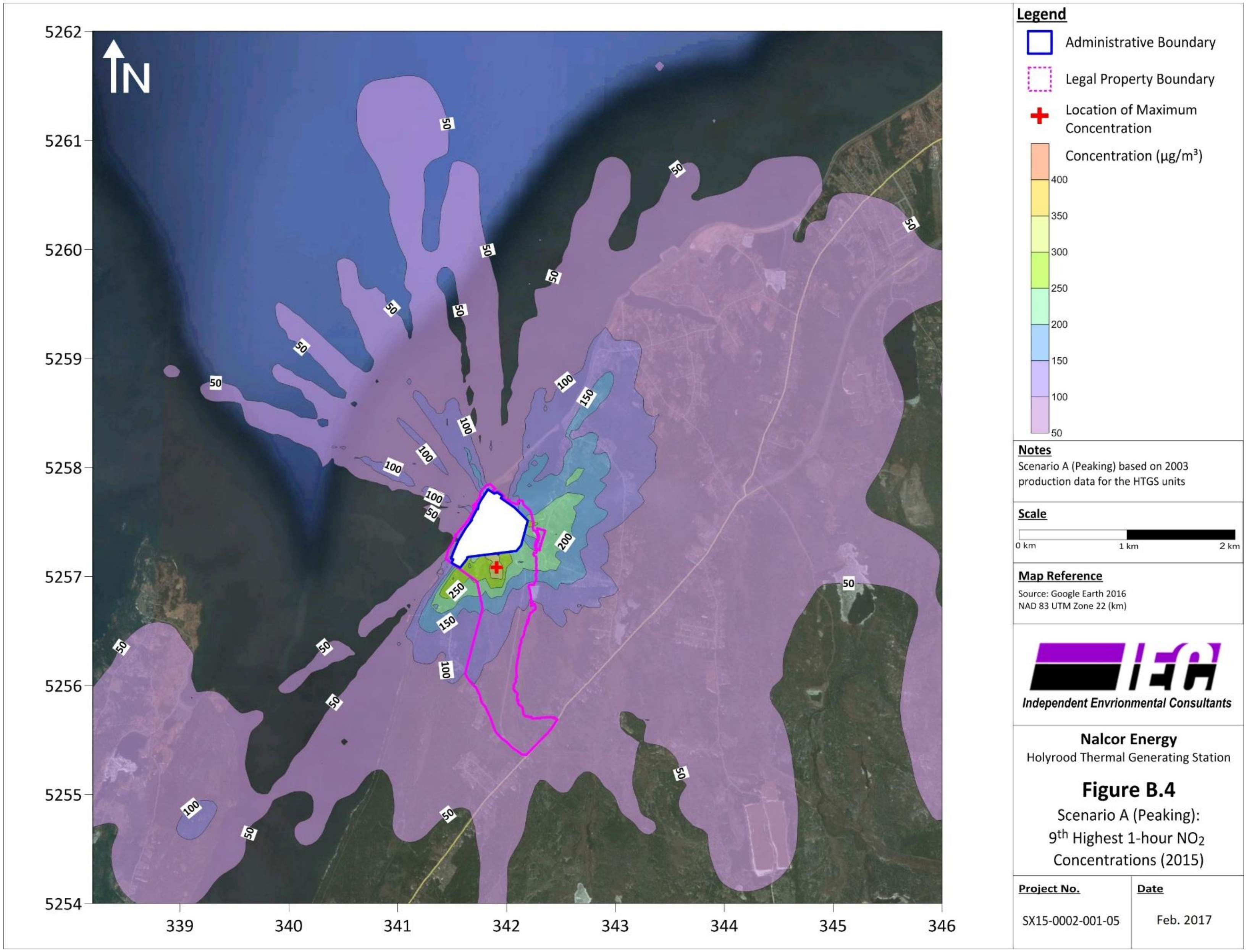
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.3
Scenario A (Peaking):
9th Highest 1-hour NO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017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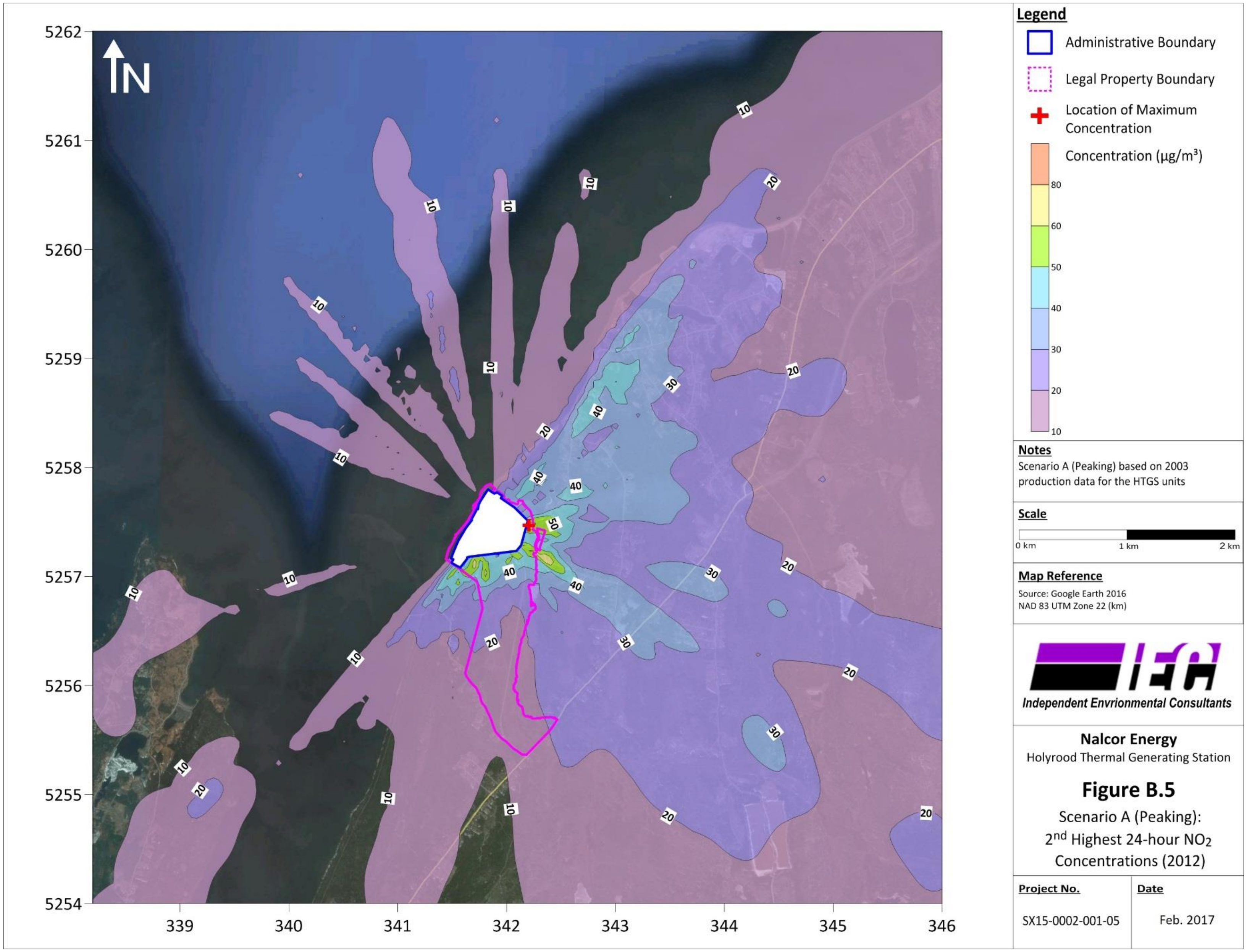
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (μg/m³)
400
350
300
250
200
150
100
50
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Environmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.4
Scenario A (Peaking):
9th Highest 1-hour NO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017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Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
80
60
50
40
30
20
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Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.5
Scenario A (Peaking):
2nd Highest 24-hour NO2 Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017
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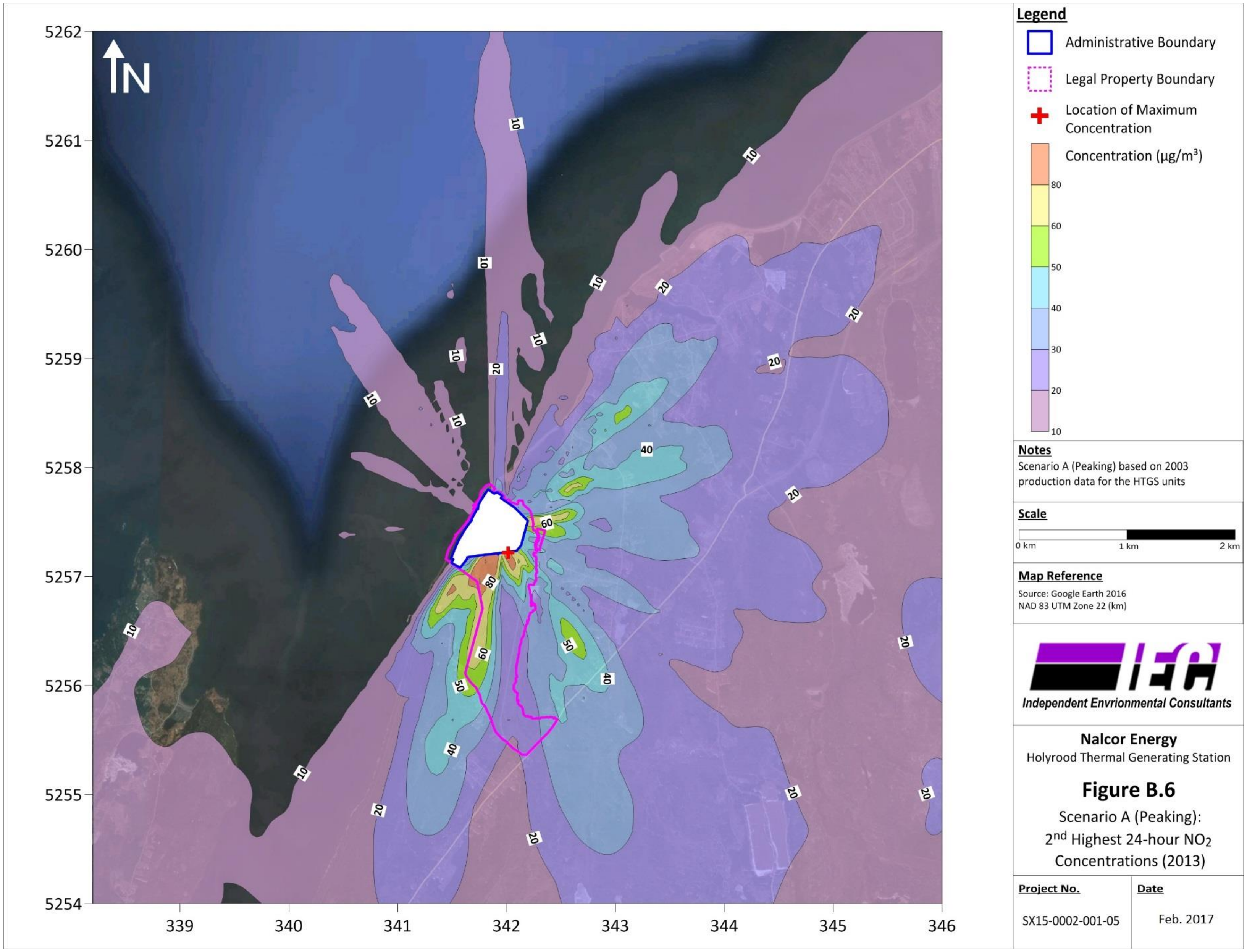
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Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
80
60
50
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20
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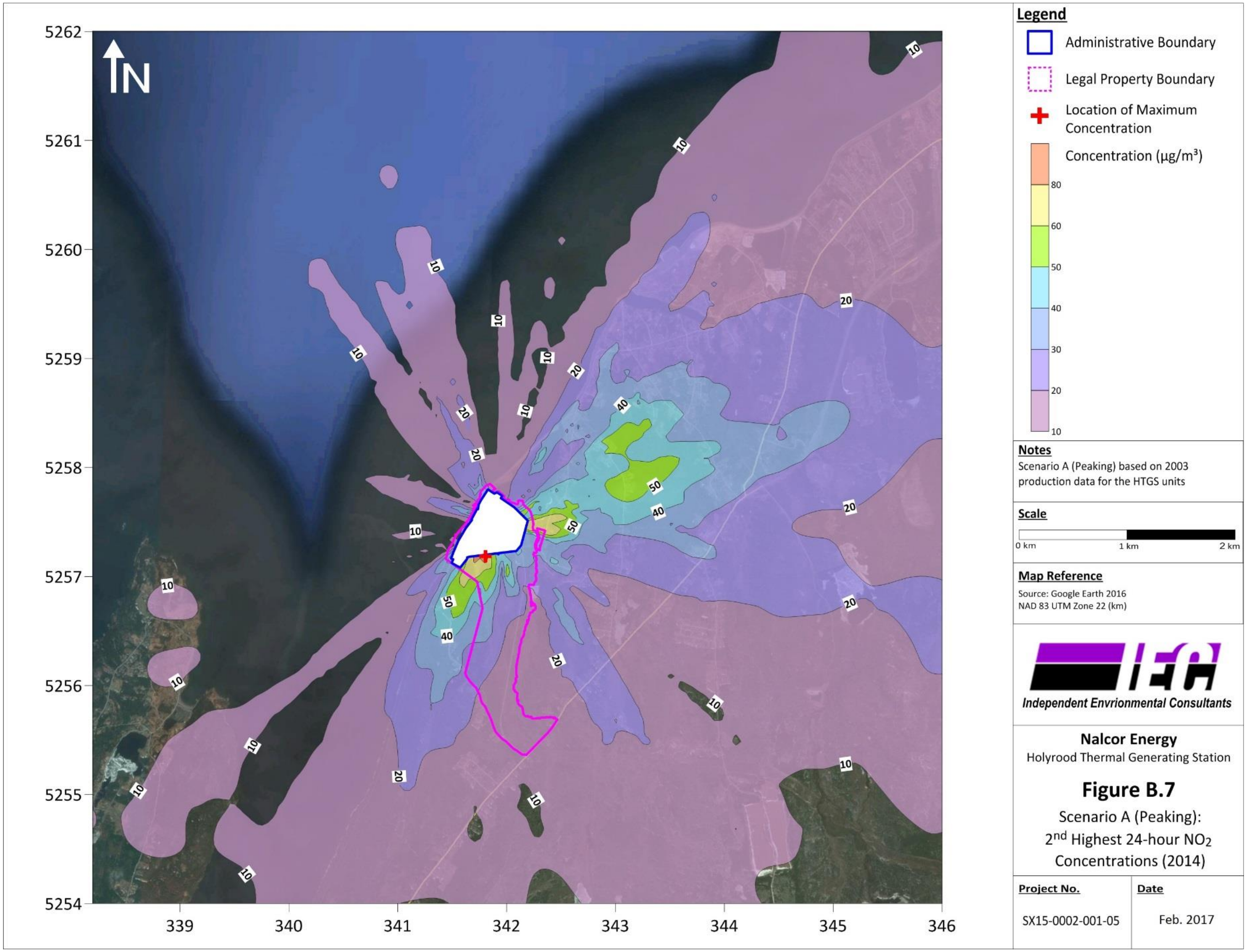
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.6
Scenario A (Peaking):
2nd Highest 24-hour NO2 Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017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5254
339
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346
N
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (μg/m³)
80
60
50
40
30
20
10
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.7
Scenario A (Peaking):
2nd Highest 24-hour NO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017

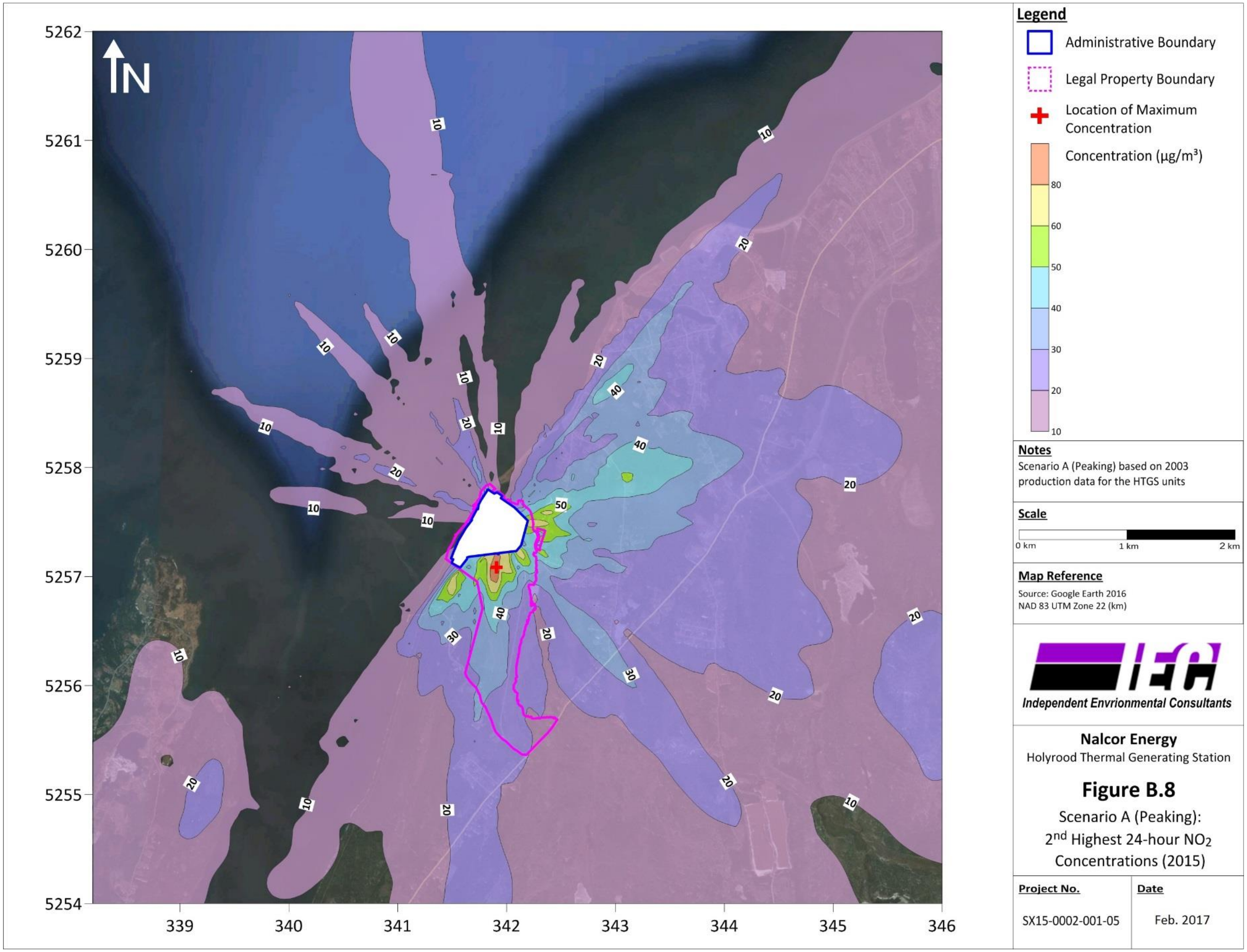
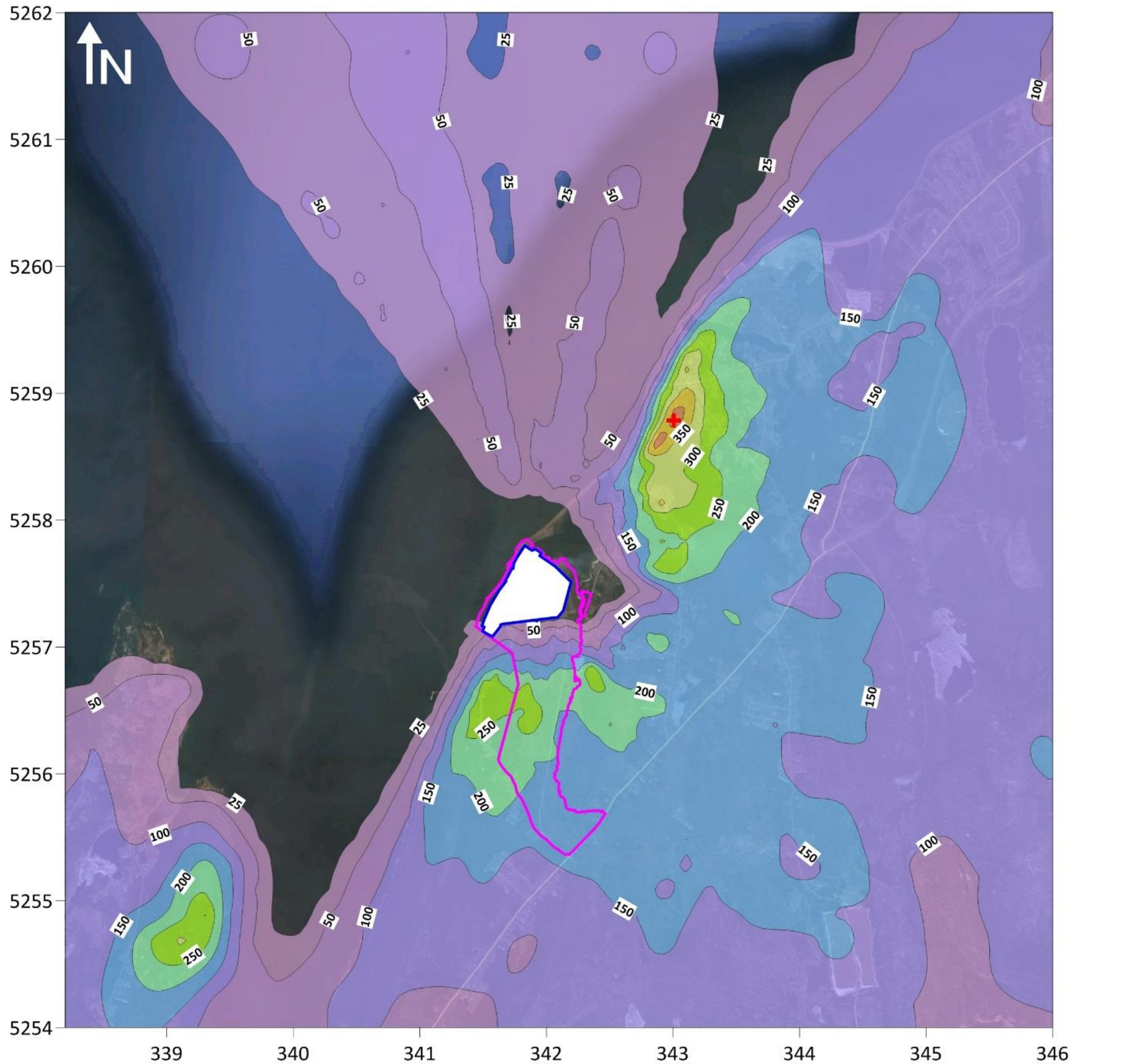


Figure B.8
Scenario A (Peaking): 2nd Highest 24-hour NO_2 Concentrations (2015)



Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units

Scale
0 km 1 km 2 km

Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

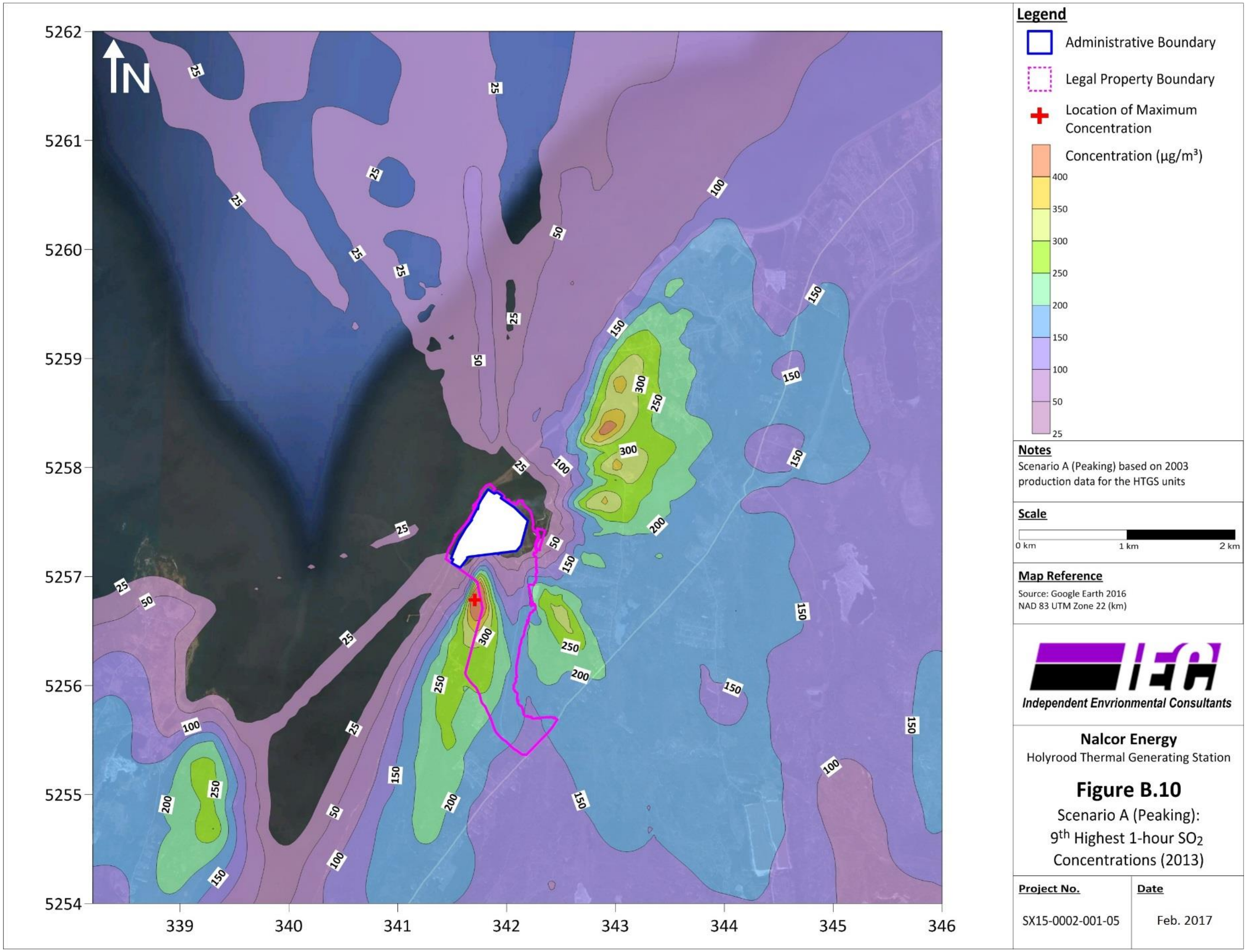
Independent Envrionmental Consultants

Nalcor Energy
Holyrood Thermal Generating Station

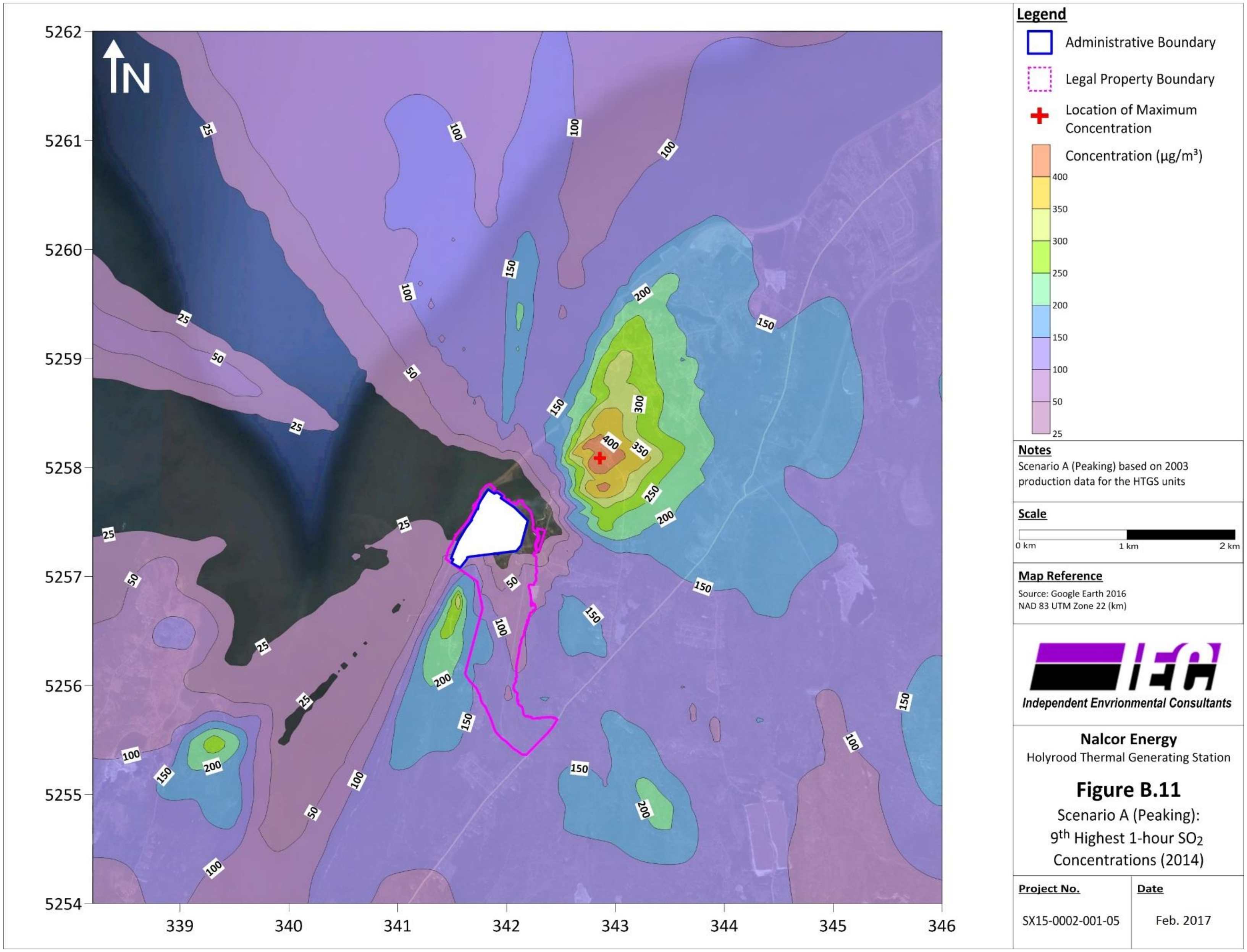
Figure B.9

Scenario A (Peaking):
9th Highest 1-hour SO_2
Concentrations (2012)

Project No.	Date
SX15-0002-001-05	Feb. 2017



N
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.10
Scenario A (Peaking):
9th Highest 1-hour SO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017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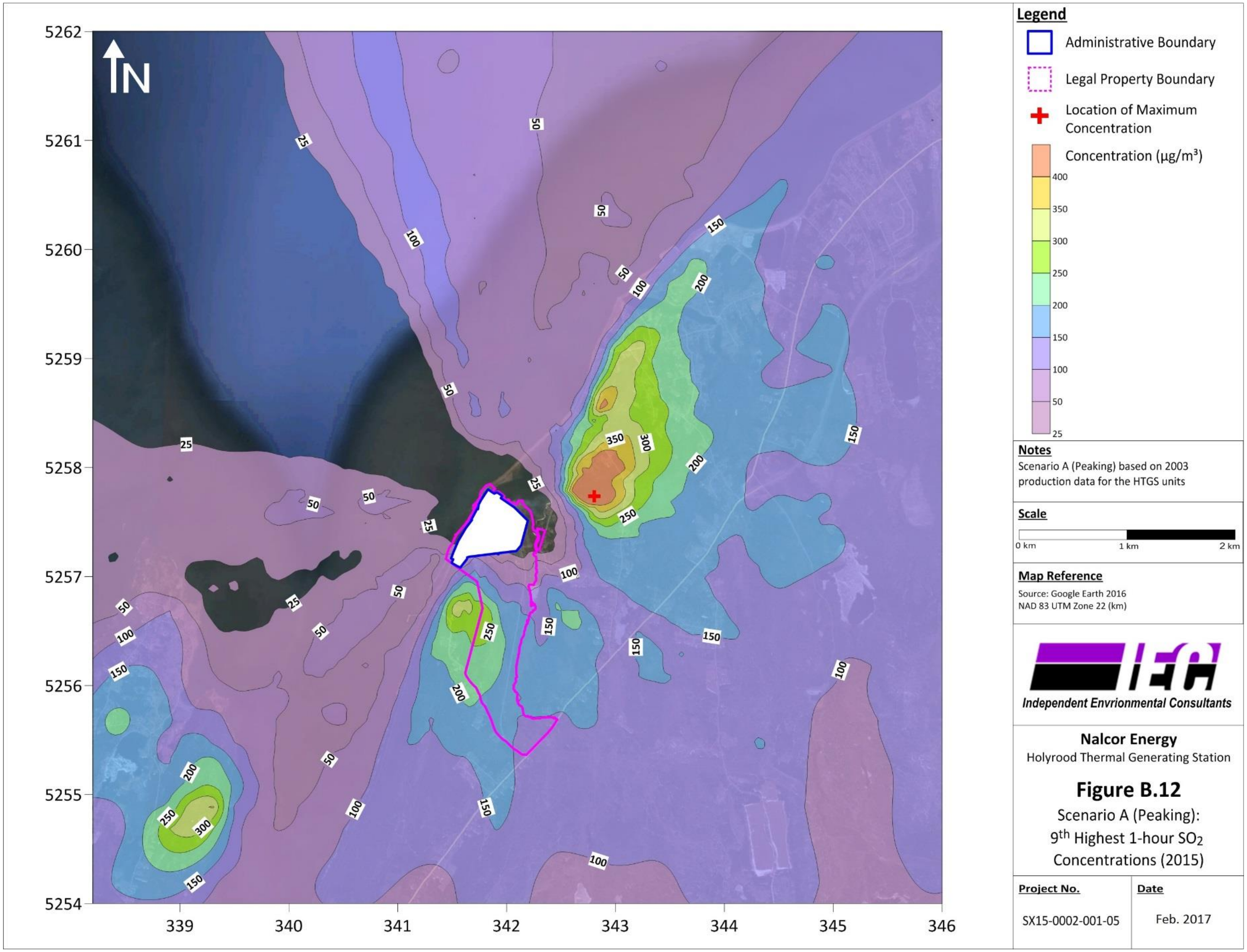
N
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (μg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.11
Scenario A (Peaking):
9th Highest 1-hour SO2 Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017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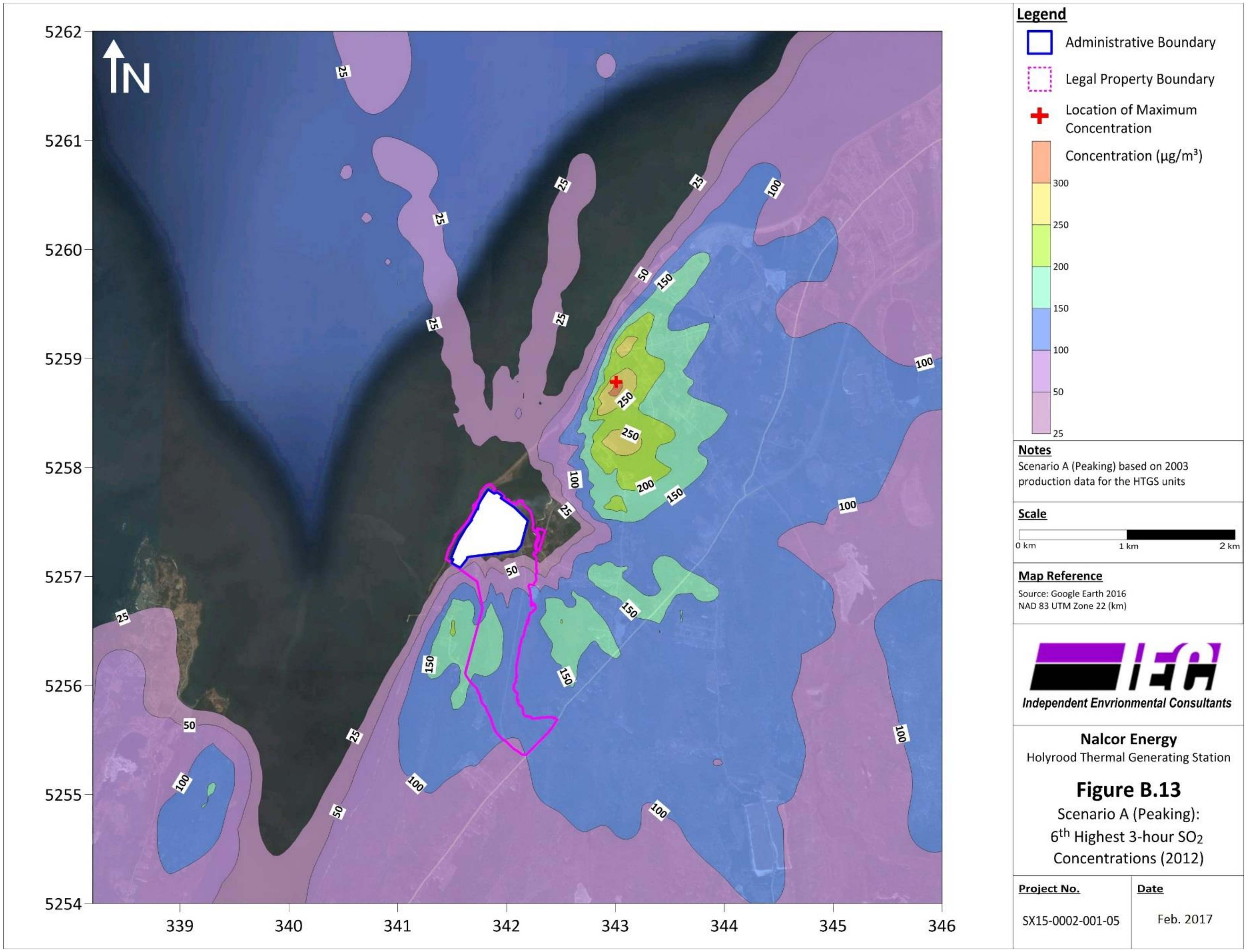
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.12
Scenario A (Peaking): 9th Highest 1-hour SO_2 Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017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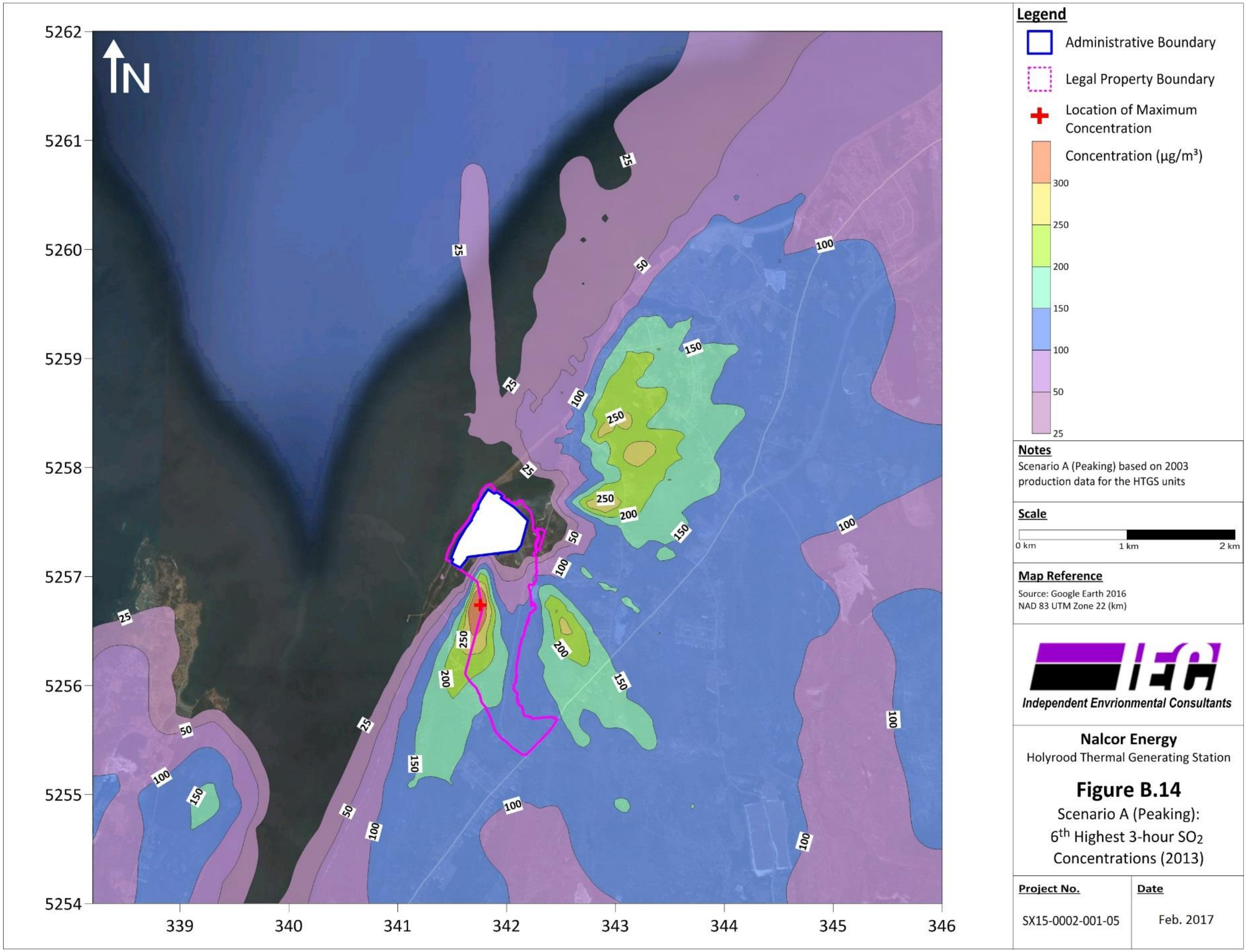
150
200
250
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.13
Scenario A (Peaking):
6th Highest 3-hour SO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017



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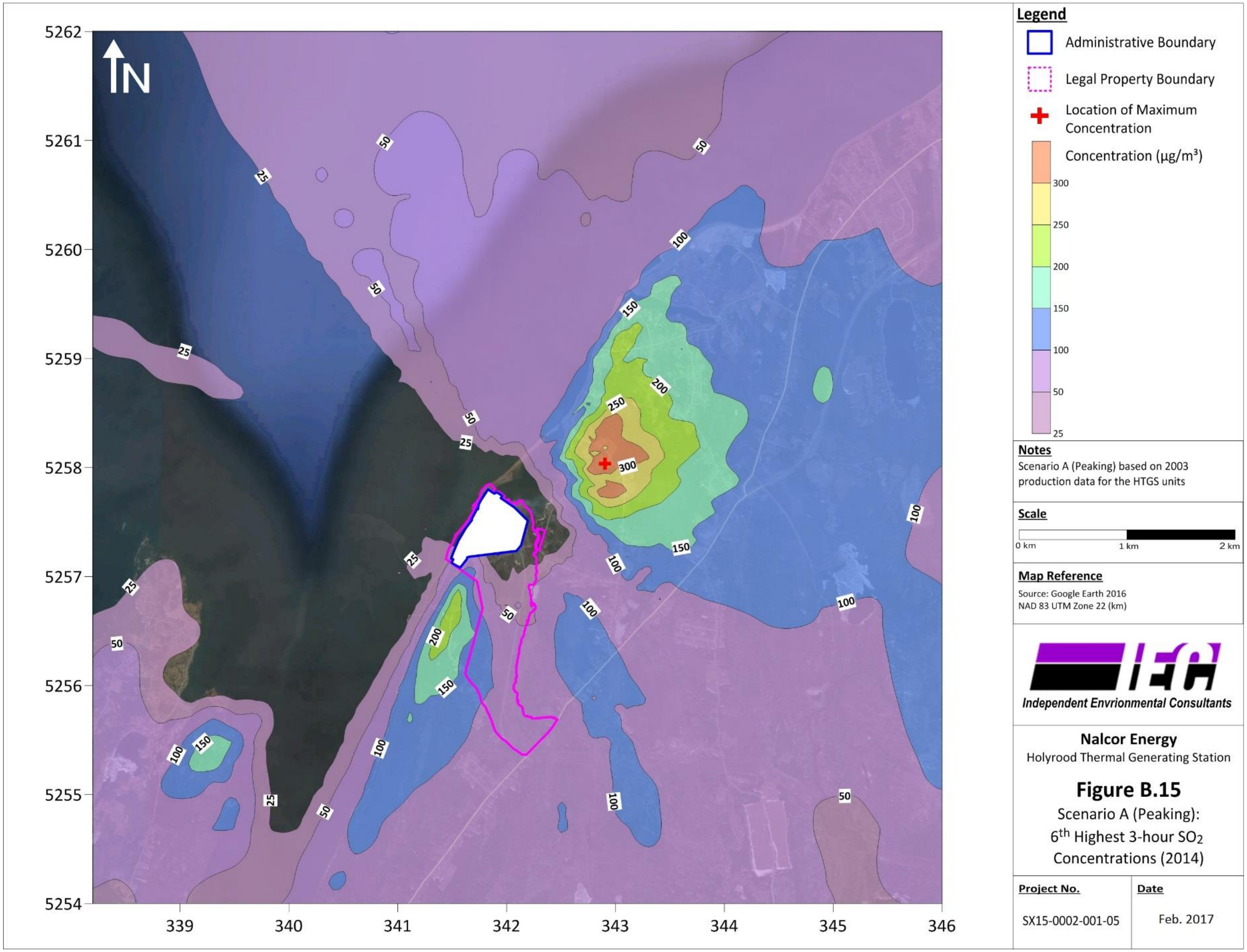
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.14
Scenario A (Peaking):
6th Highest 3-hour SO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017


Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.15
Scenario A (Peaking):
6th Highest 3-hour SO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017
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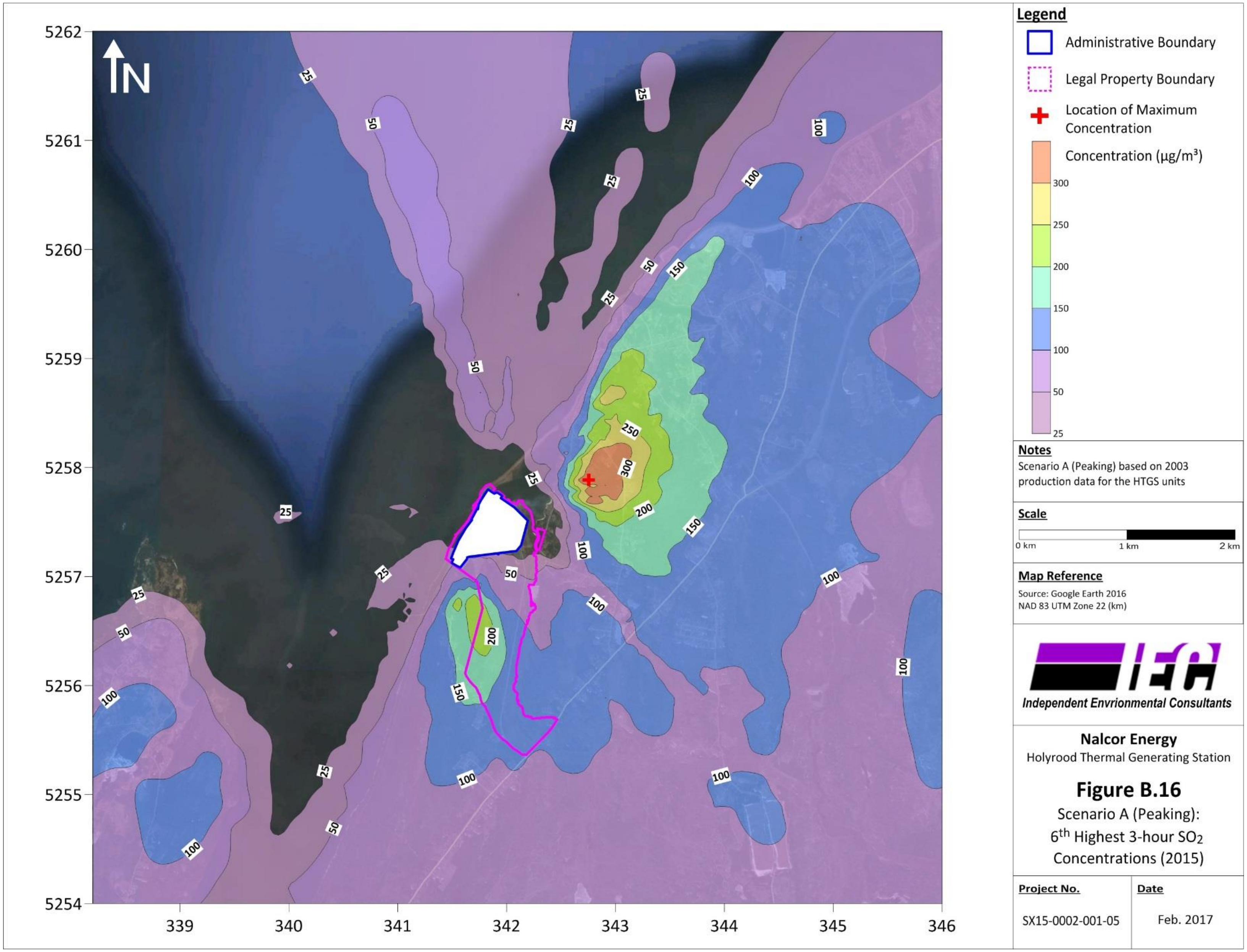
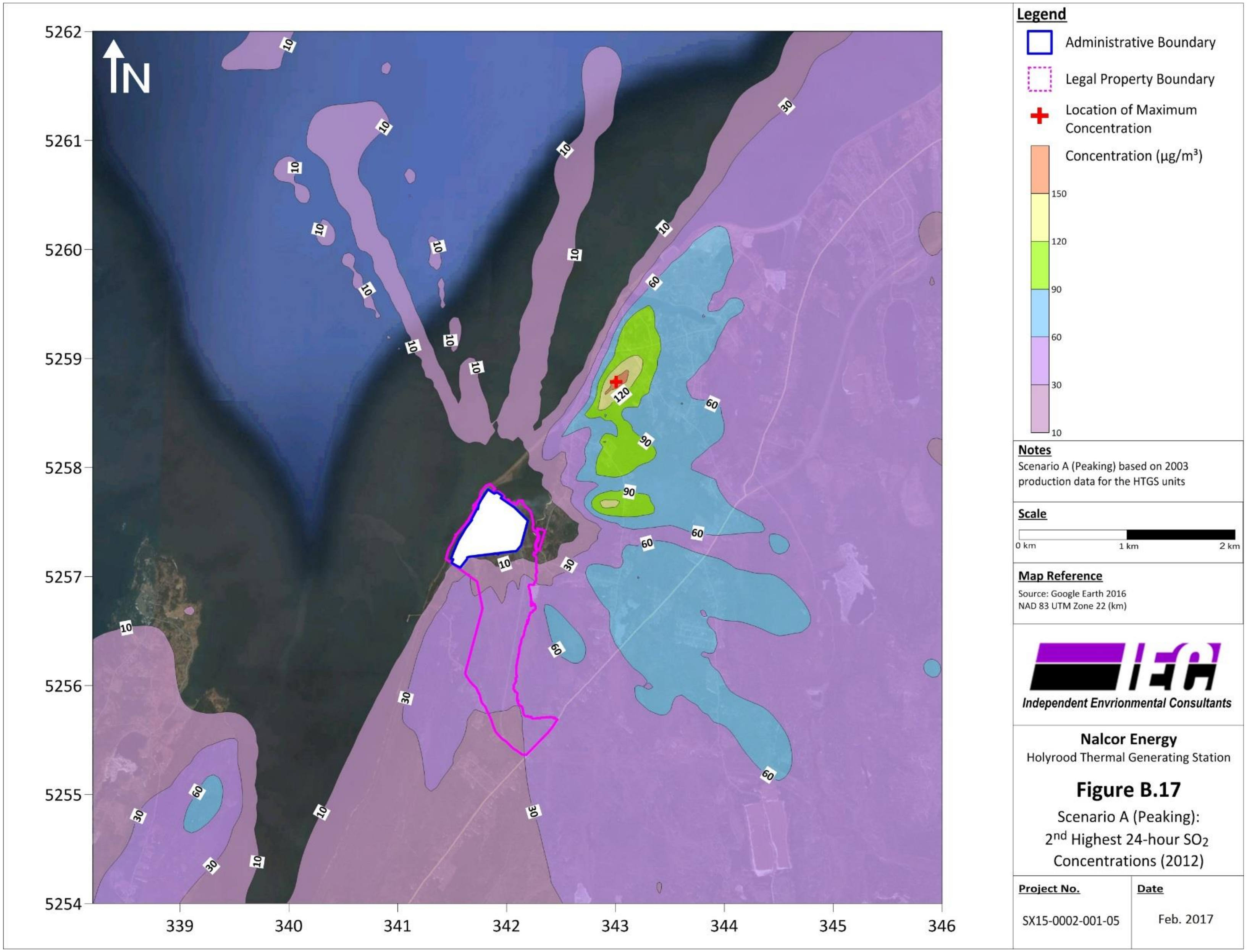


Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.16
Scenario A (Peaking):
6th Highest 3-hour SO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017



Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (μg/m³)
150
120
90
60
30
10
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.17
Scenario A (Peaking):
2nd Highest 24-hour SO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017

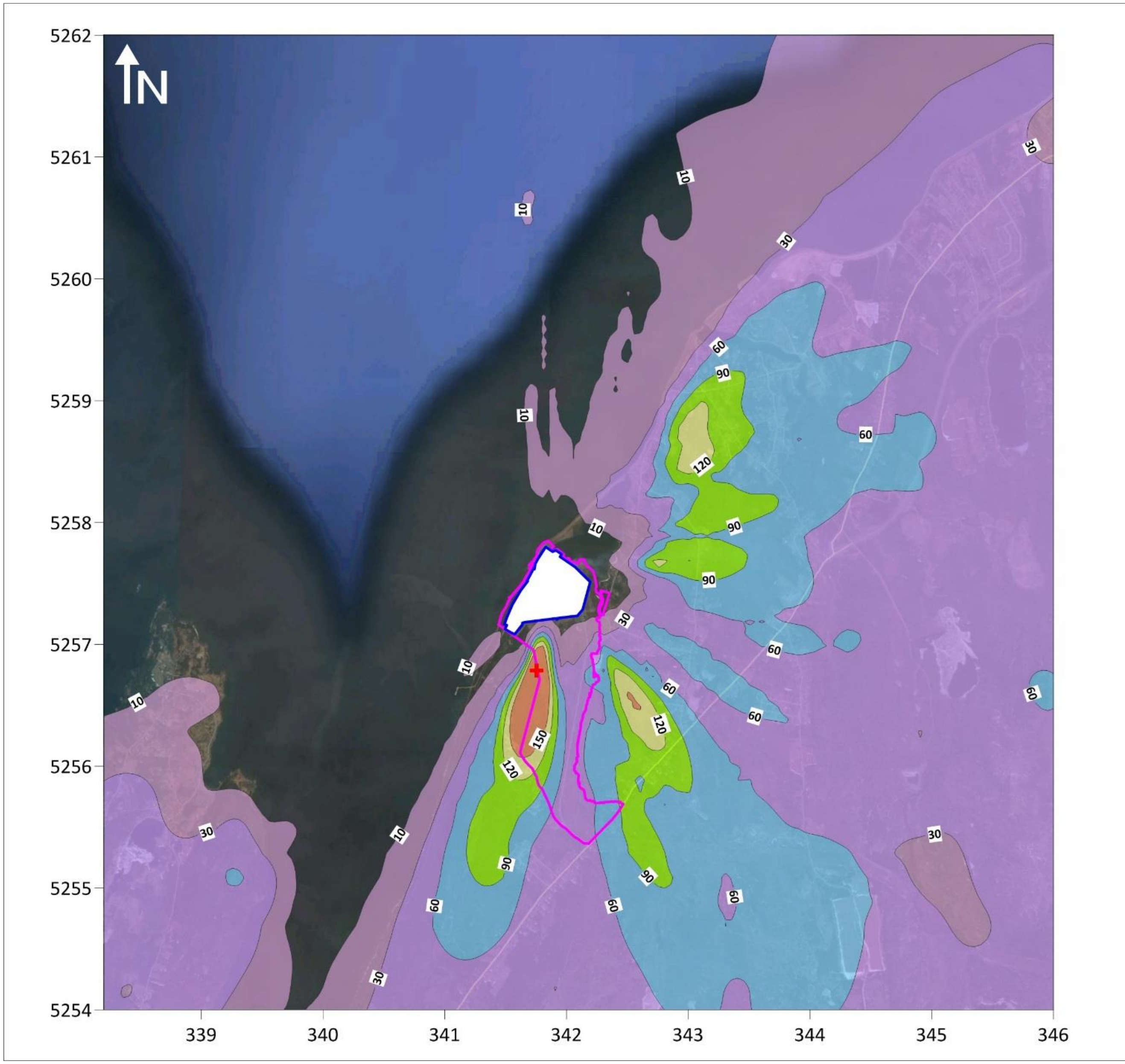
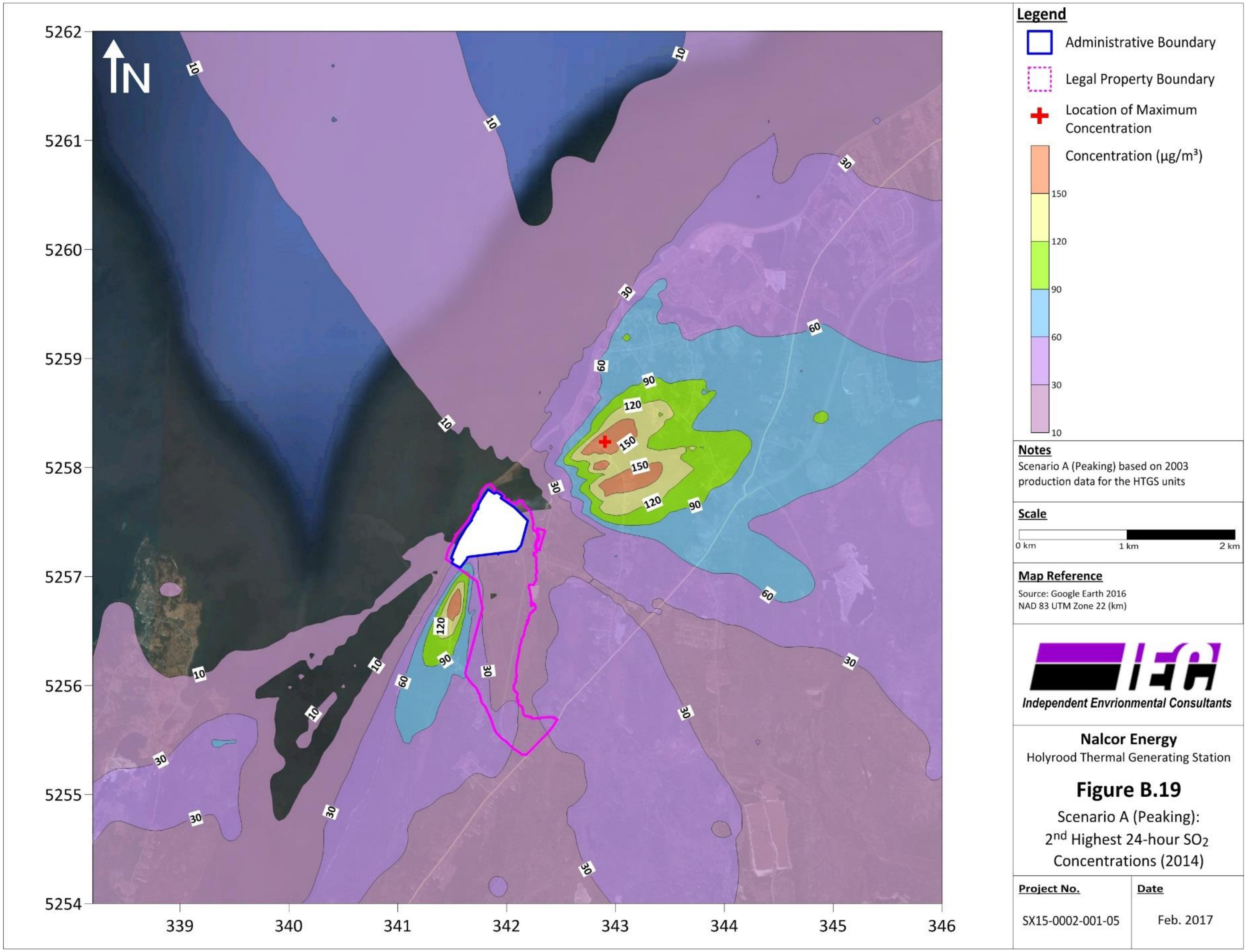
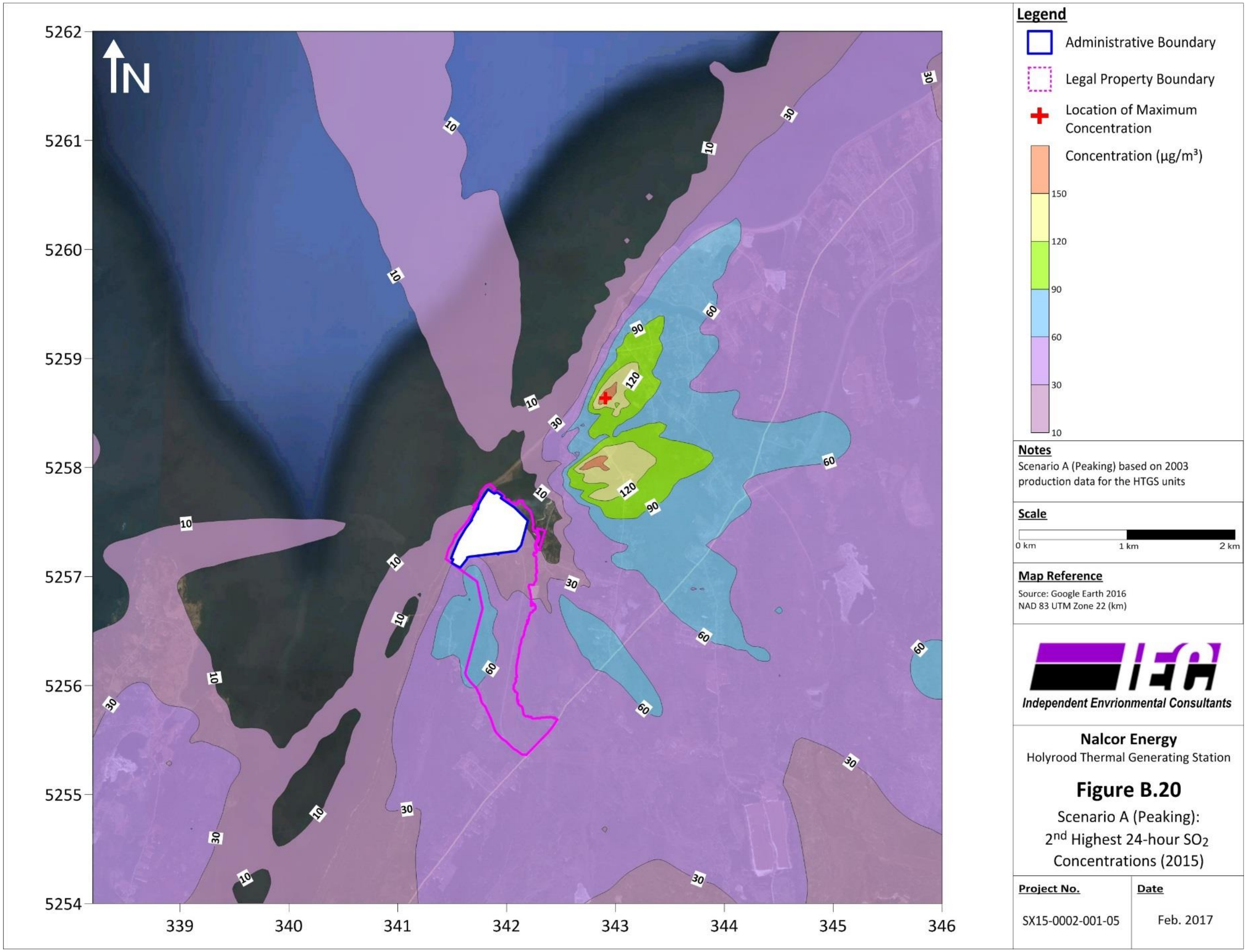


Figure B.18

Scenario A (Peaking): 2nd Highest 24-hour SO_2 Concentrations (2013)



Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
Notes
Scenario A (Peaking) based on 2003 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure B.19
Scenario A (Peaking):
2nd Highest 24-hour SO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017

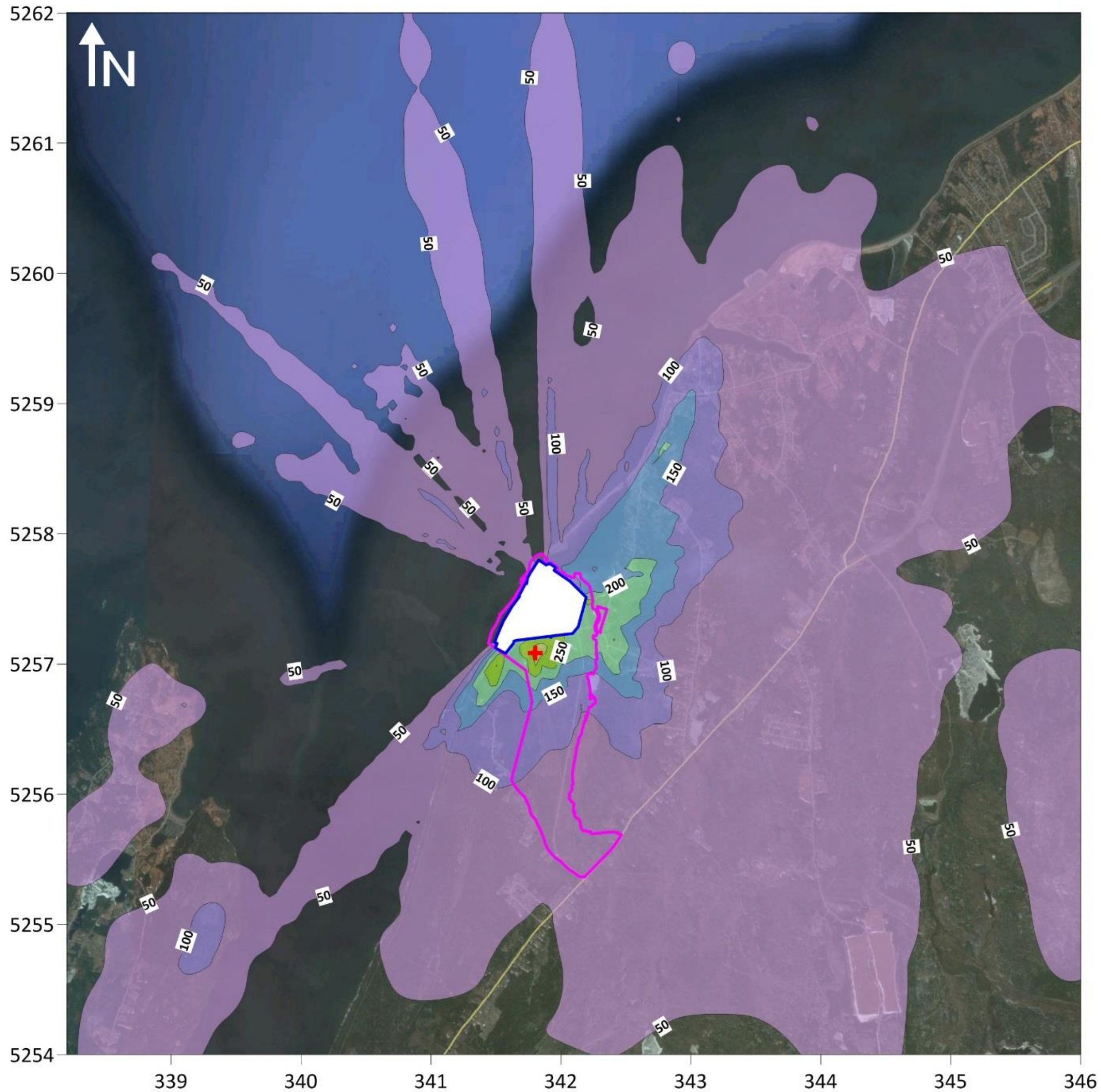


Nalcor Energy
Holyrood Thermal Generating Station

Figure B.20
Scenario A (Peaking):
2nd Highest 24-hour SO_2
Concentrations (2015)

Appendix C:

Scenario B Isopleths



Legend

Administrative Boundary

Legal Property Boundary

Location of Maximum Concentration

Concentration (μg/m³)

400
350
300
250
200
150
100
50

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km 1 km 2 km

Map Reference

Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

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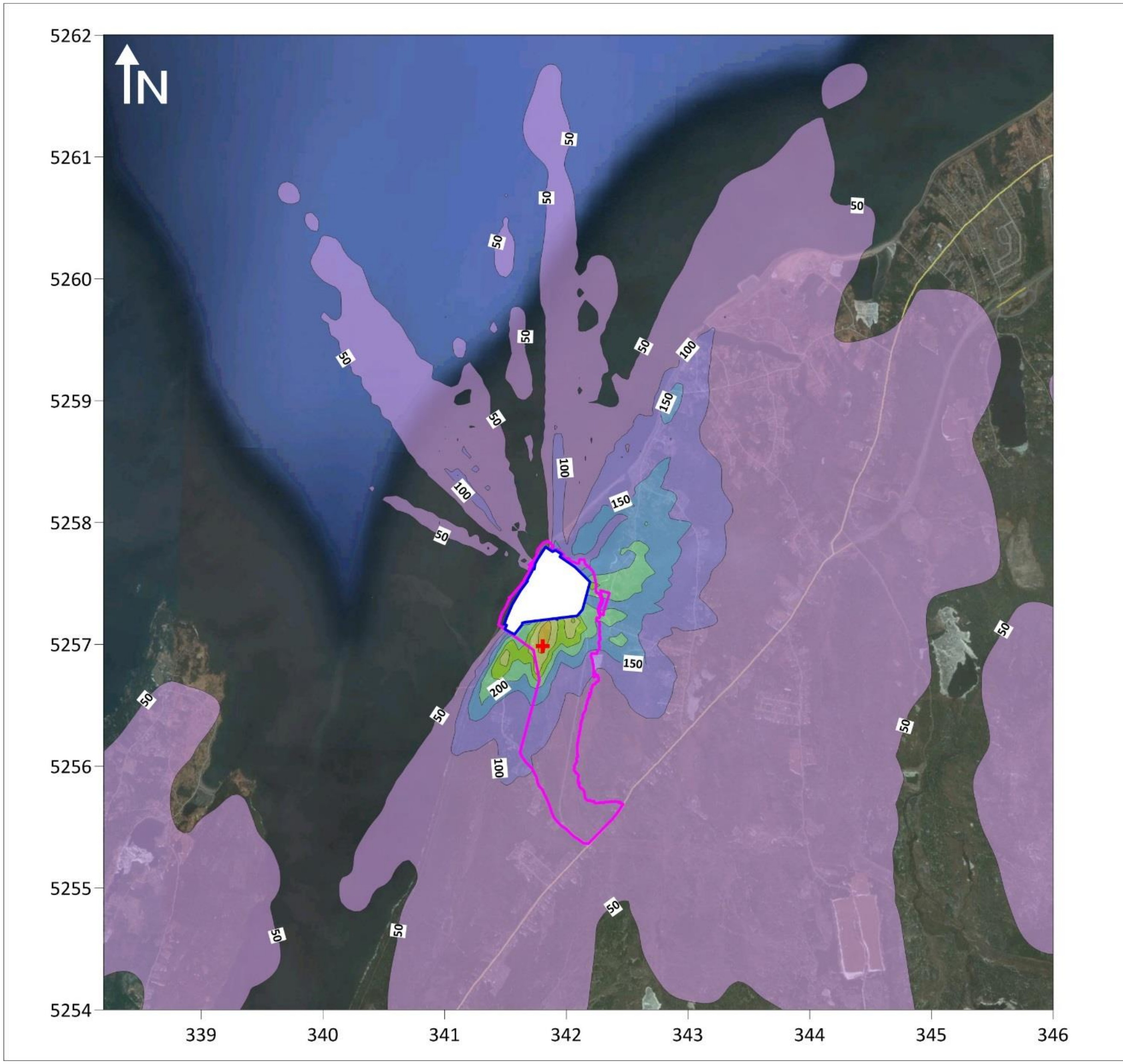
Nalcor Energy

Holyrood Thermal Generating Station

Figure C.1

Scenario B (Peaking):
9th Highest 1-hour NO_2
Concentrations (2012)

Project No.	**Date**
SX15-0002-001-05	Feb. 2017



Legend

- Administrative Boundary
- Legal Property Boundary
- Location of Maximum Concentration
- Concentration (µg/m³): 400, 350, 300, 250, 200, 150, 100, 50

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km, 1 km, 2 km

Map Reference

Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

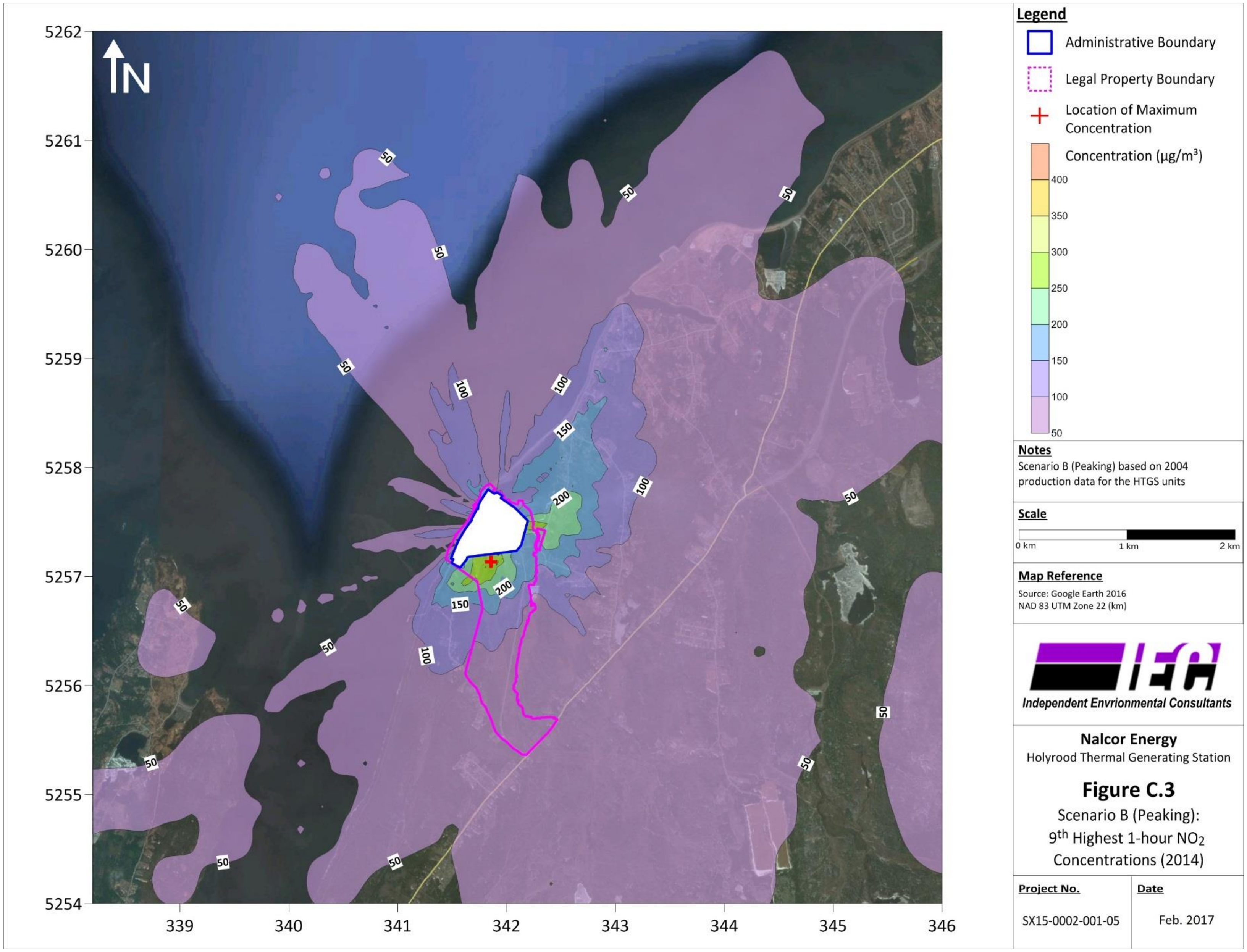
Independent Envrionmental Consultants

Nalcor Energy
Holyrood Thermal Generating Station

Figure C.2

Scenario B (Peaking): 9th Highest 1-hour NO_2 Concentrations (2013)

Project No.	**Date**
SX15-0002-001-05	Feb. 2017



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5260
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5255
5254
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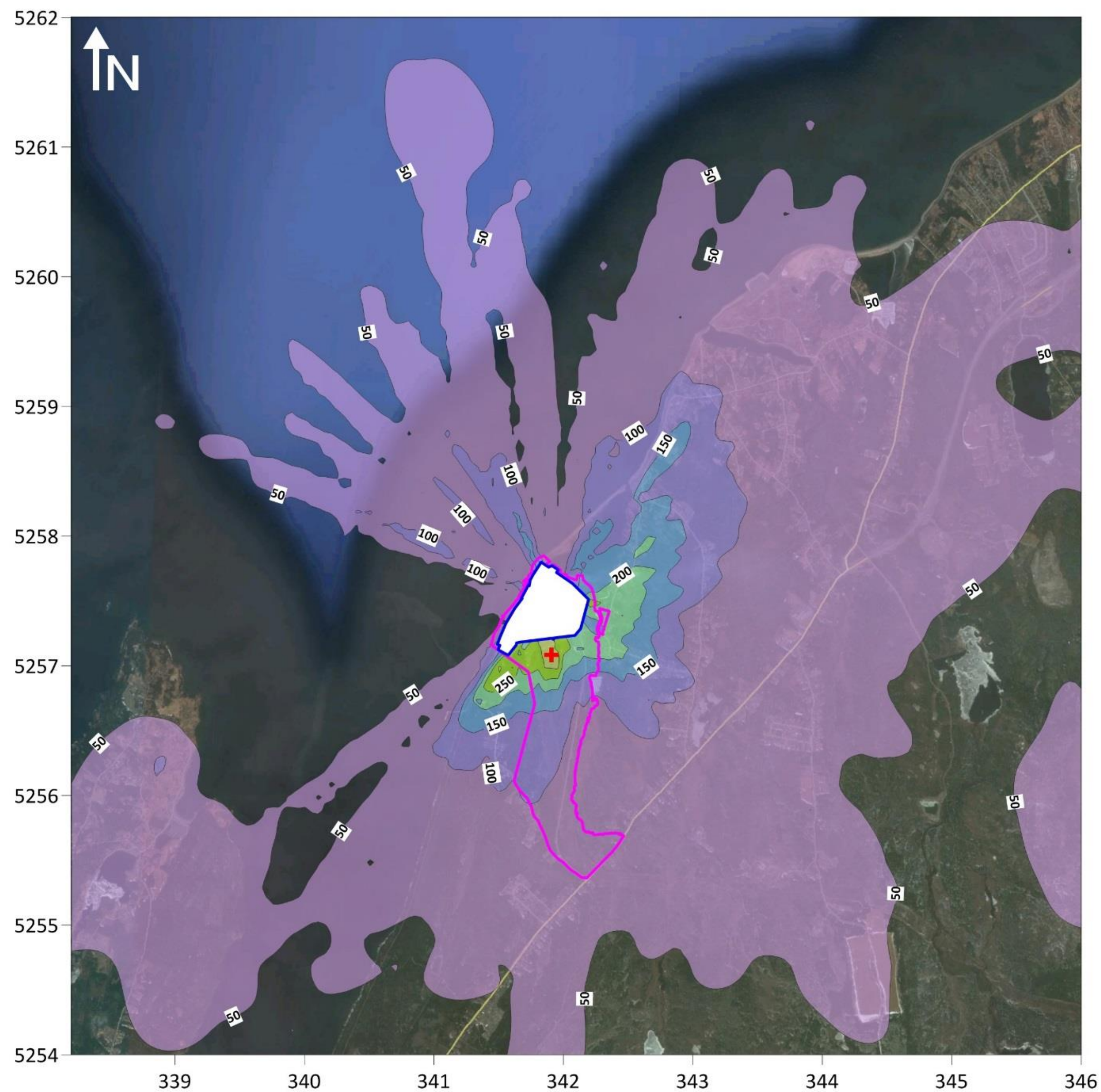
341
342
343
344
345
346
N
50
100
150
200
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.3
Scenario B (Peaking):
9th Highest 1-hour NO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017



Legend

Administrative Boundary

Legal Property Boundary

Location of Maximum Concentration

Concentration (µg/m³)

400, 350, 300, 250, 200, 150, 100, 50

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km — 1 km — 2 km

Map Reference

Source: Google Earth 2016

NAD 83 UTM Zone 22 (km)

Independent Envrionmental Consultants

Nalcor Energy

Holyrood Thermal Generating Station

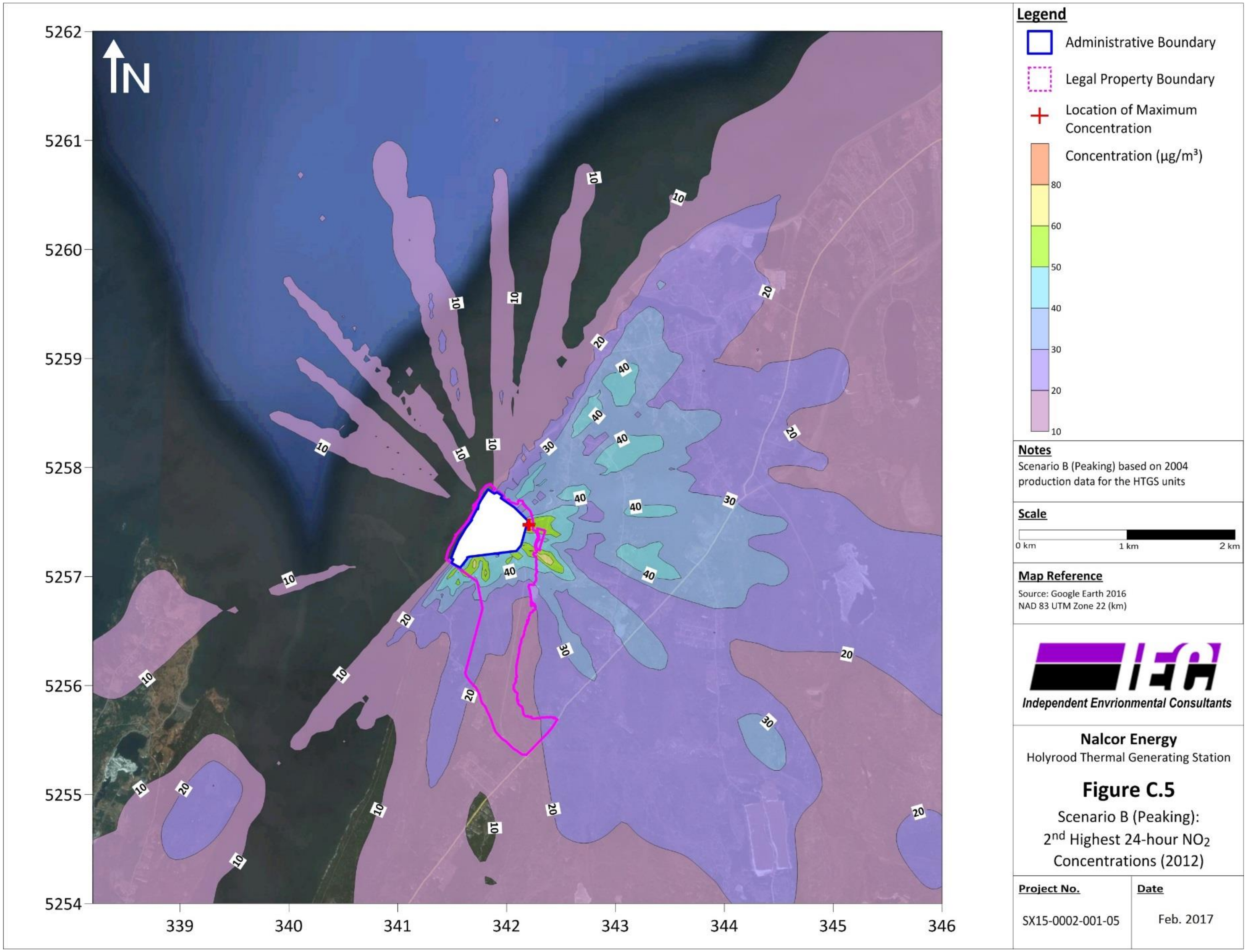
Figure C.4

Scenario B (Peaking):

9th Highest 1-hour NO_2

Concentrations (2015)

Project No.	Date
SX15-0002-001-05	Feb. 2017



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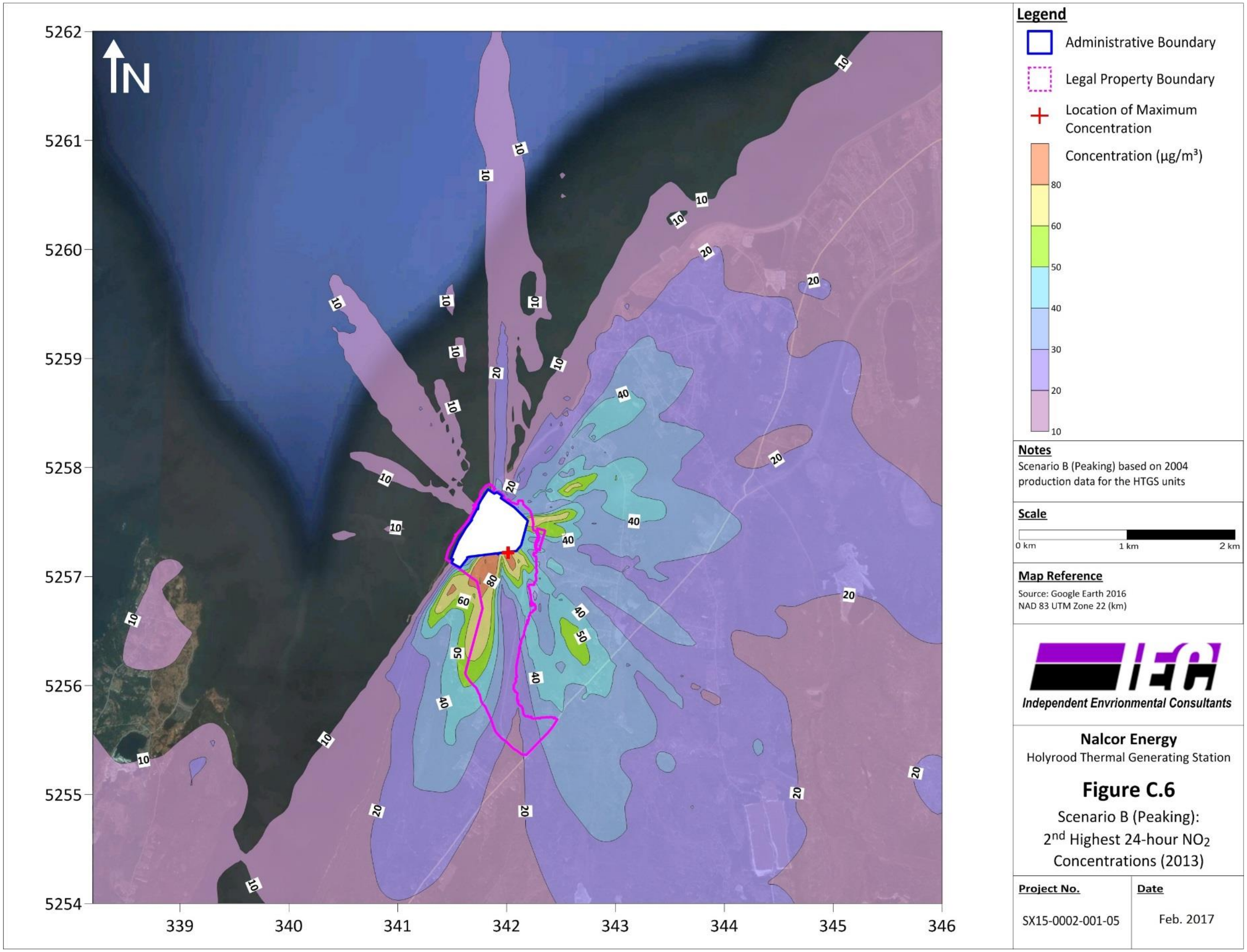
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
80
60
50
40
30
20
10
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.5
Scenario B (Peaking):
2nd Highest 24-hour NO2 Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017



Nalcor Energy
Holyrood Thermal Generating Station

Figure C.6
Scenario B (Peaking): 2nd Highest 24-hour NO_2 Concentrations (2013)

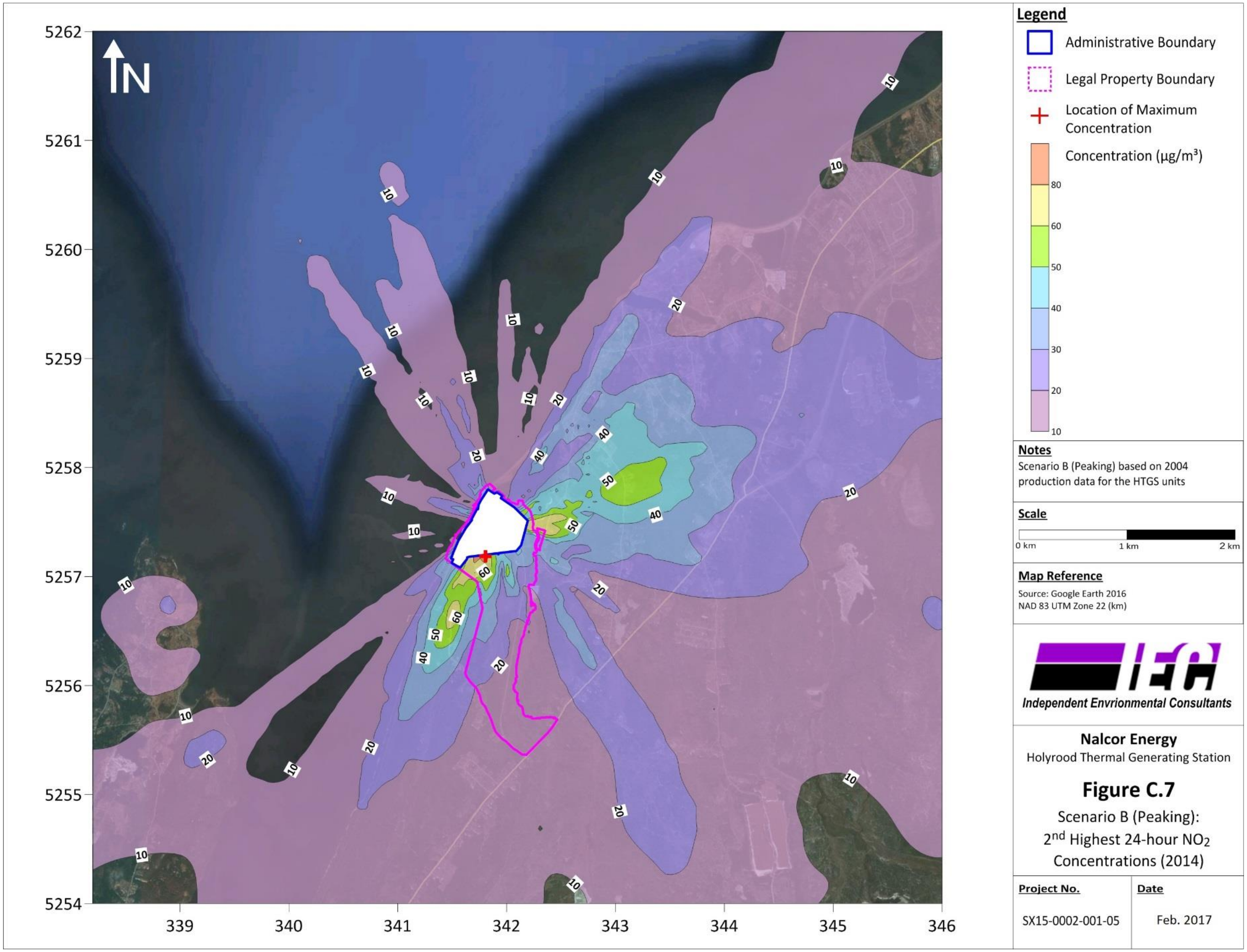
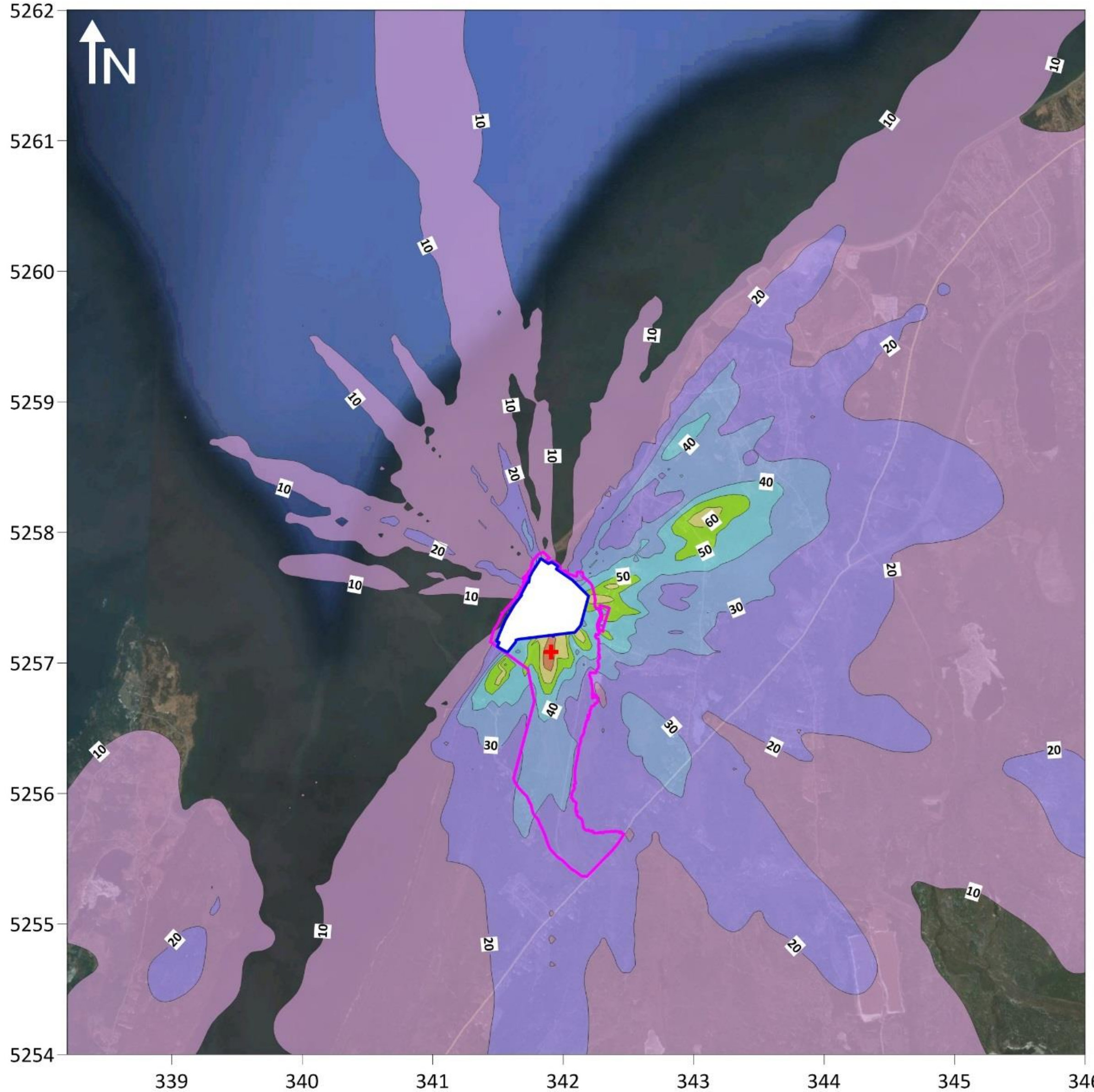


Figure C.7
Scenario B (Peaking): 2nd Highest 24-hour NO_2 Concentrations (2014)



Legend

- Administrative Boundary
- Legal Property Boundary
- Location of Maximum Concentration
- Concentration (μg/m³): 80, 60, 50, 40, 30, 20, 10

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km 1 km 2 km

Map Reference

Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

Independent Envrionmental Consultants

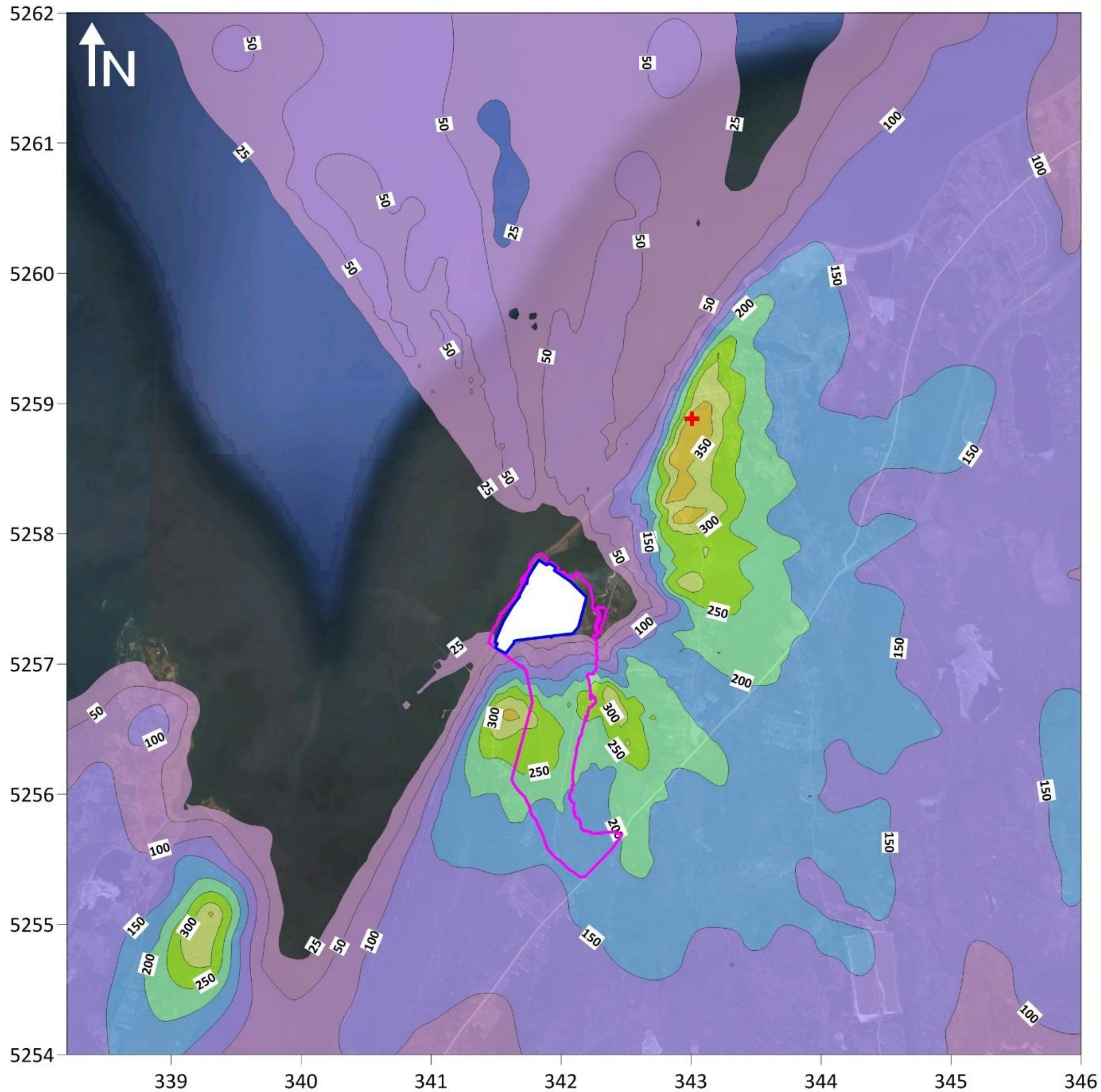
Nalcor Energy

Holyrood Thermal Generating Station

Figure C.8

Scenario B (Peaking):
2nd Highest 24-hour NO_2
Concentrations (2015)

Project No.	Date
SX15-0002-001-05	Feb. 2017



Legend

- Administrative Boundary
- Legal Property Boundary
- Location of Maximum Concentration
- Concentration (µg/m³): 400, 350, 300, 250, 200, 150, 100, 50, 25

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km — 1 km — 2 km

Map Reference

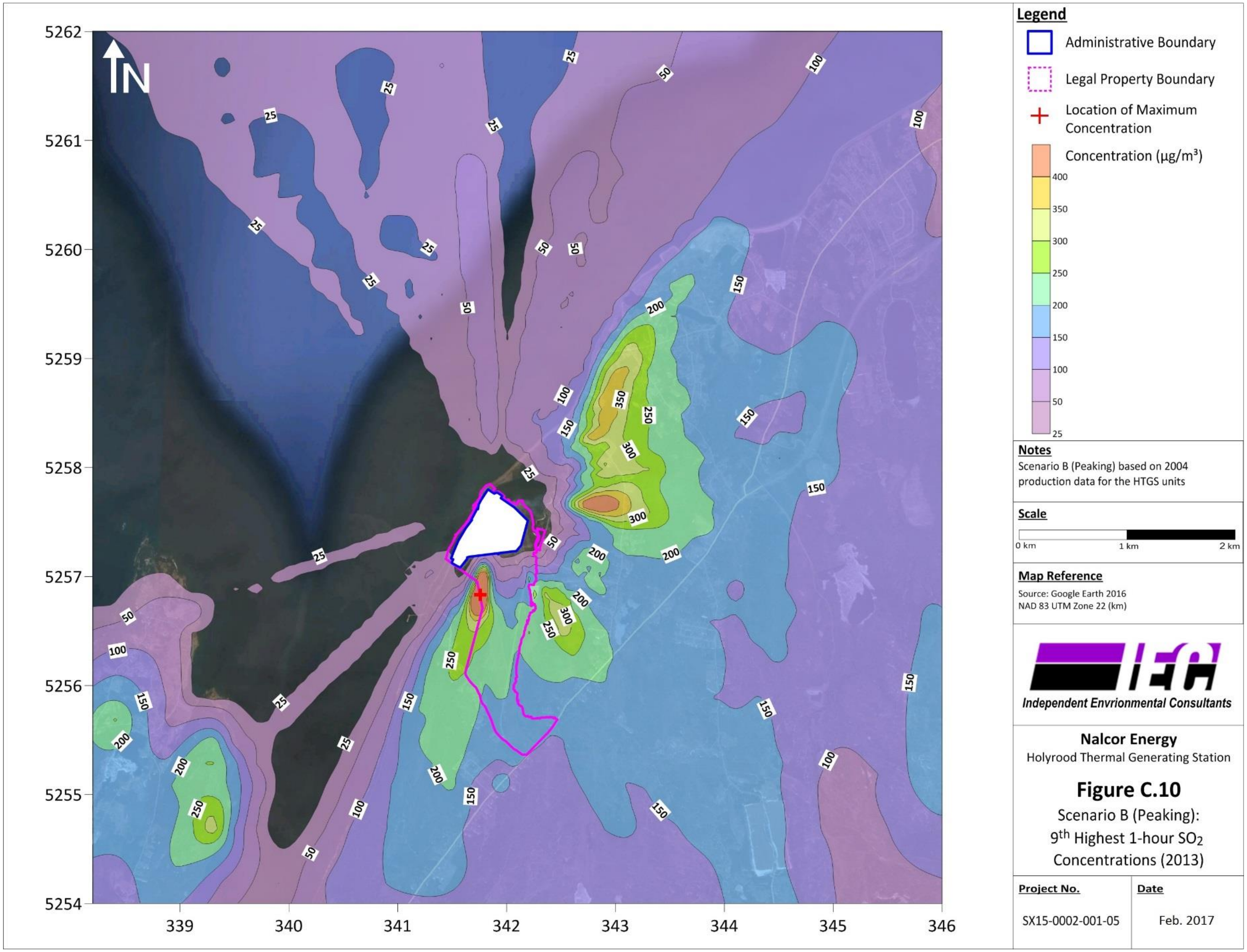
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

Independent Envrionmental Consultants

Nalcor Energy
Holyrood Thermal Generating Station

Figure C.9
Scenario B (Peaking):
9th Highest 1-hour SO_2
Concentrations (2012)

Project No.	Date
SX15-0002-001-05	Feb. 2017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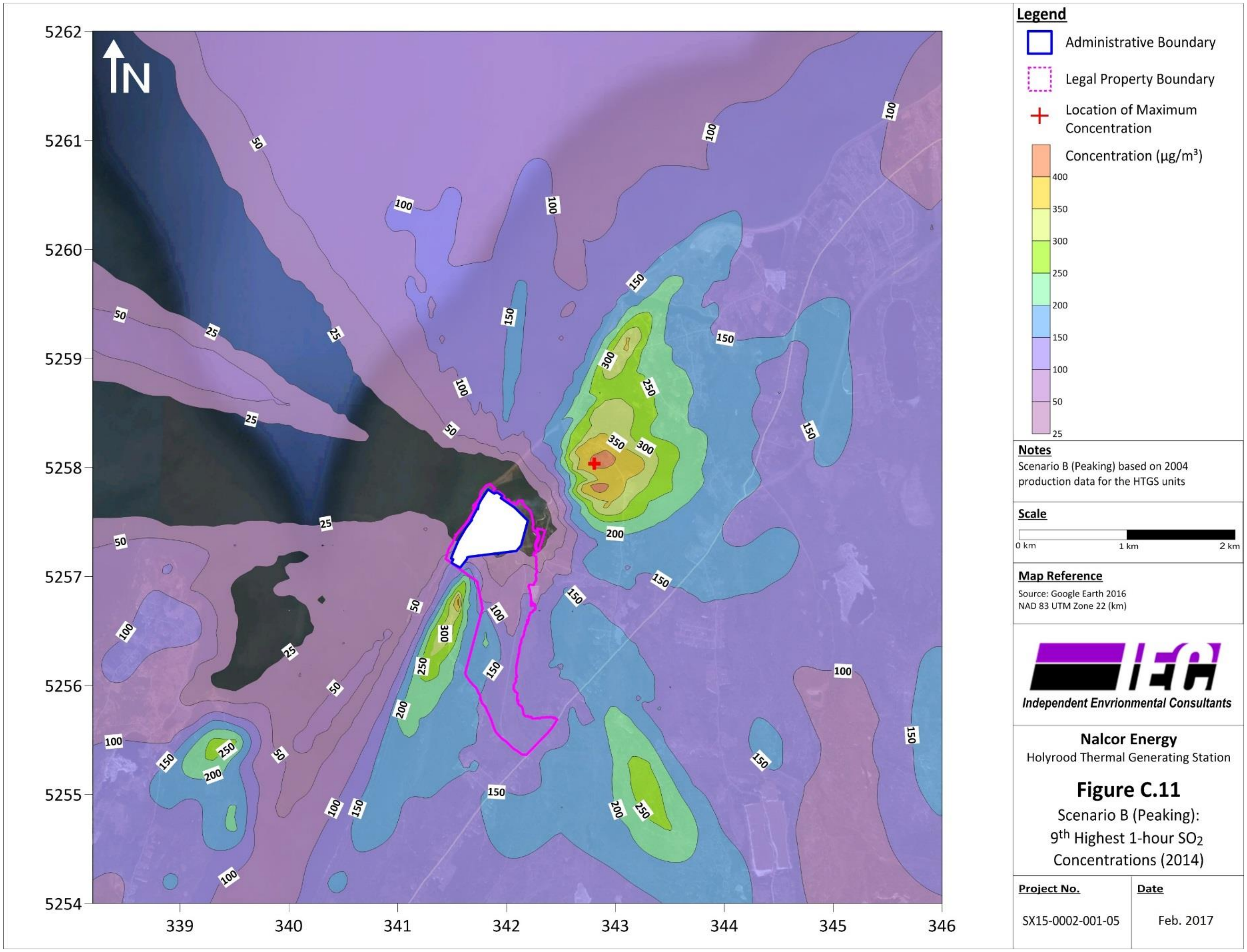
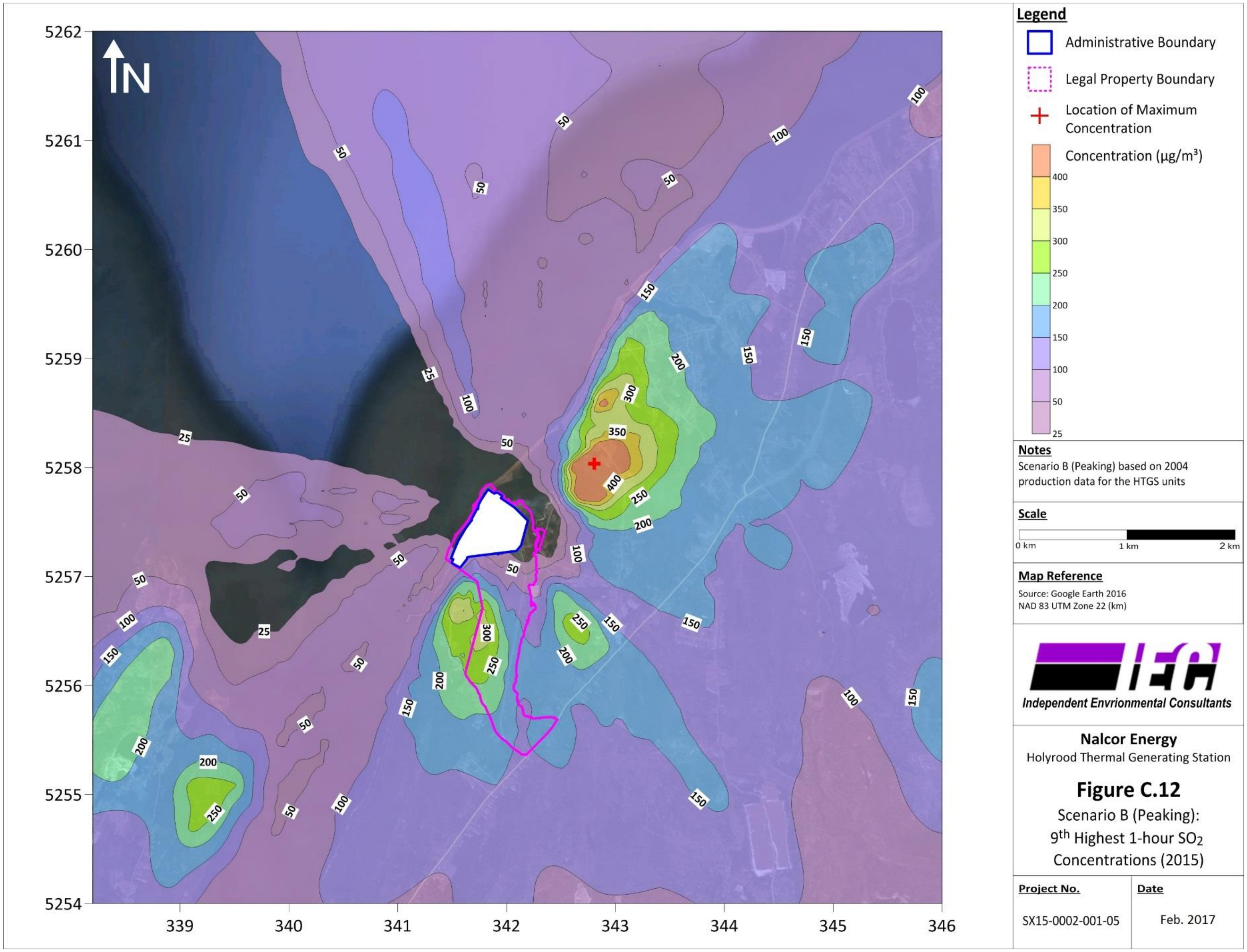
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.10
Scenario B (Peaking):
9th Highest 1-hour SO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017



Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrironmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.11
Scenario B (Peaking):
9th Highest 1-hour SO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017



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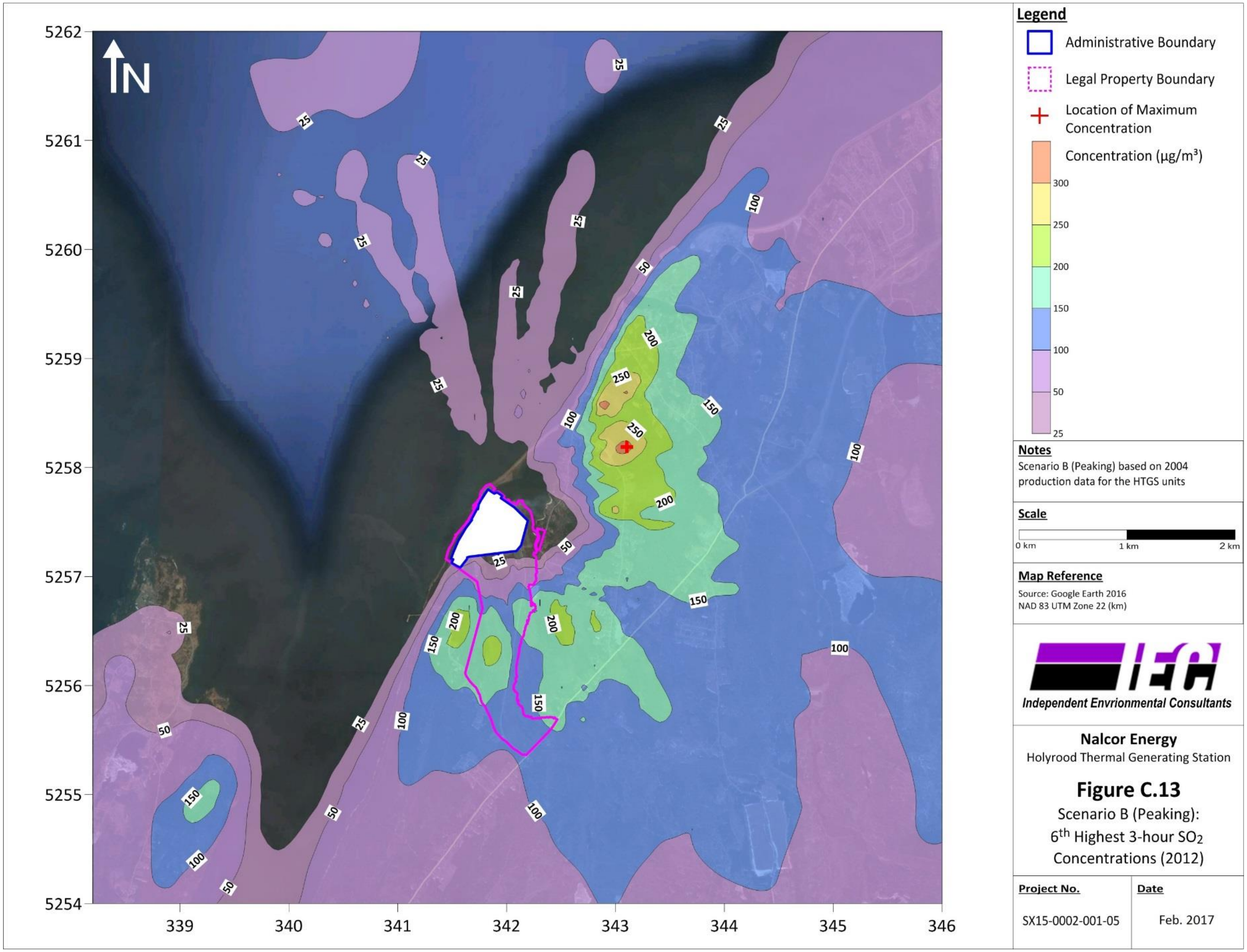
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.12
Scenario B (Peaking):
9th Highest 1-hour SO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017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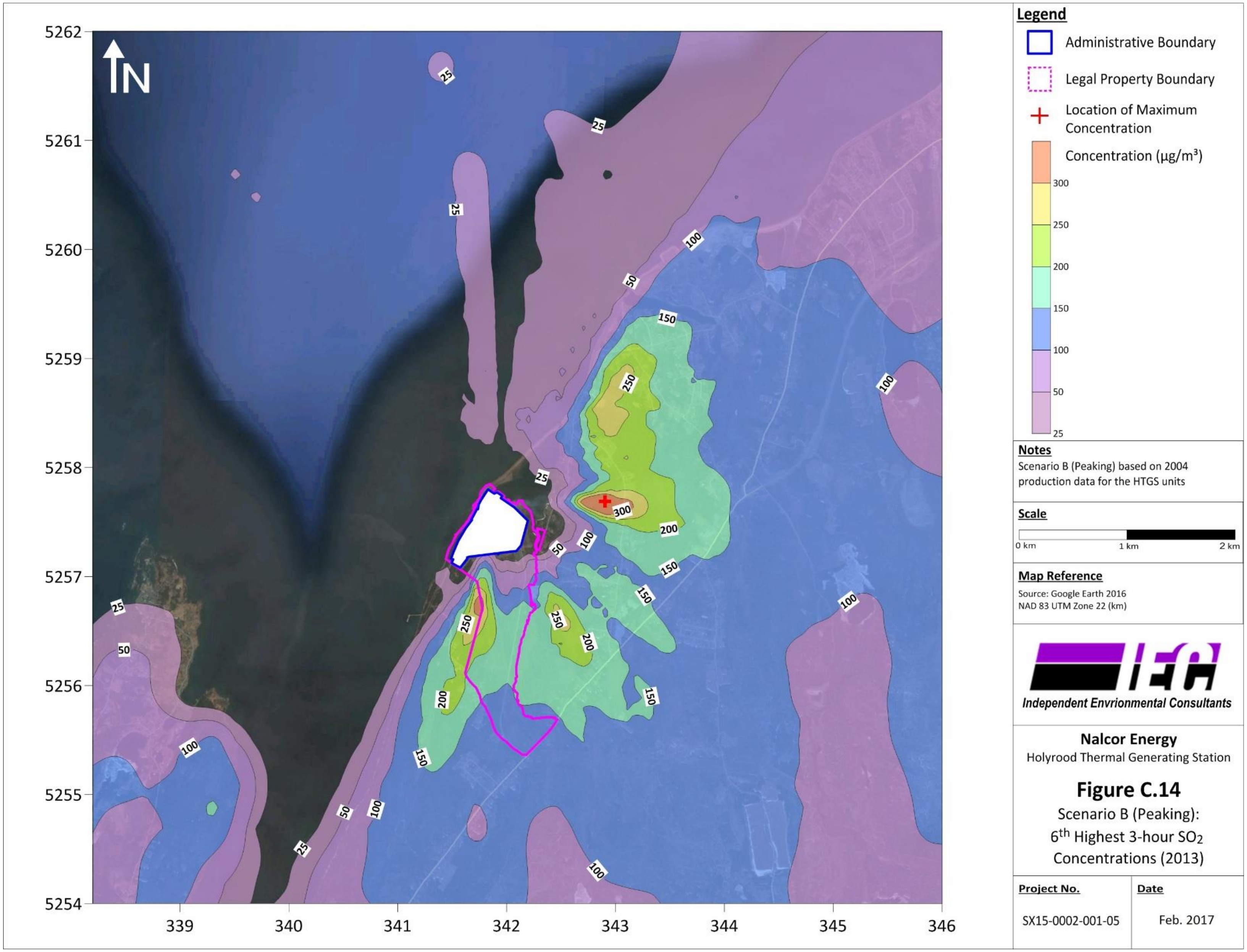
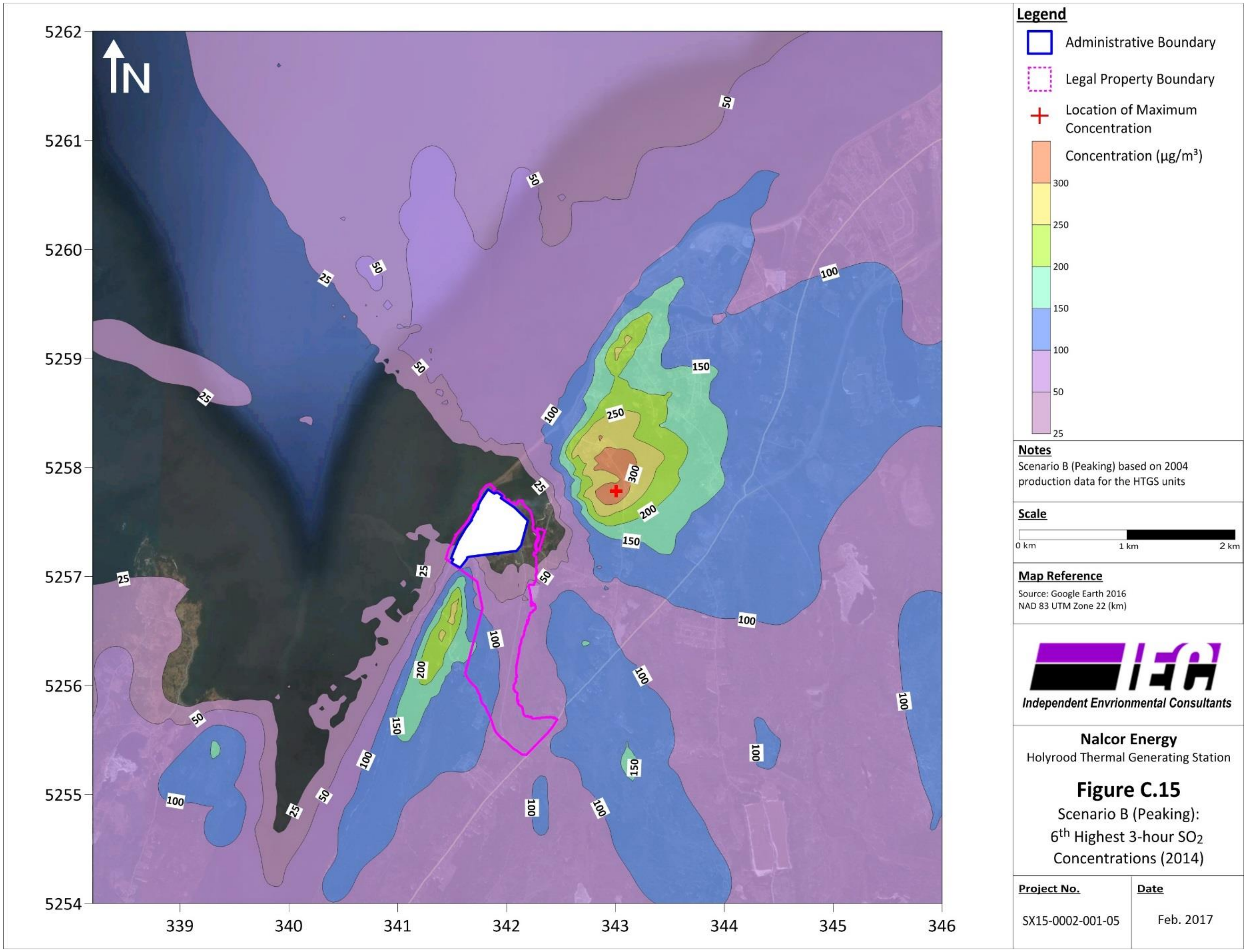
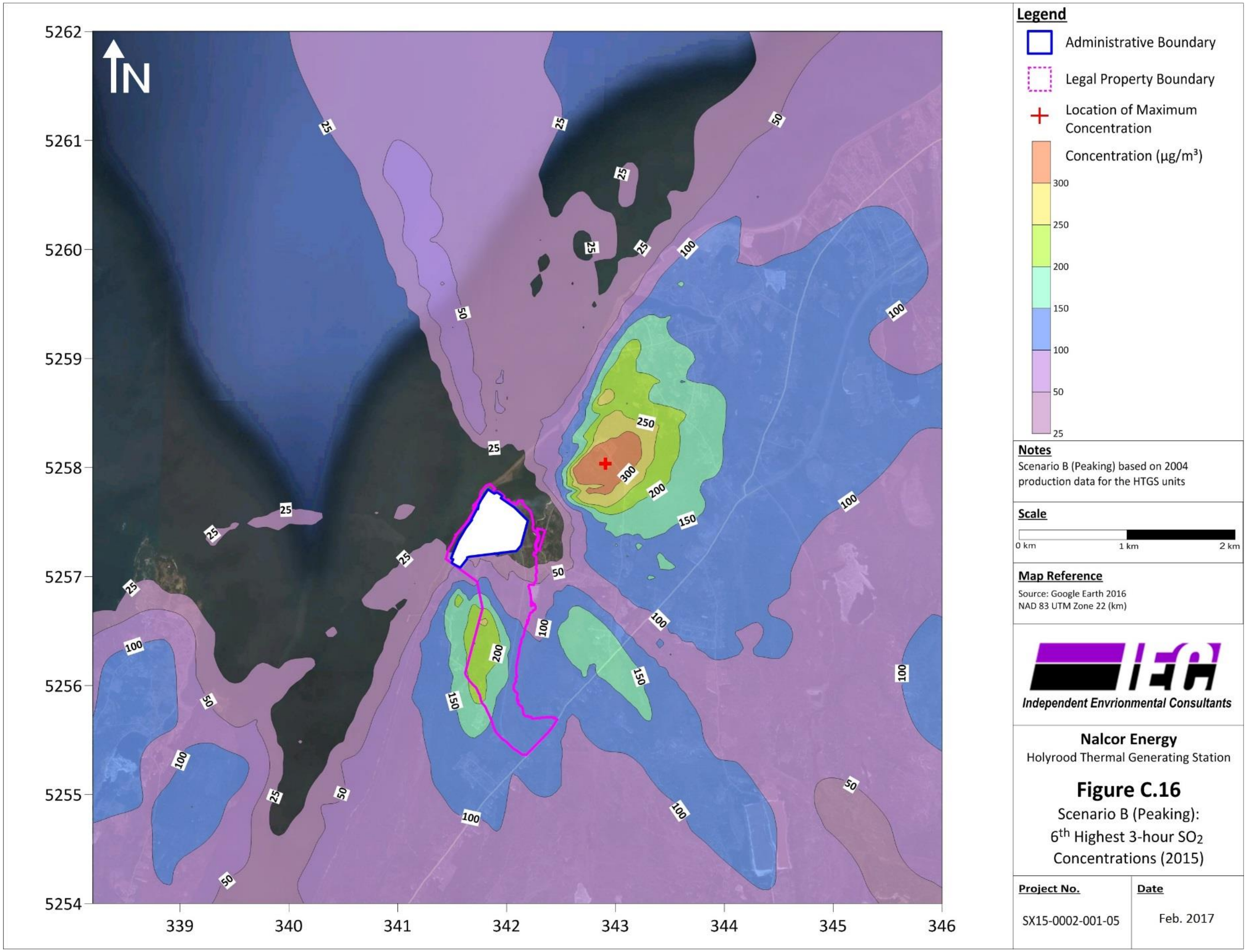
N
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.13
Scenario B (Peaking):
6th Highest 3-hour SO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017


Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.14
Scenario B (Peaking):
6th Highest 3-hour SO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017

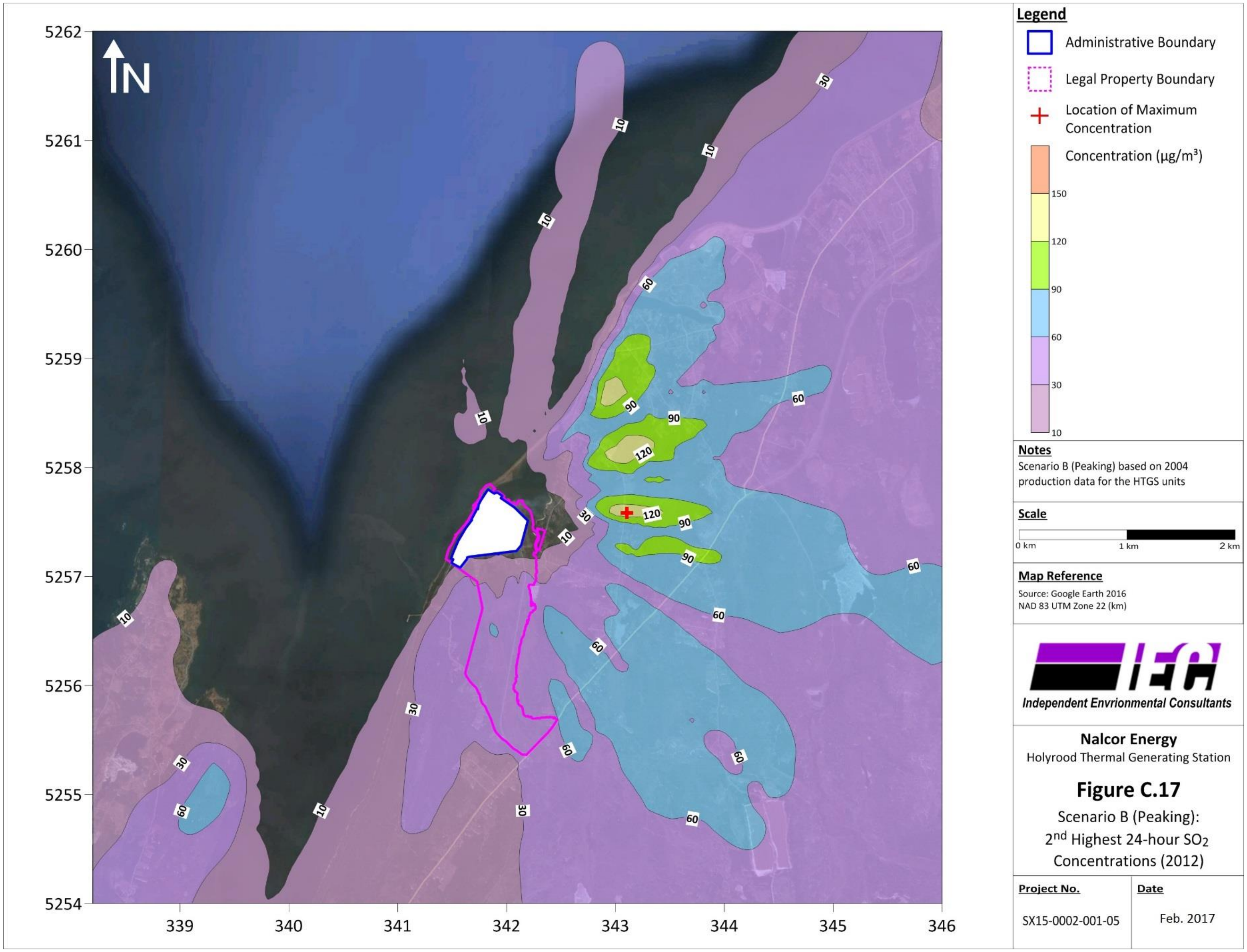


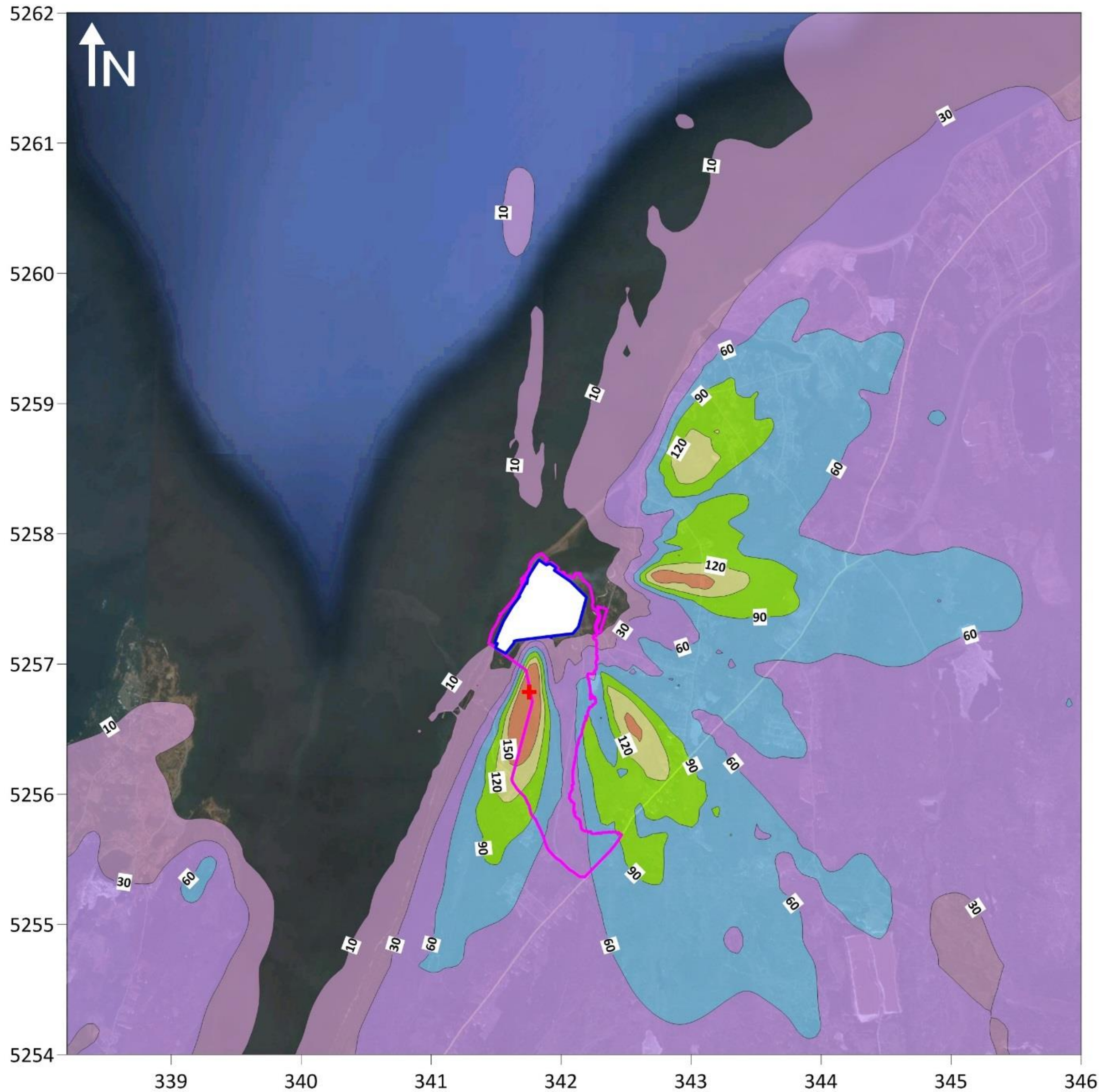
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
300
250
200
150
100
50
25
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Environmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.15
Scenario B (Peaking):
6th Highest 3-hour SO2 Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017



Nalcor Energy
Holyrood Thermal Generating Station

Figure C.16
Scenario B (Peaking):
6th Highest 3-hour SO_2 Concentrations (2015)


Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
150
120
90
60
30
10
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.17
Scenario B (Peaking):
2nd Highest 24-hour SO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017
5262
5261
5260
5259
5258
5257
5256
5255
5254
339
340
341
342
343
344
345
346
N



Legend

- Administrative Boundary
- Legal Property Boundary
- Location of Maximum Concentration
- Concentration (µg/m³): 10, 30, 60, 90, 120, 150

Notes

Scenario B (Peaking) based on 2004 production data for the HTGS units

Scale

0 km, 1 km, 2 km

Map Reference

Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)

Independent Envrionmental Consultants

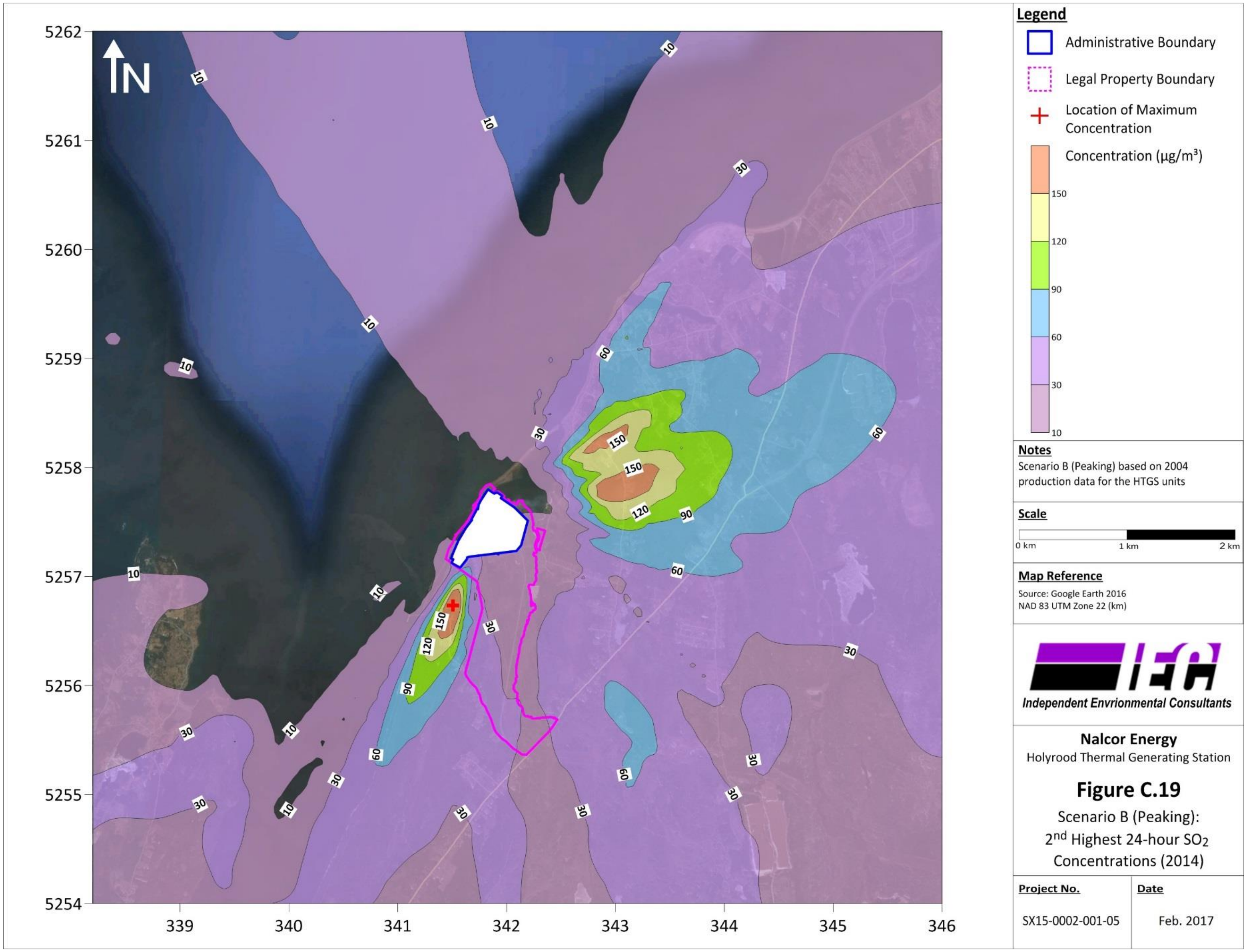
Nalcor Energy

Holyrood Thermal Generating Station

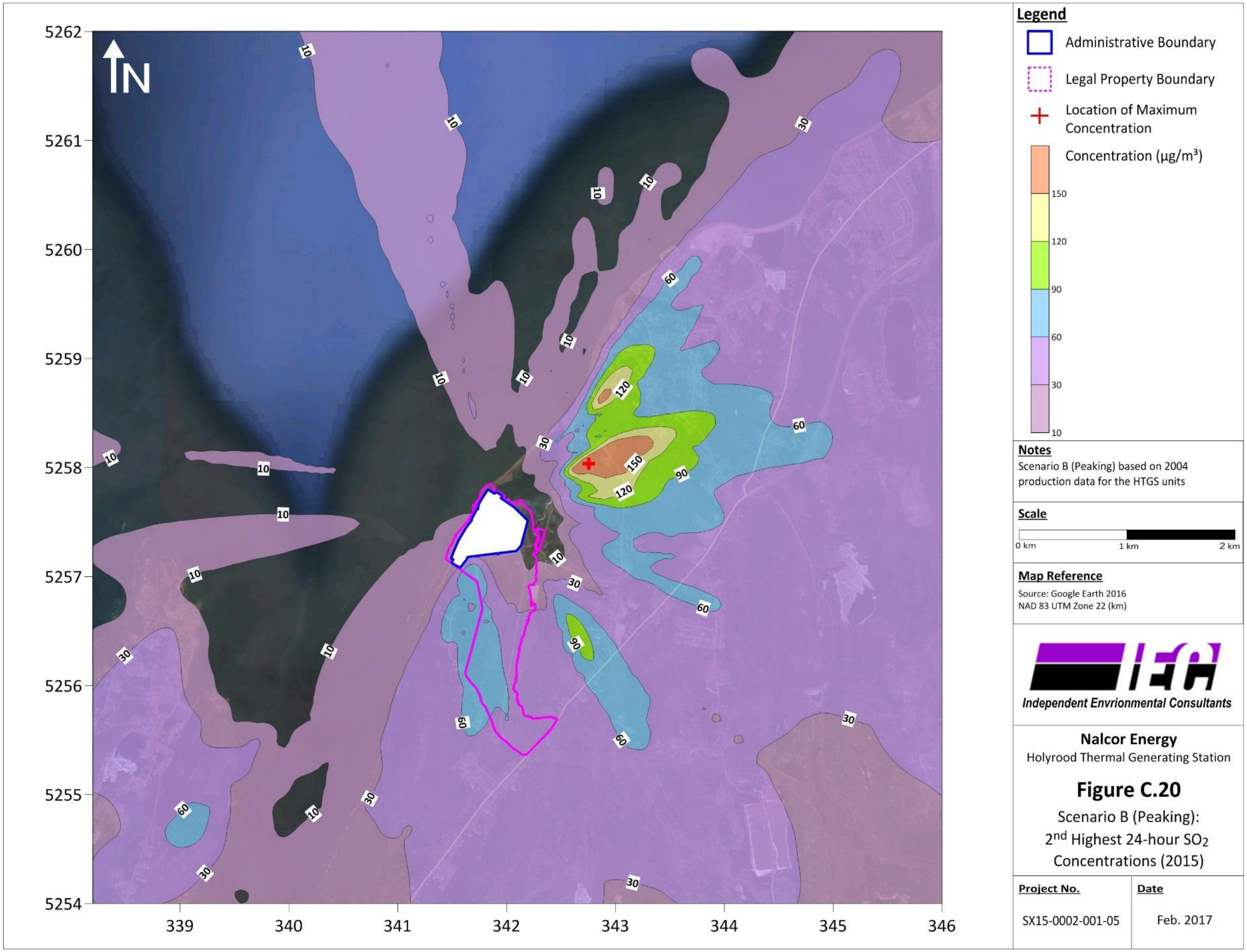
Figure C.18

Scenario B (Peaking):
2nd Highest 24-hour SO_2 Concentrations (2013)

Project No.	Date
SX15-0002-001-05	Feb. 2017



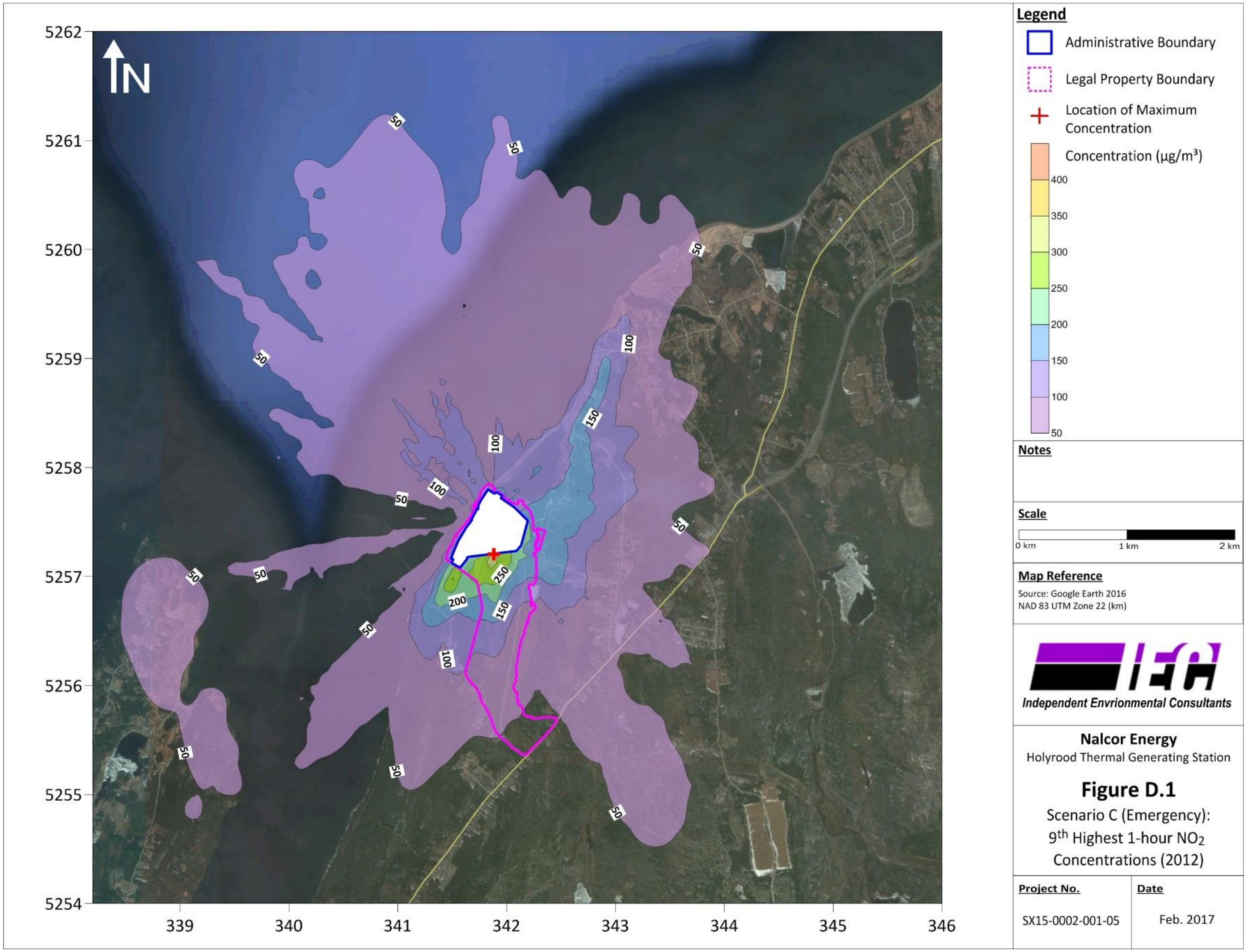
5262
5261
5260
5259
5258
5257
5256
5255
5254
339
340
341
342
343
344
345
346
N
10
30
60
90
120
150
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
150
120
90
60
30
10
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.19
Scenario B (Peaking):
2nd Highest 24-hour SO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017



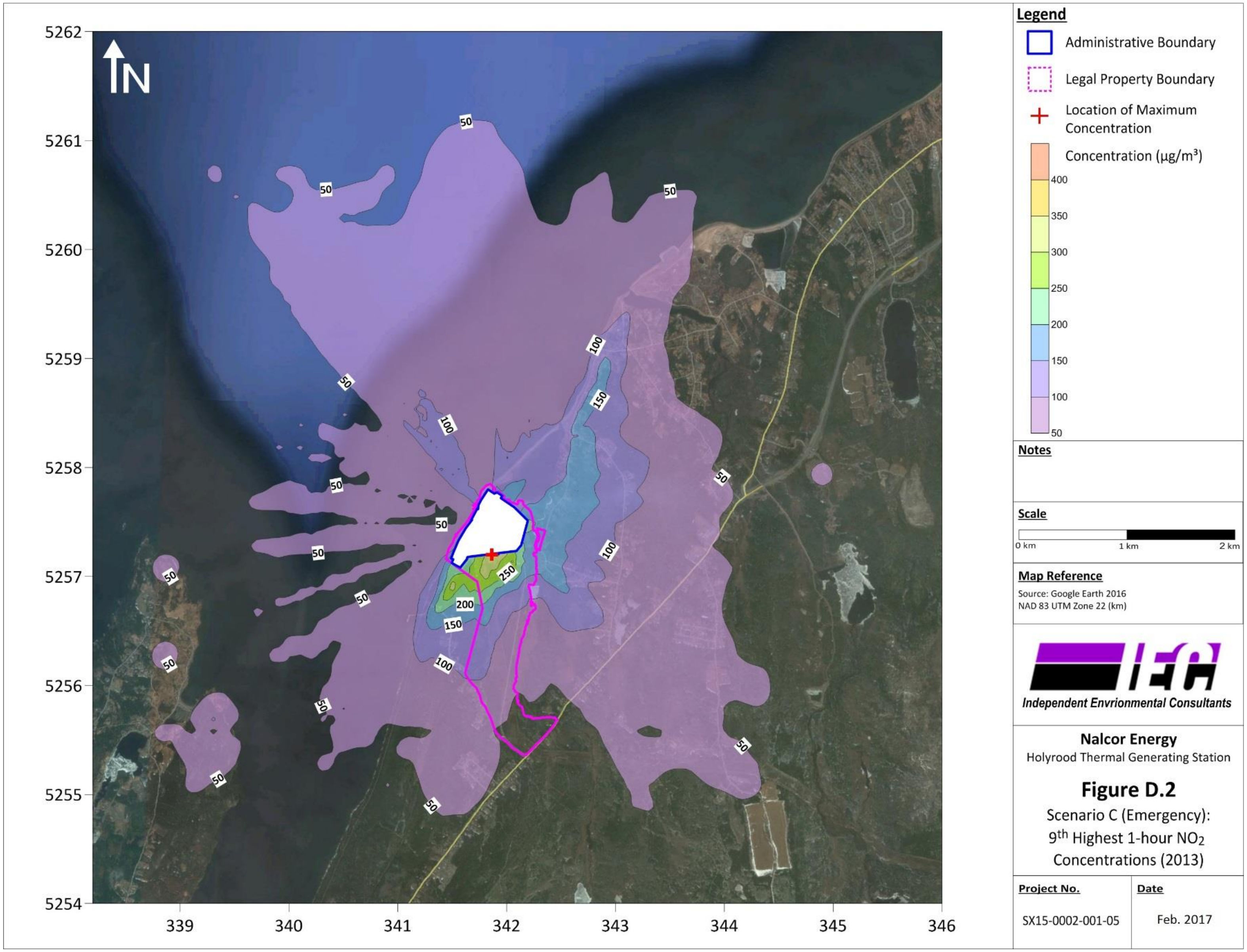
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
150
120
90
60
30
10
Notes
Scenario B (Peaking) based on 2004 production data for the HTGS units
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure C.20
Scenario B (Peaking):
2nd Highest 24-hour SO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017

Appendix D:

Scenario C Isopleths



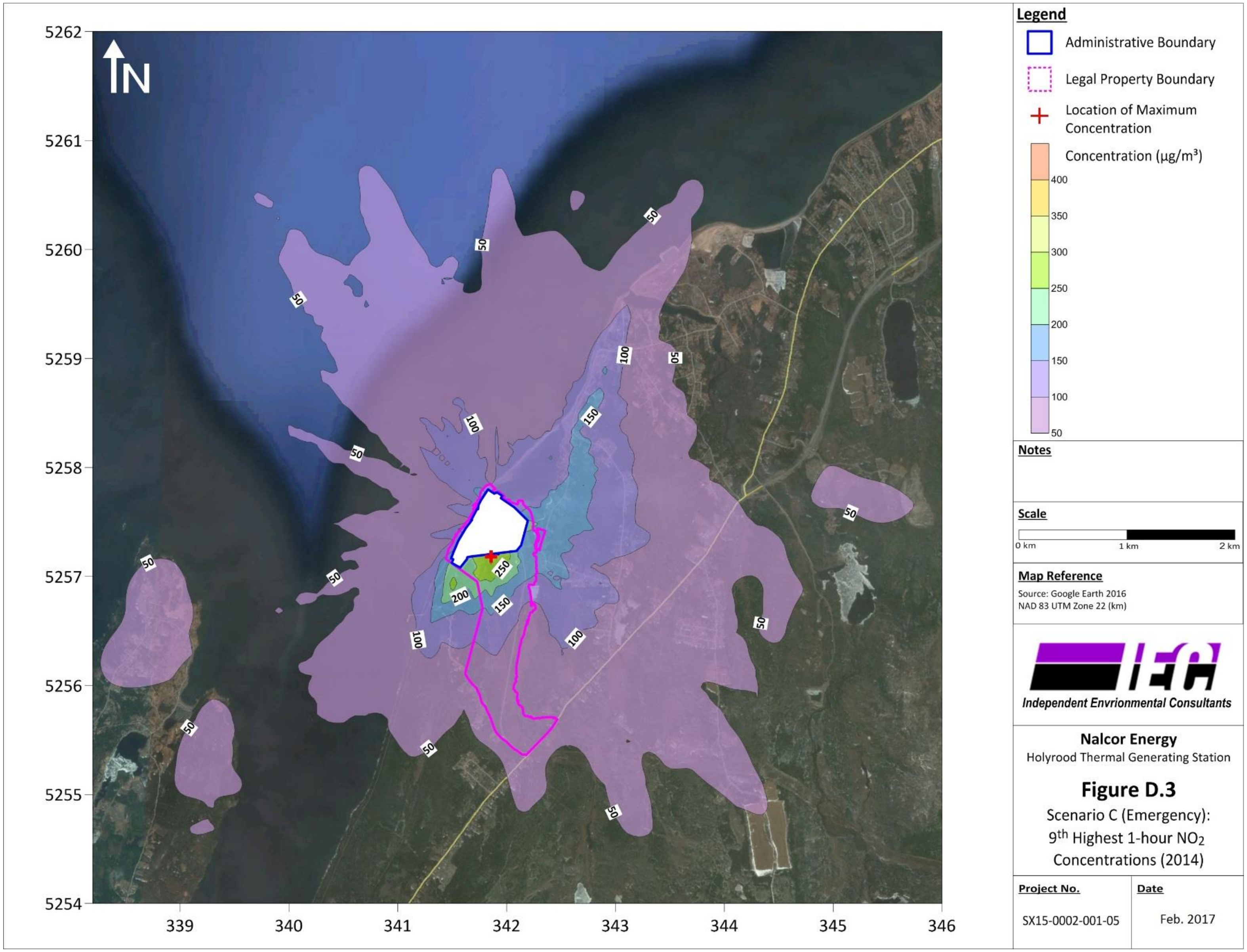
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.1
Scenario C (Emergency):
9th Highest 1-hour NO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017
N
5262
5261
5260
5259
5258
5257
5256
5255
5254
339
340
341
342
343
344
345
346



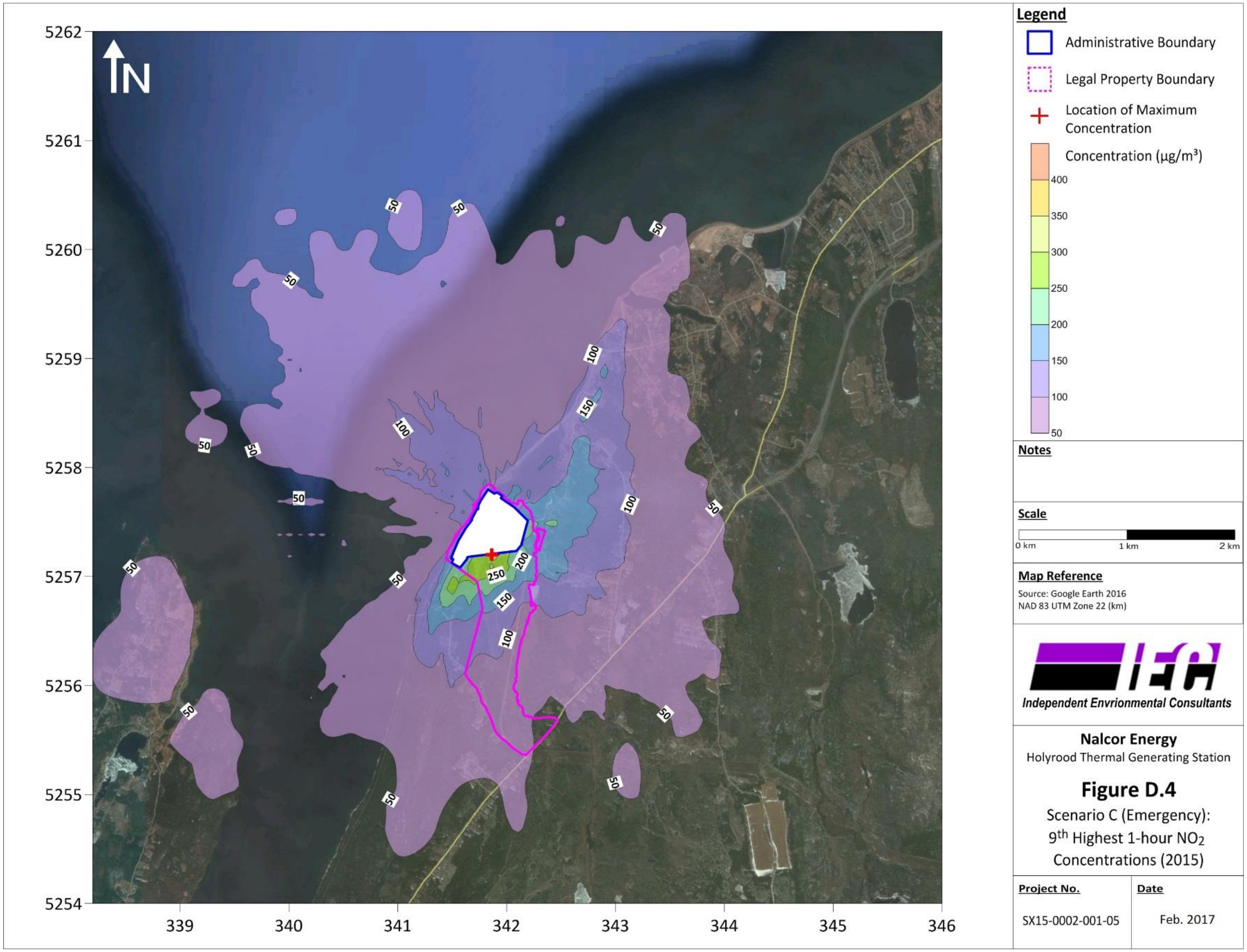
Nalcor Energy
Holyrood Thermal Generating Station

Figure D.2
Scenario C (Emergency):
9th Highest 1-hour NO_2
Concentrations (2013)

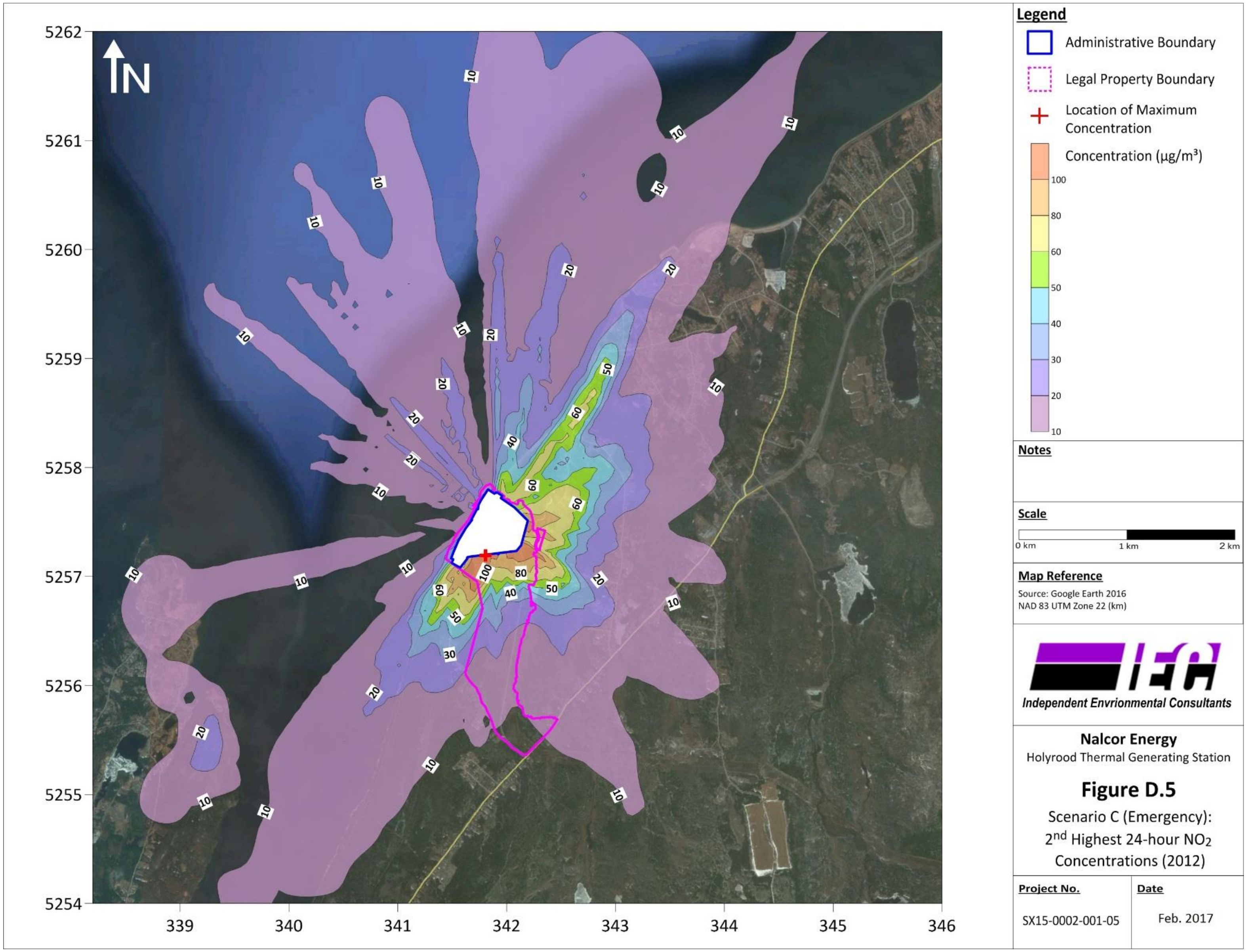
Project No.	Date
SX15-0002-001-05	Feb. 2017



Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.3
Scenario C (Emergency):
9th Highest 1-hour NO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017



N
5262
5261
5260
5259
5258
5257
5256
5255
5254
339
340
341
342
343
344
345
346
50
100
150
200
250
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
400
350
300
250
200
150
100
50
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.4
Scenario C (Emergency):
9th Highest 1-hour NO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017


Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
100
80
60
50
40
30
20
10
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.5
Scenario C (Emergency):
2nd Highest 24-hour NO2
Concentrations (2012)
Project No.
SX15-0002-001-05
Date
Feb. 2017
N
5262
5261
5260
5259
5258
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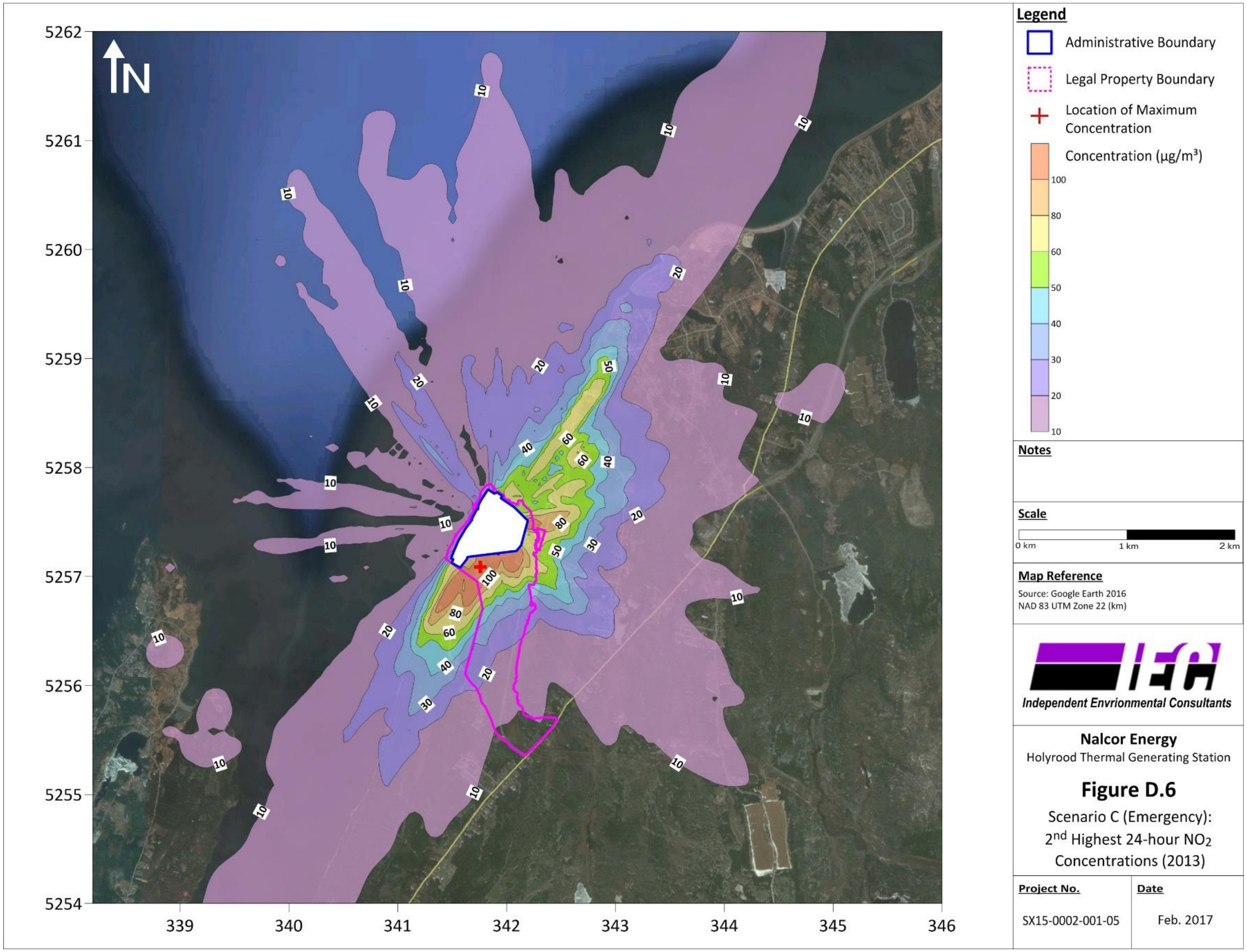
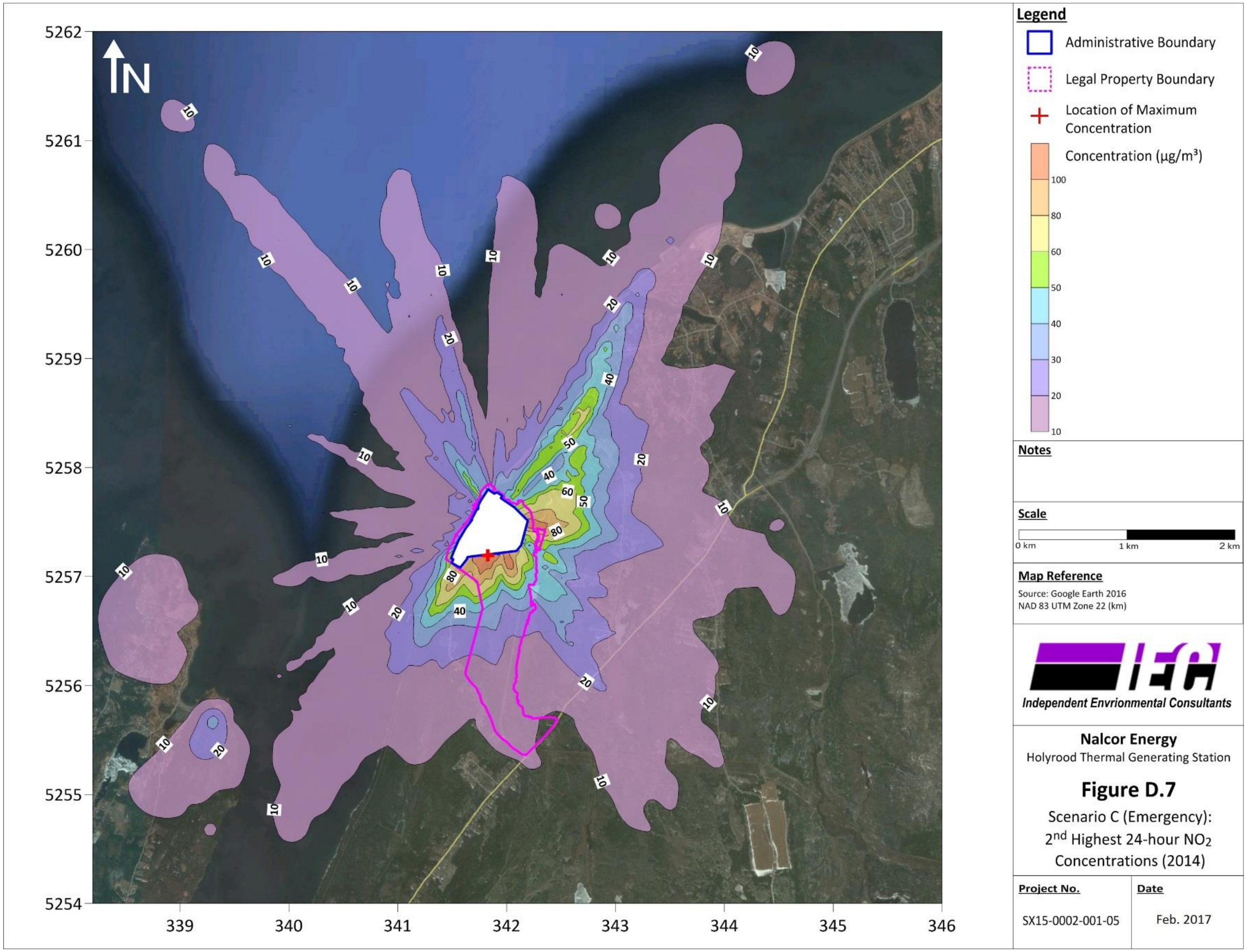
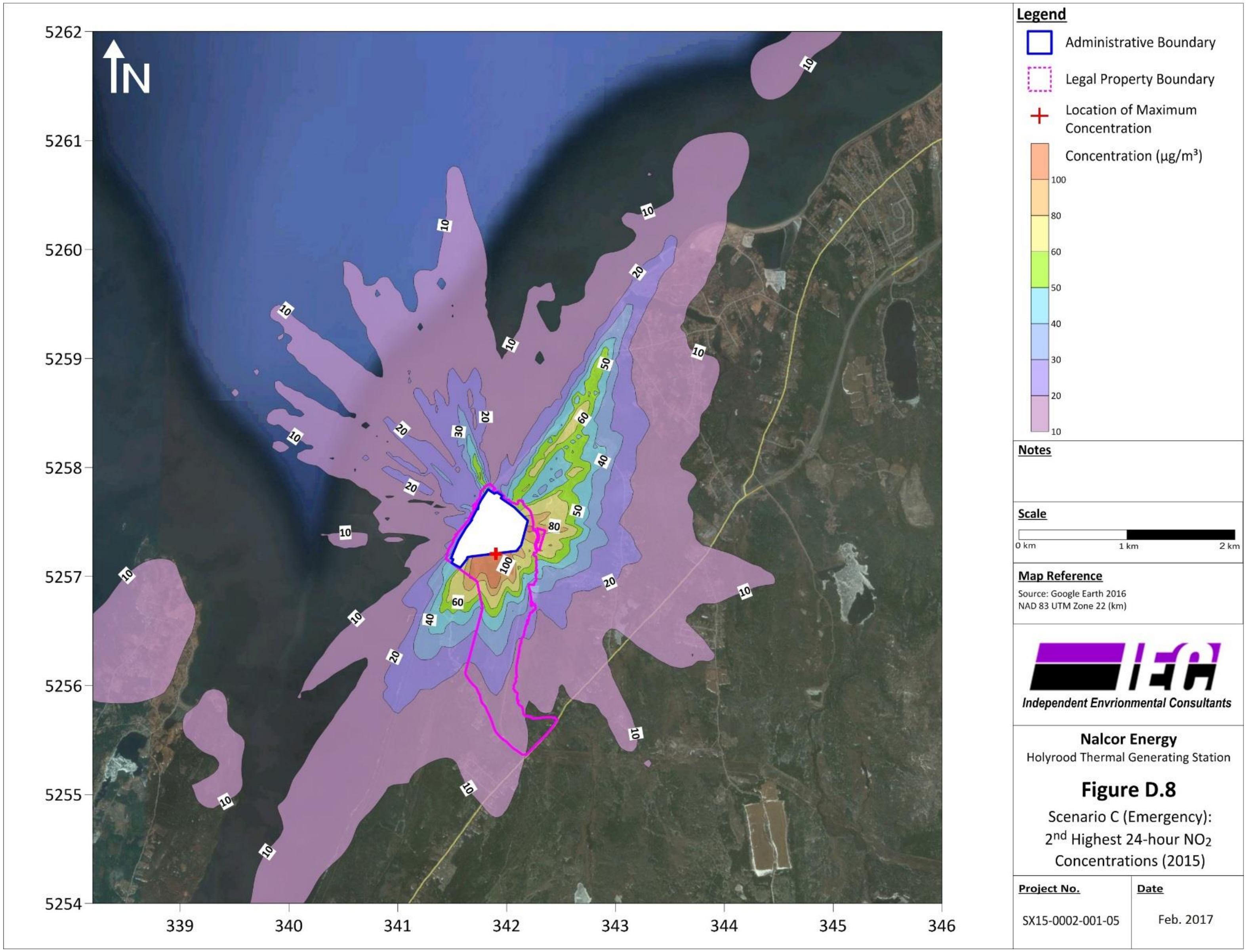

Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
100
80
60
50
40
30
20
10
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.6
Scenario C (Emergency):
2nd Highest 24-hour NO2
Concentrations (2013)
Project No.
SX15-0002-001-05
Date
Feb. 2017


5262
5261
5260
5259
5258
5257
5256
5255
5254
339
340
341
342
343
344
345
346
N
10
20
40
50
60
80
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
100
80
60
50
40
30
20
10
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.7
Scenario C (Emergency):
2nd Highest 24-hour NO2
Concentrations (2014)
Project No.
SX15-0002-001-05
Date
Feb. 2017


5262
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5256
5255
5254
339
340
341
342
343
344
345
346
N
Legend
Administrative Boundary
Legal Property Boundary
Location of Maximum Concentration
Concentration (µg/m³)
100
80
60
50
40
30
20
10
Notes
Scale
0 km
1 km
2 km
Map Reference
Source: Google Earth 2016
NAD 83 UTM Zone 22 (km)
IEC
Independent Envrionmental Consultants
Nalcor Energy
Holyrood Thermal Generating Station
Figure D.8
Scenario C (Emergency):
2nd Highest 24-hour NO2
Concentrations (2015)
Project No.
SX15-0002-001-05
Date
Feb. 2017

Appendix E:

Scenario A Top-50 Tables

Table E.1: TOP-50 EVENTS FOR 1-HOUR NO_2 CONCENTRATIONS FOR SCENARIO A

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration ($\mu g/m^3$)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2014	93	1900	593.80	342.006	5257.036
2	2014	93	1900	585.52	342.006	5257.085
3	2013	85	1800	558.54	341.806	5256.985
4	2015	41	700	553.16	341.556	5256.985
5	2013	85	1800	540.36	341.806	5257.036
6	2014	93	1900	540.25	342.006	5256.985
7	2013	60	1800	535.22	341.806	5257.036
8	2013	85	1700	530.56	341.806	5256.936
9	2015	41	700	529.39	341.506	5256.936
10	2013	60	1800	528.40	341.806	5256.985
11	2014	93	1900	525.80	342.056	5256.885
12	2014	93	2000	521.91	342.106	5256.885
13	2014	93	2000	517.63	342.056	5257.036
14	2013	60	1700	517.56	341.806	5256.985
15	2013	85	1700	517.51	341.806	5256.885
16	2013	60	1700	516.26	341.806	5256.936
17	2014	93	1900	514.28	342.056	5256.936
18	2013	85	1700	514.11	341.806	5256.985
19	2014	93	2000	506.10	342.106	5256.936
20	2013	85	1800	505.20	341.806	5256.936
21	2015	41	800	504.17	341.556	5256.985
22	2014	93	1900	503.57	342.006	5257.135
23	2014	93	1900	501.27	342.056	5256.835
24	2013	85	1800	498.71	341.756	5256.835
25	2014	93	2000	497.75	342.056	5256.985
26	2013	105	1600	493.60	341.806	5257.193
27	2014	349	1700	493.08	341.806	5256.885
28	2012	353	1700	492.70	341.806	5256.985
29	2015	41	800	491.40	341.506	5256.936
30	2015	44	1000	491.08	342.106	5257.186
31	2015	29	1800	488.98	341.656	5256.985
32	2015	44	1000	488.36	342.091	5257.230
33	2012	26	2000	488.17	341.856	5256.835
34	2012	353	1700	487.93	341.806	5257.036
35	2013	105	1600	486.66	341.787	5257.191
36	2013	60	1700	486.24	341.806	5256.885
37	2013	105	1600	484.01	341.825	5257.196
38	2014	349	1700	483.59	341.806	5256.936

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	**2015**	**41**	**700**	**482.71**	**341.556**	**5257.036**
40	**2012**	**26**	**2000**	**481.73**	**341.856**	**5256.885**
41	**2013**	**85**	**1700**	**479.38**	**341.806**	**5256.835**
42	**2014**	**349**	**1700**	**478.90**	**341.806**	**5256.835**
43	**2014**	**93**	**1800**	**478.35**	**341.956**	**5257.085**
44	**2013**	**105**	**1600**	**476.77**	**341.806**	**5257.186**
45	**2015**	**44**	**1000**	**475.25**	**342.106**	**5257.235**
46	**2015**	**44**	**1000**	**475.10**	**342.110**	**5257.232**
47	**2012**	**19**	**2000**	**474.76**	**341.856**	**5257.036**
48	**2013**	**60**	**1800**	**474.07**	**341.806**	**5256.936**
49	**2015**	**41**	**700**	**473.76**	**341.606**	**5257.036**
50	**2013**	**60**	**1700**	**473.66**	**341.806**	**5257.036**

Notes:
Events above the 1-hour NO2 AAQS of 400 µg/m³ are in **bold**

Table E.2: TOP-50 EVENTS FOR 24-HOUR NO_2 CONCENTRATIONS FOR SCENARIO A

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2013	53	0	137.15	341.88	5257.20
2	2015	40	0	128.83	341.91	5257.09
3	2013	57	0	127.88	342.01	5257.19
4	2013	57	0	125.33	342.00	5257.22
5	2015	40	0	125.27	341.91	5257.04
6	2013	59	0	124.07	342.02	5257.22
7	2013	57	0	122.29	342.06	5257.09
8	2013	53	0	121.08	341.90	5257.21
9	2015	40	0	119.93	341.91	5257.14
10	2013	57	0	118.83	342.02	5257.22
11	2013	58	0	118.69	342.07	5257.23
12	2013	57	0	117.57	342.06	5257.04
13	2013	58	0	116.92	342.09	5257.23
14	2015	40	0	116.52	341.91	5256.99
15	2013	58	0	116.30	342.11	5257.19
16	2014	350	0	116.29	341.81	5257.19
17	2013	119	0	115.67	341.71	5257.04
18	2013	12	0	115.60	341.88	5257.20
19	2014	350	0	114.48	341.81	5257.19
20	2013	53	0	114.39	341.86	5257.09
21	2013	119	0	113.48	341.71	5256.99
22	2014	350	0	113.47	341.79	5257.19
23	2013	53	0	110.42	341.86	5257.14
24	2013	59	0	109.34	342.06	5257.14
25	2013	53	0	108.55	341.86	5257.20
26	2013	53	0	108.12	341.86	5257.04
27	2013	53	0	107.80	341.91	5257.19
28	2013	59	0	107.38	342.03	5257.22
29	2013	119	0	107.21	341.76	5257.09
30	2012	354	0	105.92	341.51	5256.99
31	2013	120	0	105.38	341.76	5257.09
32	2013	57	0	105.21	342.06	5257.14
33	2014	118	0	104.93	341.71	5257.19
34	2015	40	0	104.91	341.91	5257.19
35	2013	57	0	104.81	342.01	5257.14
36	2013	119	0	104.75	341.66	5256.94
37	2013	68	0	104.09	341.51	5256.84
38	2014	118	0	103.79	341.71	5257.18

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2013	12	0	103.64	341.90	5257.21
40	2013	68	0	103.39	341.51	5256.89
41	2013	12	0	103.16	341.86	5257.20
42	2013	59	0	102.87	342.00	5257.22
43	2013	12	0	102.79	341.86	5257.14
44	2013	12	0	102.43	341.86	5257.09
45	2013	53	0	101.83	341.91	5257.14
46	2013	68	0	101.68	341.56	5256.89
47	2013	59	0	101.55	342.01	5257.19
48	2013	120	0	101.42	341.71	5257.04
49	2013	68	0	101.36	341.56	5256.94
50	2014	118	0	100.27	341.69	5257.18

Notes:
Events above the 24-hour NO_2 AAQS of 200 µg/m³ are in **bold**

Table E.3: TOP-50 EVENTS FOR 1-HOUR SO_2 CONCENTRATIONS FOR SCENARIO A

Rank	Year	Julian Day	Hour	1-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2015	100	900	1411.70	341.768	5257.188
2	2015	100	900	1409.20	341.756	5257.186
3	2015	100	900	1406.70	341.749	5257.187
4	2015	100	900	1406.50	341.787	5257.191
5	2015	100	900	1391.10	341.730	5257.185
6	2015	100	900	1391.00	341.806	5257.193
7	2015	100	900	1390.10	341.806	5257.186
8	2015	100	900	1365.40	341.756	5257.135
9	2015	100	900	1365.30	341.711	5257.182
10	2015	100	900	1365.30	341.825	5257.196
11	2015	100	900	1356.50	341.706	5257.186
12	2015	100	900	1354.50	341.806	5257.135
13	2015	100	900	1330.80	341.844	5257.199
14	2015	100	900	1327.90	341.692	5257.180
15	2015	100	900	1317.70	341.706	5257.135
16	2015	100	900	1309.10	341.856	5257.186
17	2015	100	900	1288.90	341.863	5257.202
18	2015	100	900	1288.40	341.756	5257.085
19	2015	100	900	1284.60	341.856	5257.135
20	2015	100	900	1279.60	341.673	5257.176
21	2015	100	900	1279.40	341.806	5257.085
22	2015	100	900	1246.80	341.662	5257.162
23	2015	100	900	1245.90	341.706	5257.085
24	2015	100	900	1240.10	341.882	5257.204
25	2015	100	900	1218.80	341.856	5257.085
26	2015	100	900	1210.30	341.656	5257.135
27	2015	100	900	1209.30	341.652	5257.146
28	2015	100	900	1187.80	341.756	5257.036
29	2015	100	900	1184.90	341.901	5257.206
30	2015	100	900	1180.50	341.806	5257.036
31	2015	100	900	1176.60	341.906	5257.186
32	2015	100	900	1166.60	341.641	5257.131
33	2015	100	900	1164.80	341.906	5257.135
34	2015	100	900	1153.00	341.706	5257.036
35	2015	100	900	1152.90	341.656	5257.085
36	2015	100	900	1128.40	341.856	5257.036
37	2015	100	900	1125.00	341.920	5257.208
38	2015	100	900	1124.20	341.630	5257.117

Rank	Year	Julian Day	Hour	1-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	**2015**	**84**	**1500**	**1123.90**	**343.306**	**5257.686**
40	**2015**	**84**	**1500**	**1115.30**	**343.306**	**5257.585**
41	**2015**	**100**	**900**	**1114.00**	**341.906**	**5257.085**
42	**2015**	**84**	**1500**	**1113.00**	**343.206**	**5257.686**
43	**2015**	**84**	**1500**	**1107.40**	**343.206**	**5257.585**
44	**2015**	**84**	**1500**	**1102.90**	**343.406**	**5257.686**
45	**2015**	**84**	**1500**	**1092.40**	**343.406**	**5257.585**
46	**2015**	**100**	**900**	**1084.00**	**341.620**	**5257.102**
47	**2015**	**100**	**900**	**1077.40**	**341.656**	**5257.036**
48	**2015**	**100**	**900**	**1075.60**	**341.756**	**5256.985**
49	**2015**	**84**	**1500**	**1069.70**	**343.106**	**5257.686**
50	**2015**	**100**	**900**	**1067.80**	**341.806**	**5256.985**

Notes:
Events above the 1-hour SO_2 AAQS of 900 µg/m³ are in **bold**

Table E.4: TOP-50 EVENTS FOR 3-HOUR SO_2 CONCENTRATIONS FOR SCENARIO A

Rank	Year	Julian Day	Hour	3-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	**2013**	**12**	**900**	**824.05**	**341.756**	**5256.786**
2	**2013**	**12**	**900**	**819.30**	**341.756**	**5256.835**
3	**2013**	**12**	**900**	**762.42**	**341.806**	**5256.835**
4	**2013**	**12**	**900**	**753.76**	**341.806**	**5256.885**
5	**2013**	**12**	**900**	**741.76**	**341.756**	**5256.885**
6	**2013**	**12**	**900**	**729.37**	**341.756**	**5256.735**
7	**2013**	**12**	**900**	**713.98**	**341.806**	**5256.786**
8	**2013**	**12**	**900**	**692.90**	**341.806**	**5256.936**
9	**2015**	**33**	**900**	**677.79**	**342.706**	**5257.835**
10	**2015**	**33**	**900**	**671.87**	**342.756**	**5257.835**
11	**2015**	**49**	**900**	**644.31**	**339.506**	**5255.085**
12	**2013**	**12**	**900**	**638.63**	**341.756**	**5256.686**
13	**2013**	**12**	**900**	**634.60**	**341.806**	**5256.735**
14	**2015**	**49**	**900**	**629.71**	**339.306**	**5254.885**
15	**2015**	**33**	**900**	**628.56**	**342.806**	**5257.835**
16	**2013**	**12**	**1200**	**620.99**	**341.756**	**5256.835**
17	**2013**	**12**	**900**	**620.23**	**341.756**	**5256.936**
18	**2013**	**12**	**1200**	**617.78**	**341.756**	**5256.786**
19	**2015**	**33**	**900**	**616.80**	**342.656**	**5257.835**
20	**2015**	**49**	**900**	**616.74**	**339.306**	**5255.085**
21	2013	53	1200	596.72	341.706	5256.786
22	2013	53	1200	593.98	341.756	5256.835
23	2013	12	1200	591.56	341.706	5256.786
24	2015	33	900	588.48	342.756	5257.885
25	2015	33	900	587.33	342.806	5257.885
26	2013	12	900	587.01	341.806	5256.985
27	2013	12	1200	582.84	341.706	5256.735
28	2013	53	1200	581.50	341.706	5256.835
29	2014	8	900	576.45	342.756	5258.036
30	2013	53	1200	575.48	341.756	5256.885
31	2013	12	1200	572.39	341.756	5256.885
32	2013	12	900	569.16	341.706	5256.735
33	2013	12	1200	568.23	341.756	5256.735
34	2013	11	900	567.81	341.756	5256.735
35	2015	33	900	566.11	342.856	5257.835
36	2013	53	1200	563.11	341.756	5256.786
37	2014	8	900	562.73	342.856	5258.085
38	2014	8	900	560.99	342.806	5258.036

Rank	Year	Julian Day	Hour	3-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2013	12	900	559.10	341.806	5256.686
40	2013	12	900	556.96	341.706	5256.786
41	2013	53	900	551.11	341.706	5256.786
42	2014	8	900	550.14	342.806	5258.085
43	2015	33	900	549.60	342.856	5257.885
44	2015	6	900	547.62	342.856	5257.735
45	2012	14	900	543.19	342.906	5258.786
46	2013	12	900	542.71	341.706	5256.686
47	2014	8	900	542.10	342.906	5258.085
48	2014	8	900	540.36	342.706	5258.036
49	2015	6	900	539.30	342.906	5257.735
50	2014	119	1200	538.85	341.606	5256.835

Notes:
Events above the 3-hour SO_2 AAQS of 600 µg/m³ are in **bold**

Table E.5: TOP-50 EVENTS FOR 24-HOUR SO_2 CONCENTRATIONS FOR SCENARIO A

Rank	Year	Julian Day	Hour	24-hour SO_2 Concentration ($\mu g/m^3$)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2014	8	0	294.11	343.006	5258.085
2	2013	11	0	292.23	341.756	5256.735
3	2013	11	0	290.67	341.756	5256.686
4	2014	8	0	283.91	343.106	5258.186
5	2014	8	0	283.35	343.106	5258.085
6	2014	8	0	282.89	342.906	5258.085
7	2013	11	0	282.59	341.706	5256.686
8	2014	8	0	281.17	343.206	5258.186
9	2014	8	0	274.90	342.906	5258.036
10	2014	8	0	273.91	342.856	5258.036
11	2013	11	0	272.33	341.706	5256.585
12	2013	11	0	271.83	341.706	5256.735
13	2013	11	0	270.20	341.756	5256.786
14	2014	8	0	262.08	342.806	5258.036
15	2014	8	0	259.25	342.856	5258.085
16	2014	8	0	259.15	343.306	5258.186
17	2013	12	0	250.49	341.756	5256.786
18	2013	11	0	248.58	341.706	5256.485
19	2013	12	0	247.88	341.756	5256.735
20	2014	8	0	243.40	343.206	5258.085
21	2013	12	0	241.30	341.756	5256.686
22	2013	11	0	241.28	341.706	5256.786
23	2013	11	0	239.19	341.806	5256.686
24	2013	12	0	238.93	341.756	5256.835
25	2013	11	0	238.09	341.756	5256.835
26	2013	11	0	237.76	341.806	5256.735
27	2014	8	0	236.37	342.756	5258.036
28	2014	350	0	235.78	341.506	5256.735
29	2014	350	0	233.86	341.506	5256.686
30	2014	8	0	233.47	342.906	5258.135
31	2014	8	0	233.19	343.006	5258.186
32	2014	350	0	233.12	341.456	5256.686
33	2014	48	0	232.48	342.806	5258.286
34	2014	48	0	231.89	342.756	5258.235
35	2014	8	0	230.75	343.306	5258.286
36	2014	48	0	230.58	342.856	5258.286
37	2014	8	0	229.67	343.406	5258.186
38	2014	48	0	229.02	342.906	5258.335

Rank	Year	Julian Day	Hour	24-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2013	12	0	228.34	341.706	5256.686
40	2014	48	0	226.96	342.856	5258.335
41	2014	8	0	226.75	343.406	5258.286
42	2013	12	0	226.14	341.706	5256.585
43	2014	48	0	225.84	342.806	5258.235
44	2014	350	0	225.15	341.406	5256.585
45	2013	12	0	223.70	341.706	5256.735
46	2014	8	0	223.65	342.806	5257.985
47	2014	350	0	223.49	341.406	5256.485
48	2014	8	0	223.47	342.756	5257.985
49	2014	8	0	222.72	342.806	5258.085
50	2013	12	0	222.05	341.706	5256.485

Notes:
Events above the 24-hour SO_2 AAQS of 300 µg/m³ are in **bold**

Appendix F:

Scenario B Top-50 Tables

Table F.1: TOP-50 EVENTS FOR 1-HOUR NO_2 CONCENTRATIONS FOR SCENARIO B

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2014	93	1900	591.83	342.006	5257.036
2	2014	93	1900	580.36	342.006	5257.085
3	2013	85	1800	566.93	341.806	5256.985
4	2015	41	700	553.74	341.556	5256.985
5	2015	100	900	548.20	341.706	5257.186
6	2013	85	1800	546.50	341.806	5257.036
7	2015	100	900	544.20	341.692	5257.180
8	2013	60	1800	544.12	341.806	5257.036
9	2015	100	900	542.76	341.711	5257.182
10	2014	93	1900	540.62	342.006	5256.985
11	2013	60	1800	538.01	341.806	5256.985
12	2015	100	900	534.91	341.730	5257.185
13	2015	100	900	534.65	341.673	5257.176
14	2013	85	1700	534.00	341.806	5256.936
15	2014	93	1900	529.86	342.056	5256.885
16	2015	41	700	529.71	341.506	5256.936
17	2014	93	2000	525.52	342.106	5256.885
18	2013	60	1700	524.89	341.806	5256.985
19	2013	60	1700	524.25	341.806	5256.936
20	2013	85	1700	523.16	341.806	5256.885
21	2015	100	900	519.23	341.749	5257.187
22	2014	93	2000	518.18	342.056	5257.036
23	2014	93	1900	517.48	342.056	5256.936
24	2015	100	900	517.30	341.662	5257.162
25	2013	85	1700	514.71	341.806	5256.985
26	2013	85	1800	513.69	341.806	5256.936
27	2014	93	2000	509.78	342.106	5256.936
28	2015	100	900	509.47	341.756	5257.186
29	2014	93	1900	505.26	342.056	5256.835
30	2015	41	800	504.87	341.556	5256.985
31	2013	85	1800	504.25	341.756	5256.835
32	2013	105	1600	500.61	341.806	5257.193
33	2012	353	1700	500.21	341.806	5256.985
34	2015	100	900	498.98	341.652	5257.146
35	2014	93	2000	498.93	342.056	5256.985
36	2014	93	1900	496.50	342.006	5257.135
37	2015	100	900	496.08	341.768	5257.188
38	2014	349	1700	494.56	341.806	5256.885

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	**2013**	**60**	**1700**	**494.22**	**341.806**	**5256.885**
40	**2012**	**353**	**1700**	**493.97**	**341.806**	**5257.036**
41	**2015**	**100**	**900**	**493.84**	**341.706**	**5257.135**
42	**2013**	**105**	**1600**	**493.00**	**341.825**	**5257.196**
43	**2012**	**26**	**2000**	**492.85**	**341.856**	**5256.835**
44	**2015**	**29**	**1800**	**492.39**	**341.656**	**5256.985**
45	**2015**	**41**	**800**	**491.77**	**341.506**	**5256.936**
46	**2015**	**100**	**900**	**491.47**	**341.656**	**5257.135**
47	**2015**	**44**	**1000**	**491.39**	**342.106**	**5257.186**
48	**2013**	**105**	**1600**	**491.32**	**341.787**	**5257.191**
49	**2015**	**44**	**1000**	**488.99**	**342.091**	**5257.230**
50	**2013**	**85**	**1700**	**486.30**	**341.806**	**5256.835**

Notes:
Events above the 1-hour NO2 AAQS of 400 µg/m³ are in **bold**

Table F.2: TOP-50 EVENTS FOR 24-HOUR NO_2 CONCENTRATIONS FOR SCENARIO B

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2013	53	0	140.56	341.882	5257.204
2	2015	40	0	130.34	341.906	5257.085
3	2013	57	0	128.96	342.006	5257.186
4	2015	40	0	126.77	341.906	5257.036
5	2013	57	0	126.58	341.996	5257.217
6	2013	59	0	125.80	342.015	5257.221
7	2013	53	0	124.21	341.901	5257.206
8	2013	57	0	123.68	342.056	5257.085
9	2013	58	0	122.05	342.072	5257.228
10	2015	40	0	121.21	341.906	5257.135
11	2013	58	0	120.25	342.091	5257.230
12	2013	57	0	119.98	342.015	5257.221
13	2013	53	0	119.71	341.856	5257.085
14	2013	57	0	119.16	342.056	5257.036
15	2013	58	0	119.10	342.106	5257.186
16	2015	40	0	117.91	341.906	5256.985
17	2013	12	0	117.42	341.882	5257.204
18	2013	119	0	116.76	341.706	5257.036
19	2014	350	0	116.20	341.806	5257.193
20	2013	53	0	115.20	341.856	5257.036
21	2013	119	0	115.04	341.706	5256.985
22	2014	350	0	114.38	341.806	5257.186
23	2013	53	0	114.11	341.856	5257.135
24	2014	350	0	113.19	341.787	5257.191
25	2013	53	0	111.03	341.863	5257.202
26	2013	53	0	110.58	341.906	5257.186
27	2013	59	0	110.49	342.056	5257.135
28	2013	59	0	109.42	342.034	5257.223
29	2013	119	0	108.97	341.756	5257.085
30	2013	120	0	106.81	341.756	5257.085
31	2013	57	0	106.05	342.056	5257.135
32	2015	40	0	105.78	341.906	5257.186
33	2013	53	0	105.72	341.856	5256.985
34	2013	12	0	105.54	341.901	5257.206
35	2013	12	0	105.49	341.856	5257.085
36	2013	57	0	105.48	342.006	5257.135
37	2013	119	0	105.39	341.656	5256.936
38	2012	354	0	105.28	341.506	5256.985

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2014	118	0	105.04	341.706	5257.186
40	2013	12	0	104.97	341.856	5257.135
41	2013	53	0	104.68	341.906	5257.135
42	2013	12	0	104.65	341.863	5257.202
43	2013	68	0	104.18	341.506	5256.835
44	2014	118	0	103.90	341.711	5257.182
45	2013	59	0	103.51	341.996	5257.217
46	2013	68	0	103.50	341.506	5256.885
47	2013	12	0	103.21	341.856	5257.036
48	2013	120	0	102.45	341.706	5257.036
49	2013	59	0	101.89	342.006	5257.186
50	2013	68	0	101.81	341.556	5256.885

Notes:
Events above the 24-hour NO_2 AAQS of 200 µg/m³ are in **bold**

Table F.3: TOP-50 EVENTS FOR 1-HOUR SO_2 CONCENTRATIONS FOR SCENARIO B

Rank	Year	Julian Day	Hour	1-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2015	100	900	1427.50	341.706	5257.186
2	2015	100	900	1424.30	341.711	5257.182
3	2015	100	900	1418.70	341.692	5257.180
4	2015	100	900	1416.00	341.730	5257.185
5	2015	100	900	1395.40	341.673	5257.176
6	2015	100	900	1394.80	341.749	5257.187
7	2015	100	900	1382.90	341.756	5257.186
8	2015	100	900	1371.60	341.706	5257.135
9	2015	100	900	1369.30	341.662	5257.162
10	2015	100	900	1361.50	341.768	5257.188
11	2015	100	900	1337.40	341.652	5257.146
12	2015	100	900	1331.50	341.756	5257.135
13	2015	100	900	1330.60	341.656	5257.135
14	2015	100	900	1314.80	341.787	5257.191
15	2015	100	900	1299.10	341.641	5257.131
16	2015	100	900	1279.30	341.706	5257.085
17	2015	100	900	1261.30	341.806	5257.186
18	2015	100	900	1260.60	341.630	5257.117
19	2015	100	900	1259.90	341.806	5257.193
20	2015	100	900	1246.90	341.656	5257.085
21	2015	100	900	1241.70	341.756	5257.085
22	2015	100	900	1224.70	341.806	5257.135
23	2015	100	900	1217.50	341.620	5257.102
24	2015	100	900	1196.90	341.825	5257.196
25	2015	100	900	1166.40	341.609	5257.086
26	2015	100	900	1162.50	341.706	5257.036
27	2015	100	900	1158.20	341.606	5257.085
28	2015	100	900	1147.40	341.806	5257.085
29	2015	100	900	1137.90	341.656	5257.036
30	2015	100	900	1129.20	341.756	5257.036
31	2015	100	900	1128.80	341.844	5257.199
32	2015	100	900	1117.80	341.598	5257.071
33	2015	100	900	1094.00	341.582	5257.080
34	2015	84	1500	1093.00	343.206	5257.585
35	2015	84	1500	1090.90	343.206	5257.686
36	2015	84	1500	1086.70	343.306	5257.686
37	2015	100	900	1086.30	341.856	5257.186
38	2015	84	1500	1085.10	343.306	5257.585

Rank	Year	Julian Day	Hour	1-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	**2015**	**84**	**1500**	**1070.00**	**343.106**	**5257.585**
40	**2015**	**100**	**900**	**1068.90**	**341.606**	**5257.036**
41	**2014**	**112**	**1400**	**1067.70**	**341.662**	**5257.162**
42	**2014**	**112**	**1400**	**1065.20**	**341.673**	**5257.176**
43	**2015**	**100**	**900**	**1064.60**	**341.856**	**5257.135**
44	**2015**	**84**	**1500**	**1063.70**	**343.106**	**5257.686**
45	**2015**	**100**	**900**	**1061.90**	**341.566**	**5257.086**
46	**2014**	**112**	**1400**	**1057.50**	**341.652**	**5257.146**
47	**2015**	**100**	**900**	**1054.40**	**341.863**	**5257.202**
48	**2015**	**84**	**1500**	**1053.40**	**343.406**	**5257.686**
49	**2015**	**84**	**1500**	**1049.00**	**343.406**	**5257.585**
50	**2015**	**100**	**900**	**1040.20**	**341.806**	**5257.036**

Notes:
Events above the 1-hour SO_2 AAQS of 900 µg/m³ are in **bold**

Table F.4: TOP-50 EVENTS FOR 3-HOUR SO_2 CONCENTRATIONS FOR SCENARIO B

Rank	Year	Julian Day	Hour	3-hour SO_2 Concentration ($\mu g/m^3$)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2013	53	1200	841.62	341.756	5256.885
2	2013	53	1200	812.03	341.756	5256.936
3	2013	53	1200	804.75	341.756	5256.835
4	2013	53	900	781.71	341.756	5256.835
5	2013	353	1200	766.03	342.706	5257.635
6	2013	53	900	748.75	341.756	5256.885
7	2013	53	900	748.00	341.756	5256.786
8	2015	49	900	746.98	339.506	5255.085
9	2013	53	1200	746.64	341.706	5256.835
10	2013	53	1200	728.20	341.756	5256.985
11	2013	53	900	727.83	341.706	5256.786
12	2013	53	1200	717.57	341.706	5256.786
13	2013	53	1200	709.66	341.756	5256.786
14	2013	53	900	703.09	341.706	5256.835
15	2013	353	1200	693.06	342.756	5257.635
16	2013	53	900	691.03	341.756	5256.936
17	2013	53	1200	681.63	341.706	5256.885
18	2013	12	900	669.98	341.756	5256.835
19	2013	353	1200	667.26	342.656	5257.635
20	2013	12	900	662.46	341.806	5256.885
21	2014	119	1200	650.25	341.606	5256.835
22	2013	53	900	647.90	341.706	5256.735
23	2013	12	900	644.40	341.756	5256.786
24	2012	120	1200	641.25	343.006	5258.786
25	2013	12	900	640.08	341.806	5256.835
26	2013	12	900	637.92	341.806	5256.936
27	2013	12	900	636.36	341.756	5256.885
28	2013	53	900	636.07	341.756	5256.735
29	2014	119	1200	632.85	341.606	5256.885
30	2015	33	900	630.43	342.706	5257.835
31	2013	353	1200	627.53	342.706	5257.686
32	2015	95	900	609.39	342.706	5258.036
33	2014	119	1200	606.22	341.656	5256.985
34	2015	354	900	604.28	342.756	5257.985
35	2014	119	1200	603.97	341.656	5256.936
36	2013	53	900	602.56	341.756	5256.985
37	2013	53	1200	601.28	341.706	5256.735
38	2013	353	1200	601.02	342.806	5257.635

Rank	Year	Julian Day	Hour	3-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2015	33	900	598.94	342.656	5257.835
40	2013	53	900	597.40	341.706	5256.885
41	2015	33	900	594.95	342.756	5257.835
42	2015	95	900	594.66	342.656	5258.036
43	2013	12	1200	589.94	341.756	5256.835
44	2012	354	900	589.03	339.306	5254.686
45	2015	354	900	588.59	342.806	5257.985
46	2013	353	1200	587.08	342.756	5257.686
47	2013	53	1200	584.64	341.806	5256.936
48	2015	95	1200	584.01	342.756	5258.036
49	2015	354	900	580.93	342.706	5257.985
50	2013	53	1200	578.88	341.756	5257.036

Notes:
Events above the 3-hour SO_2 AAQS of 600 µg/m³ are in **bold**

Table F.5: TOP-50 EVENTS FOR 24-HOUR SO_2 CONCENTRATIONS FOR SCENARIO B

Rank	Year	Julian Day	Hour	24-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	2012	120	0	214.32	343.006	5258.786
2	2012	120	0	191.53	343.006	5258.686
3	2012	120	0	190.03	343.106	5258.786
4	2012	120	0	188.76	343.106	5258.885
5	2012	347	0	169.65	343.106	5257.485
6	2012	347	0	169.17	343.206	5257.485
7	2012	30	0	166.75	343.106	5258.186
8	2012	347	0	165.00	343.306	5257.485
9	2012	345	0	164.56	343.106	5257.686
10	2012	120	0	163.54	343.206	5258.885
11	2012	347	0	162.88	343.106	5257.585
12	2012	345	0	162.26	343.006	5257.686
13	2012	120	0	161.71	342.906	5258.686
14	2012	347	0	160.67	343.406	5257.485
15	2012	30	0	159.24	343.006	5258.186
16	2012	30	0	157.91	343.006	5258.085
17	2012	30	0	157.15	342.906	5258.085
18	2012	347	0	156.68	343.206	5257.585
19	2012	120	0	156.40	343.206	5258.985
20	2012	345	0	155.93	343.206	5257.686
21	2012	120	0	153.80	343.006	5258.885
22	2012	120	0	153.66	342.906	5258.635
23	2012	30	0	153.06	343.206	5258.186
24	2012	347	0	152.37	343.506	5257.485
25	2012	120	0	151.35	343.106	5258.985
26	2012	30	0	151.28	343.206	5258.286
27	2012	30	0	148.88	342.906	5258.135
28	2012	347	0	148.51	343.006	5257.585
29	2012	324	0	148.46	343.106	5258.085
30	2012	347	0	148.08	343.006	5257.485
31	2012	347	0	148.03	343.406	5257.385
32	2012	347	0	147.65	343.306	5257.585
33	2012	345	0	147.21	343.306	5257.686
34	2012	347	0	146.49	343.506	5257.385
35	2012	345	0	145.39	342.906	5257.635
36	2012	345	0	145.09	342.906	5257.686
37	2012	30	0	144.86	343.306	5258.286
38	2012	30	0	144.68	343.106	5258.286

Rank	Year	Julian Day	Hour	24-hour SO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2012	347	0	144.49	343.306	5257.385
40	2012	30	0	143.97	342.856	5258.085
41	2012	347	0	143.74	343.606	5257.485
42	2012	345	0	143.30	343.106	5257.585
43	2012	348	0	143.02	343.506	5257.085
44	2012	347	0	142.60	343.606	5257.385
45	2012	348	0	141.01	343.406	5257.085
46	2012	347	0	140.89	343.406	5257.585
47	2012	348	0	140.42	343.606	5257.085
48	2012	359	0	139.67	342.856	5258.635
49	2012	345	0	139.66	343.006	5257.585
50	2012	120	0	139.48	343.106	5258.686

Notes:
Events above the 24-hour SO_2 AAQS of 300 µg/m³ are in **bold**

Appendix G:

Scenario C Top-50 Tables

Table G.1: TOP-50 EVENTS FOR 1-HOUR NO_2 CONCENTRATIONS FOR SCENARIO C

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	**2015**	**255**	**1200**	**452.47**	**341.7560**	**5257.6350**
2	**2014**	**131**	**1300**	**437.72**	**341.7060**	**5257.0850**
3	**2015**	**94**	**200**	**435.34**	**341.7300**	**5257.5950**
4	**2015**	**94**	**200**	**434.91**	**341.7220**	**5257.5790**
5	**2015**	**255**	**1200**	**431.53**	**341.7500**	**5257.6410**
6	**2013**	**79**	**200**	**429.97**	**341.7060**	**5257.0360**
7	**2015**	**94**	**200**	**428.32**	**341.7390**	**5257.6090**
8	**2013**	**308**	**200**	**427.31**	**341.8440**	**5257.1990**
9	**2015**	**255**	**1200**	**425.80**	**341.7470**	**5257.6250**
10	**2012**	**195**	**2100**	**425.10**	**341.9960**	**5257.2170**
11	**2015**	**255**	**1200**	**424.57**	**341.7530**	**5257.6550**
12	**2015**	**94**	**200**	**420.16**	**341.7130**	**5257.5630**
13	**2013**	**111**	**2200**	**419.40**	**341.7560**	**5256.9360**
14	**2013**	**79**	**200**	**418.00**	**341.6560**	**5256.8850**
15	**2015**	**102**	**2100**	**417.76**	**341.7560**	**5257.0360**
16	**2013**	**67**	**2300**	**413.70**	**341.5060**	**5256.8850**
17	**2013**	**111**	**2200**	**412.69**	**341.7560**	**5256.9850**
18	**2013**	**66**	**200**	**412.43**	**341.8560**	**5256.9850**
19	**2013**	**79**	**200**	**409.96**	**341.7060**	**5256.9850**
20	**2014**	**93**	**1900**	**409.75**	**342.0060**	**5257.0850**
21	**2012**	**195**	**2100**	**409.62**	**341.9770**	**5257.2150**
22	**2015**	**94**	**200**	**408.35**	**341.7470**	**5257.6250**
23	**2014**	**93**	**1900**	**407.96**	**342.0060**	**5257.0360**
24	**2013**	**85**	**1800**	**407.93**	**341.8060**	**5256.9850**
25	**2015**	**255**	**1200**	**407.38**	**341.7630**	**5257.6720**
26	**2013**	**308**	**200**	**404.26**	**341.8250**	**5257.1960**
27	**2012**	**166**	**100**	**402.70**	**341.7060**	**5256.9850**
28	**2015**	**41**	**700**	**401.92**	**341.5560**	**5256.9850**
29	**2015**	**105**	**2200**	**401.33**	**341.8630**	**5257.2020**
30	**2014**	**349**	**1700**	**400.41**	**341.8060**	**5256.9360**
31	**2013**	**85**	**1800**	**400.20**	**341.8060**	**5257.0360**
32	2013	79	200	399.90	341.6560	5256.9360
33	2015	152	0	399.89	341.7560	5257.0850
34	2013	308	200	399.02	341.8630	5257.2020
35	2013	66	200	399.02	341.8560	5256.9360
36	2015	94	200	398.62	341.7050	5257.5480
37	2013	111	2200	398.01	341.8060	5257.0850
38	2015	244	2100	396.89	341.9560	5256.7860

Rank	Year	Julian Day	Hour	1-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2012	166	100	396.39	341.7060	5257.0360
40	2013	37	2100	396.16	341.8820	5257.2040
41	2014	148	0	395.64	341.8820	5257.2040
42	2015	94	200	395.35	341.7060	5257.5850
43	2015	41	700	395.19	341.6060	5257.0360
44	2015	102	2100	395.03	341.7560	5256.9850
45	2015	105	2200	394.69	341.8820	5257.2040
46	2015	127	2200	393.88	341.7560	5256.9850
47	2014	349	1700	393.76	341.8060	5256.8850
48	2013	66	200	393.31	341.8560	5257.0360
49	2012	195	2100	392.79	342.0150	5257.2210
50	2015	94	200	392.48	341.7560	5257.6350

Notes:
Events above the 1-hour NO2 AAQS of 400 µg/m³ are in **bold**

Table G.2: TOP-50 EVENTS FOR 24-HOUR NO_2 CONCENTRATIONS FOR SCENARIO C

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration ($\mu g/m^3$)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
1	**2013**	**119**	**0**	**219.43**	**341.756**	**5257.085**
2	**2014**	**350**	**0**	**213.25**	**341.787**	**5257.191**
3	**2014**	**350**	**0**	**212.06**	**341.806**	**5257.193**
4	**2015**	**40**	**0**	**211.10**	**341.906**	**5257.135**
5	**2015**	**40**	**0**	**207.68**	**341.906**	**5257.085**
6	**2013**	**119**	**0**	**207.24**	**341.756**	**5257.036**
7	**2014**	**350**	**0**	**207.20**	**341.806**	**5257.186**
8	**2013**	**57**	**0**	**205.80**	**341.996**	**5257.217**
9	**2013**	**119**	**0**	**203.34**	**341.706**	**5256.985**
10	**2013**	**58**	**0**	**202.65**	**342.072**	**5257.228**
11	**2015**	**40**	**0**	**202.62**	**341.906**	**5257.186**
12	**2013**	**59**	**0**	**201.06**	**342.015**	**5257.221**
13	2013	12	0	199.56	341.882	5257.204
14	2013	120	0	199.39	341.756	5257.085
15	2013	57	0	198.27	342.006	5257.186
16	2013	119	0	195.89	341.756	5257.135
17	2013	57	0	195.12	342.015	5257.221
18	2015	322	0	194.02	341.901	5257.206
19	2015	40	0	193.34	341.901	5257.206
20	2015	322	0	193.08	341.882	5257.204
21	2013	119	0	193.05	341.706	5257.036
22	2013	12	0	191.30	341.863	5257.202
23	2013	119	0	190.16	341.706	5256.936
24	2013	69	0	190.07	341.506	5256.936
25	2012	127	0	189.99	341.756	5257.085
26	2013	120	0	189.74	341.756	5257.036
27	2013	138	0	189.23	341.768	5257.188
28	2013	58	0	188.09	342.106	5257.186
29	2015	40	0	187.10	341.906	5257.036
30	2013	68	0	186.54	341.506	5256.885
31	2015	322	0	184.17	341.906	5257.186
32	2015	40	0	182.76	341.920	5257.208
33	2013	138	0	182.00	341.756	5257.186
34	2014	350	0	181.94	341.756	5257.135
35	2013	12	0	181.25	341.856	5257.135
36	2013	12	0	180.78	341.856	5257.186
37	2013	105	0	180.57	341.825	5257.196
38	2013	58	0	180.30	342.091	5257.230

Rank	Year	Julian Day	Hour	24-hour NO_2 Concentration (µg/m³)	X Coordinate (UTM-km)	X Coordinate (UTM-km)
39	2013	105	0	178.31	341.806	5257.186
40	2013	138	0	178.24	341.756	5257.135
41	2013	59	0	177.77	342.034	5257.223
42	2013	59	0	177.32	341.996	5257.217
43	2013	105	0	177.26	341.806	5257.193
44	2015	307	0	176.64	341.977	5257.215
45	2015	121	0	176.37	341.756	5257.186
46	2012	127	0	176.14	341.706	5256.985
47	2015	121	0	175.49	341.768	5257.188
48	2015	322	0	175.39	341.906	5257.135
49	2013	120	0	175.10	341.756	5257.135
50	2012	127	0	174.45	341.756	5257.036

Notes:
Events above the 24-hour NO_2 AAQS of 200 µg/m³ are in **bold**

APPENDIX C

Holyrood Thermal Generating Station Ambient Air Monitoring Program Results for the Period January 1, 2015 to March 31, 2017

Holyrood Thermal Generating Station Ambient Air Monitoring Program Results for the Period January, 2015 To March, 2017

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
Butter Pot	January, 2015	SO_2	0.00	2.09	71.23	900	1.05	2.09	6.23	300
		NO_X	0.00	1.54	35.43	400	0.78	1.54	4.05	200
		NO_2	0.00	1.15	30.51	400	0.53	1.15	3.28	200
		$PM_{2.5}$	0.0	5.7	19.3	NA	0.0	5.7	8.9	25
	February, 2015	SO_2	0.00	2.60	60.77	900	0.77	2.59	7.37	300
		NO_X	0.00	1.17	38.96	400	0.52	1.17	3.44	200
		NO_2	0.00	1.06	32.54	400	0.50	1.06	2.87	200
		$PM_{2.5}$	0.0	5.7	16.7	NA	0.0	5.7	11.5	25
	March, 2015	SO_2	0.00	2.77	78.08	900	0.78	2.77	8.81	300
		NO_X	0.00	1.43	29.62	400	0.48	1.43	4.61	200
		NO_2	0.00	1.21	20.65	400	0.45	1.21	4.03	200
		$PM_{2.5}$	0.00	4.9	27.6	NA	0.0	4.9	9.7	25
	April, 2015	SO_2	0.00	2.32	42.35	900	0.88	2.32	7.44	300
		NO_X	0.00	1.36	15.48	400	0.68	1.36	3.55	200
		NO_2	0.00	1.14	10.91	400	0.59	1.14	2.84	200
		$PM_{2.5}$	0.0	5.3	15.1	NA	0.0	5.3	8.7	25
	May, 2015	SO_2	0.00	2.41	63.58	900	0.39	2.37	7.96	300
		NO_X	0.00	1.79	35.65	400	0.66	1.78	6.27	200
		NO_2	0.00	1.51	20.74	400	0.51	1.50	4.53	200
		$PM_{2.5}$	0.0	5.4	49.7	NA	0.0	5.3	9.5	25
	June, 2015	SO_2	0.00	2.80	44.30	900	.0.78	2.80	8.75	300
		NO_X	0.00	3.06	16.48	400	1.09	3.06	5.62	200
		NO_2	0.00	1.38	8.71	400	0.76	1.38	2.69	200
		$PM_{2.5}$	0.0	3.8	18.7	NA	0.0	3.8	5.9	25
	July, 2015	SO_2	0.00	3.03	30.87	900	0.89	3.03	5.83	300
		NO_X	0.00	1.85	10.97	400	1.00	1.85	2.86	200
		NO_2	0.00	1.60	8.50	400	0.94	1.60	2.48	200
		$PM_{2.5}$	0.0	5.4	44.8	NA	0.0	5.4	14.7	25
	August, 2015	SO_2	0.00	2.72	18.21	900	0.87	2.70	4.49	300
		NO_X	0.00	1.37	13.87	400	0.21	1.34	3.44	200
		NO_2	0.00	1.34	10.10	400	0.14	1.32	3.13	200

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
		$PM_{2.5}$	0.0	5.0	36.1	NA	0.0	4.9	9.7	25
	Septembe r, 2015	SO_2	0.00	2.91	5.66	900	1.27	2.92	4.64	300
		NO_X	0.00	0.78	5.60	400	0.38	0.78	1.35	200
		NO_2	0.00	0.67	4.13	400	0.36	0.67	1.10	200
		$PM_{2.5}$	0.0	3.5	26.9	NA	0.0	3.5	8.0	25
	October, 2015	SO_2	0.00	2.13	10.72	900	0.66	2.12	3.40	300
		NO_X	0.00	0.99	11.48	400	0.25	0.98	2.29	200
		NO_2	0.00	0.92	10.44	400	0.25	0.90	2.09	200
		$PM_{2.5}$	0.0	4.3	16.7	NA	0.0	4.3	8.0	25
	Novembe r, 2015	SO_2	0.00	3.19	30.88	900	1.50	3.19	7.05	300
		NO_X	0.00	1.16	14.89	400	0.51	1.16	2.59	200
		NO_2	0.00	0.88	13.59	400	0.28	0.88	2.16	200
		$PM_{2.5}$	0.1	5.8	133.6	NA	0.1	5.8	12.7	25
	Decembe r, 2015	SO_2	0.00	2.26	21.83	900	0.87	2.25	6.21	300
		NO_X	0.00	1.23	10.77	400	0.31	1.23	3.23	200
		NO_2	0.00	0.99	10.03	400	0.20	0.99	2.85	200
		$PM_{2.5}$	0.0	5.2	34.5	NA	0.0	5.2	10.4	25
	January, 2016	SO_2	0.00	3.10	17.43	900	1.65	3.10	5.14	300
		NO_X	0.00	1.17	19.82	400	0.50	1.17	4.97	200
		NO_2	0.00	0.95	19.23	400	0.37	0.95	4.55	200
		$PM_{2.5}$	0.0	5.5	173.1	NA	0.0	5.5	13.3	25
	February, 2016	SO_2	0.00	3.75	11.31	900	0.98	3.73	6.26	300
		NO_X	0.00	0.93	10.20	400	0.38	0.93	1.77	200
		NO_2	0.00	0.72	7.31	400	0.28	0.72	1.47	200
		$PM_{2.5}$	0.0	4.8	43.6	NA	0.0	4.8	9.8	25
	March, 2016	SO_2	0.00	3.32	83.56	900	0.57	3.32	14.16	300
		NO_X	0.00	1.48	37.88	400	0.51	1.49	5.94	200
		NO_2	0.00	1.12	26.45	400	0.32	1.13	4.31	200
		$PM_{2.5}$	0.0	5.4	38.2	NA	0.0	5.4	9.3	25
	April, 2016	SO_2	0.00	3.63	193.74	900	0.73	3.63	34.72	300
		NO_X	0.00	1.51	64.36	400	0.35	1.51	13.41	200
		NO_2	0.00	1.10	32.88	400	0.24	1.10	8.70	200
		$PM_{2.5}$	0.0	5.3	36.7	NA	0.0	5.3	9.8	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	May, 2016	SO_2	0.00	3.43	92.36	900	0.61	3.40	11.75	300
		NO_X	0.00	1.68	41.30	400	0.35	1.64	3.93	200
		NO_2	0.00	1.06	19.21	400	0.29	1.04	2.70	200
		$PM_{2.5}$	0.0	4.5	44.2	NA	0.0	4.5	8.1	25
	June, 2016	SO_2	0.00	4.20	88.78	900	1.19	4.21	15.03	300
		NO_X	0.00	2.80	42.48	400	0.84	2.81	8.77	200
		NO_2	0.00	1.13	24.64	400	0.27	1.13	5.19	200
		$PM_{2.5}$	0.00	3.6	58.1	NA	0.0	3.6	9.0	25
	July, 2016	SO_2	0.00	2.25	27.17	900	0.97	2.25	5.69	300
		NO_X	0.00	0.92	11.92	400	0.34	0.92	2.68	200
		NO_2	0.00	0.71	7.96	400	0.24	0.71	2.08	200
		$PM_{2.5}$	0.00	2.9	15.5	NA	0.0	2.9	5.8	25
	August, 2016	SO_2	0.00	1.53	223.53	900	0.42	1.54	2.94	300
		NO_X	0.00	0.73	10.58	400	0.24	0.73	1.50	200
		NO_2	0.00	0.90	8.44	400	0.16	0.91	1.84	200
		$PM_{2.5}$	0.00	3.5	16.8	NA	0.00	3.5	6.5	25
	Septembe r, 2016	SO_2	0.00	2.56	30.94	900	1.86	2.56	6.21	300
		NO_X	0.00	0.82	19.49	400	0.34	0.82	3.39	200
		NO_2	0.00	0.60	12.14	400	0.25	0.60	2.27	200
		$PM_{2.5}$	0.00	4.0	44.0	NA	0.00	3.9	8.8	25
	October. 2016	SO_2	0.00	2.95	14.81	900	2.23	2.95	4.92	300
		NO_X	0.00	0.93	24.45	400	0.29	0.93	3.06	200
		NO_2	0.00	0.68	12.62	400	0.17	0.68	1.77	200
		$PM_{2.5}$	0.00	5.5	66.0	NA	0.00	5.4	8.2	25
	Novembe r, 2016	SO_2	0.00	1.18	13.65	900	0.56	1.16	2.54	300
		NO_X	0.00	1.44	33.66	400	0.49	1.43	5.37	200
		NO_2	0.00	1.24	29.75	400	0.40	1.24	4.87	200
		$PM_{2.5}$	0.00	5.1	27.7	NA	0.00	5.1	8.5	25
	Decembe r, 2016	SO_2	0.00	1.78	16.59	900	0.67	1.76	4.71	300
		NO_X	0.00	0.89	18.63	400	0.30	0.89	2.14	200
		NO_2	0.00	0.74	9.54	400	0.23	0.74	1.84	200
		$PM_{2.5}$	0.00	6.3	15.6	NA	0.00	6.3	9.6	25
	January, 2017	SO_2	0.00	3.04	26.32	900	1.42	3.04	6.36	300
		NO_X	0.00	0.91	12.18	400	0.33	0.91	2.49	200

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	**Mean**	**Max**		**Min**	**Mean**	**Max**	
		NO_2	0.00	0.73	10.76	400	0.24	0.73	2.14	200
		$PM_{2.5}$	0.4	7.1	27.5	NA	0.4	7.1	9.7	25
	February, 2017	SO_2	0.00	1.74	46.25	900	0.42	1.69	4.49	300
		NO_X	0.00	1.09	33.99	400	0.33	1.09	2.66	200
		NO_2	0.00	0.66	31.07	400	0.25	0.66	2.06	200
		$PM_{2.5}$	0.00	6.8	21.3	NA	0.00	6.8	9.4	25
	March, 2017	SO_2	0.00	3.16	50.04	900	0.39	3.16	9.98	300
		NO_X	0.00	1.42	41.89	400	0.00	1.40	5.86	200
		NO_2	0.00	0.91	38.23	400	0.22	0.90	4.56	200
		$PM_{2.5}$	0.5	7.1	35.5	NA	0.5	7.1	10.3	25
Green Acres	January, 2015	SO_2	0.00	4.39	64.24	900	1.05	4.51	11.20	300
		NO_X	0.00	2.99	25.77	400	0.60	2.95	4.70	200
		NO_2	0.00	2.99	22.28	400	0.77	2.96	4.63	200
		$PM_{2.5}$	0.0	5.5	23.5	NA	0.0	5.4	8.8	25
	February, 2015	SO_2	0.00	4.65	185.33	900	1.02	4.65	16.41	300
		NO_X	0.00	3.02	104.85	400	0.00	2.93	7.70	200
		NO_2	0.00	1.81	56.41	400	0.78	1.81	5.99	200
		$PM_{2.5}$	0.0	6.2	17.9	NA	0.0	6.2	10.6	25
	March, 2015	SO_2	0.00	5.21	90.31	900	0.42	5.23	14.12	300
		NO_X	0.00	3.49	41.71	400	0.81	3.52	11.45	200
		NO_2	0.00	1.65	20.36	400	0.59	1.70	4.98	200
		$PM_{2.5}$	0.0	5.8	19.8	NA	0.0	5.8	10.2	25
	April, 2015	SO_2	0.00	4.84	175.57	900	0.73	4.85	14.62	300
		NO_X	0.00	1.87	70.42	400	0.90	1.87	7.13	200
		NO_2	0.00	1.48	31.08	400	0.80	1.48	3.96	200
		$PM_{2.5}$	0.0	5.7	25.2	NA	0.0	5.7	8.2	25
	May, 2015	SO_2	0.00	4.70	188.03	900	1.30	4.71	36.68	300
		NO_X	0.00	2.07	56.07	400	0.87	2.07	11.98	200
		NO_2	0.00	1.67	32.28	400	0.75	1.67	7.69	200
		$PM_{2.5}$	0.0	7.1	76.5	NA	0.0	7.0	14.0	25
	June, 2015	SO_2	0.00	6.08	59.46	900	0.27	5.89	12.20	300
		NO_X	0.00	3.01	19.64	400	0.93	2.91	5.78	200
		NO_2	0.00	1.52	11.02	400	0.88	1.49	2.27	200

Location	Month	Contaminant	Hourly Concentrations (ug/m³)			Hourly AAQS (ug/m³)	Daily Concentrations (ug/m³)			Daily AAQS (ug/m³)
			Min	**Mean**	**Max**		**Min**	**Mean**	**Max**	
		$PM_{2.5}$	0.0	5.5	221.5	NA	0.0	5.5	8.4	25
	July, 2015	SO_2	0.00	6.56	130.71	900	1.70	6.56	11.16	300
		NO_X	0.00	2.37	40.53	400	0.63	2.37	3.88	200
		NO_2	0.00	2.04	17.46	400	0.61	2.04	3.00	200
		$PM_{2.5}$	0.0	7.1	28.9	NA	0.0	7.1	15.7	25
	August, 2015	SO_2	0.00	3.48	47.33	900	0.76	3.48	7.45	300
		NO_X	0.00	2.29	25.59	400	0.93	2.29	4.56	200
		NO_2	0.00	1.93	15.84	400	0.72	1.93	3.50	200
		$PM_{2.5}$	0.0	7.5	24.2	NA	0.8	7.5	11.5	25
	September, 2015	SO_2	0.00	2.38	6.35	900	0.64	2.36	4.65	300
		NO_X	0.00	1.55	11.68	400	0.58	1.62	4.28	200
		NO_2	0.00	1.36	11.10	400	0.41	1.42	4.06	200
		$PM_{2.5}$	0.0	4.8	32.7	NA	0.0	4.8	9.4	25
	October, 2015	SO_2	0.00	5.88	49.19	900	0.85	5.88	13.51	300
		NO_X	0.00	1.21	17.03	400	0.56	1.20	3.08	200
		NO_2	0.00	0.94	11.71	400	0.41	0.94	2.23	200
		$PM_{2.5}$	0.0	3.0	13.8	NA	0.0	3.0	6.9	25
	November, 2015	SO_2	0.00	5.67	52.45	900	0.63	5.71	19.44	300
		NO_X	0.00	1.59	22.50	400	0.75	1.60	6.10	200
		NO_2	0.00	1.17	15.46	400	0.53	1.18	4.69	200
		$PM_{2.5}$	0.0	2.3	22.7	NA	0.0	2.3	6.5	25
	December, 2015	SO_2	0.00	2.42	49.01	900	0.36	2.40	8.78	300
		NO_X	0.00	1.74	26.56	400	0.56	1.73	6.71	200
		NO_2	0.00	1.30	17.56	400	0.42	1.30	5.01	200
		$PM_{2.5}$	0.0	2.5	24.8	NA	0.0	2.5	6.4	25
	January, 2016	SO_2	0.00	2.17	46.51	900	0.00	2.14	7.88	300
		NO_X	0.00	1.84	47.75	400	0.57	1.84	8.71	200
		NO_2	0.00	1.36	45.48	400	0.42	1.36	8.03	200
		$PM_{2.5}$	0.0	2.3	19.6	NA	0.0	2.2	5.0	25
	February, 2016	SO_2	0.00	1.48	19.93	900	0.49	1.48	3.14	300
		NO_X	0.00	1.54	20.48	400	0.67	1.54	4.05	200
		NO_2	0.00	1.10	17.25	400	0.40	1.10	3.06	200
		$PM_{2.5}$	0.0	3.0	24.7	NA	0.0	3.0	6.6	25
	March, 2016	SO_2	0.00	3.10	98.08	900	0.41	3.08	32.82	300

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	**Mean**	**Max**		**Min**	**Mean**	**Max**	
		NO_X	0.00	2.40	62.20	400	0.52	2.39	20.38	200
		NO_2	0.00	1.57	34.54	400	0.26	1.57	12.14	200
		$PM_{2.5}$	0.0	3.5	65.2	NA	0.0	3.5	10.9	25
	April, 2016	SO_2	0.00	3.08	258.92	900	0.18	3.08	32.30	300
		NO_X	0.00	1.98	76.91	400	0.59	1.98	11.66	200
		NO_2	0.00	1.34	47.91	400	0.28	1.34	6.73	200
		$PM_{2.5}$	0.0	3.5	68.6	NA	0.0	3.5	8.8	25
	May, 2016	SO_2	0.00	2.59	132.21	900	0.21	2.59	18.24	300
		NO_X	0.00	1.61	45.31	400	0.43	1.61	6.50	200
		NO_2	0.00	1.08	25.80	400	0.25	1.08	3.56	200
		$PM_{2.5}$	0.0	2.9	43.9	NA	0.0	2.8	6.0	25
	June, 2016	SO_2	0.00	4.04	280.43	900	0.27	3.95	34.77	300
		NO_X	0.00	2.17	88.96	400	0.70	2.13	13.33	200
		NO_2	0.00	1.18	34.16	400	0.27	1.17	6.59	200
		$PM_{2.5}$	0.0	3.0	57.8	NA	0.0	3.0	7.5	25
	July,2016	SO_2	0.00	1.96	109.00	900	0.58	1.96	14.15	300
		NO_X	0.00	4.95	36.59	400	0.98	4.95	8.76	200
		NO_2	0.00	1.05	16.01	400	0.42	1.05	3.18	200
		$PM_{2.5}$	0.0	2.9	16.0	NA	0.0	2.8	7.0	25
	August, 2016	SO_2	0.00	1.92	64.88	900	0.96	1.92	6.45	300
		NO_X	0.00	1.11	18.41	400	0.55	1.11	2.61	200
		NO_2	0.00	0.74	11.25	400	0.27	0.74	1.80	200
		$PM_{2.5}$	0.00	3.5	18.7	NA	0.00	3.5	6.7	25
	Septembe r, 2016	SO_2	0.00	1.12	53.45	900	0.32	1.12	5.72	300
		NO_X	0.00	5.25	27.72	400	0.59	5.24	6.82	200
		NO_2	0.00	0.74	10.06	400	0.24	0.74	1.49	200
		$PM_{2.5}$	0.00	2.9	10.9	NA	0.00	2.9	5.4	25
	October, 2016	SO_2	0.00	1.64	72.54	900	0.37	1.64	8.86	300
		NO_X	0.00	1.52	35.29	400	0.52	1.52	5.49	200
		NO_2	0.00	1.15	21.89	400	0.38	1.15	3.91	200
		$PM_{2.5}$	0.00	3.3	90.3	NA	0.00	3.3	7.2	25
	Novembe r, 2016	SO_2	0.00	1.60	40.99	900	0.65	1.60	5.50	300
		NO_X	0.00	1.95	30.36	400	0.71	1.95	6.87	200
		NO_2	0.00	1.45	23.18	400	0.53	1.45	4.97	200
		$PM_{2.5}$	0.00	2.7	41.5	NA	0.00	2.7	8.8	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	December, 2016	SO_2	0.00	3.00	55.49	900	1.26	3.00	9.40	300
		NO_X	0.00	1.87	45.95	400	0.67	1.87	7.92	200
		NO_2	0.00	1.19	24.08	400	0.31	1.19	4.65	200
		$PM_{2.5}$	0.00	1.5	16.1	NA	0.00	1.4	4.0	25
	January, 2017	SO_2	0.00	2.07	100.77	900	0.55	2.07	8.03	300
		NO_X	0.00	1.87	59.04	400	0.63	1.87	4.21	200
		NO_2	0.00	1.12	34.85	400	0.20	1.12	2.70	200
		$PM_{2.5}$	0.00	2.6	53.0	NA	0.00	2.6	6.7	25
	February, 2017	SO_2	0.00	1.72	131.15	900	0.75	1.72	9.68	300
		NO_X	0.00	1.47	79.06	400	0.58	1.47	5.18	200
		NO_2	0.00	0.91	48.89	400	0.31	0.91	3.23	200
		$PM_{2.5}$	0.00	2.2	20.0	NA	0.00	2.2	4.9	25
	March, 2017	SO_2	0.00	1.89	120.96	900	0.25	1.89	12.28	300
		NO_X	0.00	1.73	75.56	400	0.53	1.73	7.54	200
		NO_2	0.00	1.14	50.92	400	0.31	1.14	5.38	200
		$PM_{2.5}$	0.00	2.9	57.0	NA	0.00	2.9	7.9	25
Indian Pond	January, 2015	SO_2	0.00	3.95	119.25	900	0.42	3.92	28.37	300
		NO_X	0.00	2.57	57.11	400	0.73	2.56	14.41	200
		NO_2	0.00	1.89	24.65	400	0.63	1.88	7.07	200
		$PM_{2.5}$	0.0	4.3	29.4	NA	0.0	4.2	8.4	25
	February, 2015	SO_2	0.00	2.59	57.74	900	1.06	2.59	15.50	300
		NO_X	0.00	2.26	25.98	400	0.92	2.26	8.76	200
		NO_2	0.00	1.74	15.79	400	0.75	1.74	5.91	200
		$PM_{2.5}$	0.0	5.2	27.7	NA	0.0	5.1	9.9	25
	March, 2015	SO_2	0.00	6.47	120.47	900	3.43	6.49	27.37	300
		NO_X	0.00	3.05	59.30	400	0.50	3.06	13.99	200
		NO_2	0.00	2.28	30.67	400	0.38	2.29	9.03	200
		$PM_{2.5}$	0.0	5.0	46.8	NA	0.0	5.0	9.7	25
	April, 2015	SO_2	0.00	2.17	27.27	900	1.59	2.17	3.72	300
		NO_X	0.00	1.88	19.32	400	1.05	1.88	3.61	200
		NO_2	0.00	1.42	12.80	400	0.83	1.42	2.92	200
		$PM_{2.5}$	0.0	5.9	29.2	NA	0.0	5.9	9.7	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	May, 2015	SO_2	0.00	2.53	44.70	900	1.93	2.54	5.06	300
		NO_X	0.00	2.06	17.30	400	1.03	2.07	5.26	200
		NO_2	0.00	1.76	10.79	400	0.92	1.77	3.83	200
		$PM_{2.5}$	0.0	6.0	27.3	NA	0.0	6.1	11.3	25
	June, 2015	SO_2	0.00	2.41	21.16	900	1.79	2.41	4.20	300
		NO_X	0.00	2.46	12.73	400	1.59	2.46	3.86	200
		NO_2	0.00	2.47	12.33	400	1.34	2.48	3.87	200
		$PM_{2.5}$	0.0	3.5	21.2	NA	0.0	3.5	6.9	25
	July, 2015	SO_2	0.00	2.47	66.08	900	1.27	2.45	10.58	300
		NO_X	0.00	2.71	22.34	400	0.97	2.74	5.36	200
		NO_2	0.00	2.28	14.14	400	0.50	2.33	5.09	200
		$PM_{2.5}$	0.0	3.9	32.1	NA	0.0	3.9	13.6	25
	August, 2015	SO_2	0.00	1.60	28.14	900	1.16	1.60	3.51	300
		NO_X	0.00	2.01	56.81	400	0.72	2.01	4.86	200
		NO_2	0.00	0.81	24.18	400	0.17	0.81	2.21	200
		$PM_{2.5}$	0.0	4.7	24.9	NA	0.0	4.7	8.1	25
	September, 2015	SO_2	0.00	1.80	14.52	900	1.33	1.80	6.29	300
		NO_X	0.00	1.28	24.93	400	0.54	1.28	3.11	200
		NO_2	0.00	0.88	13.35	400	0.38	0.88	2.03	200
		$PM_{2.5}$	0.0	3.8	21.3	NA	0.0	3.7	7.5	25
	October, 2015	SO_2	0.00	3.85	106.19	900	0.95	3.83	33.44	300
		NO_X	0.00	1.69	34.45	400	0.44	1.68	11.15	200
		NO_2	0.00	1.19	18.75	400	0.35	1.18	6.34	200
		$PM_{2.5}$	0.0	3.3	72.9	NA	0.0	3.4	5.3	25
	November, 2015	SO_2	0.00	4.83	107.17	900	0.90	4.82	41.34	300
		NO_X	0.00	2.55	37.68	400	0.48	2.54	15.84	200
		NO_2	0.00	1.69	21.83	400	0.32	1.69	8.98	200
		$PM_{2.5}$	0.0	2.7	83.1	NA	0.0	2.7	12.3	25
	December, 2015	SO_2	0.00	7.11	108.83	900	2.71	7.10	37.09	300
		NO_X	0.00	2.29	32.90	400	0.60	2.29	12.90	200
		NO_2	0.00	1.44	17.23	400	0.36	1.44	6.66	200
		$PM_{2.5}$	0.0	4.6	118.9	NA	0.0	4.5	14.1	25
	January, 2016	SO_2	0.00	3.61	51.69	900	1.43	3.60	9.37	300
		NO_X	0.00	1.90	38.67	400	0.42	1.88	6.16	200

Location	Month	Contaminant	Hourly Concentrations (ug/m³)			Hourly AAQS (ug/m³)	Daily Concentrations (ug/m³)			Daily AAQS (ug/m³)
			Min	Mean	Max		Min	Mean	Max	
		NO_2	0.00	1.39	36.65	400	0.26	1.37	5.58	200
		$PM_{2.5}$	0.0	3.3	106.5	NA	0.0	3.2	8.3	25
	February, 2016	SO_2	0.00	7.24	103.82	900	5.34	7.24	22.94	300
		NO_X	0.00	2.27	72.98	400	0.72	2.27	10.37	200
		NO_2	0.00	1.65	31.38	400	0.59	1.65	5.43	200
		$PM_{2.5}$	0.0	4.5	34.8	NA	0.0	4.5	7.7	25
	March, 2016	SO_2	0.00	3.50	96.91	900	1.33	3.50	15.35	300
		NO_X	0.00	1.90	50.03	400	0.56	1.89	8.66	200
		NO_2	0.00	1.39	23.67	400	0.45	1.39	5.46	200
		$PM_{2.5}$	0.0	4.1	36.9	NA	0.0	4.1	8.5	25
	April, 2016	SO_2	0.00	2.43	117.60	900	0.49	2.43	11.75	300
		NO_X	0.00	1.46	60.53	400	0.42	1.46	6.41	200
		NO_2	0.00	1.05	30.33	400	0.29	1.05	3.43	200
		$PM_{2.5}$	0.0	3.3	96.9	NA	0.0	3.3	14.8	25
	May, 2016	SO_2	0.00	1.88	74.20	900	1.20	1.88	8.79	300
		NO_X	0.00	1.12	20.28	400	0.49	1.12	2.96	200
		NO_2	0.00	0.81	12.16	400	0.24	0.81	1.92	200
		$PM_{2.5}$	0.0	2.6	31.4	NA	0.0	2.6	5.9	25
	June, 2016	SO_2	0.00	2.47	17.96	900	1.84	2.48	4.09	300
		NO_X	0.00	0.98	6.02	400	0.62	0.98	1.51	200
		NO_2	0.00	0.69	5.22	400	0.35	0.69	1.11	200
		$PM_{2.5}$	0.0	3.0	15.6	NA	0.0	3.0	7.5	25
	July, 2016	SO_2	0.00	3.54	57.86	900	1.02	3.48	9.43	300
		NO_X	0.00	2.18	22.08	400	0.65	2.13	6.24	200
		NO_2	0.00	0.78	7.84	400	0.33	0.78	1.97	200
		$PM_{2.5}$	0.0	2.9	73.1	NA	0.0	2.9	7.6	25
	August, 2016	SO_2	0.00	2.63	44.87	900	1.77	2.63	6.71	300
		NO_X	0.00	2.32	23.04	400	0.35	2.32	4.82	200
		NO_2	0.00	0.85	8.95	400	0.37	0.85	2.30	200
		$PM_{2.5}$	0.00	3.0	16.0	NA	0.00	2.9	8.5	25
	September, 2016	SO_2	0.00	1.80	44.67	900	0.95	1.80	4.46	300
		NO_X	0.00	1.47	22.67	400	0.64	1.47	3.19	200
		NO_2	0.00	0.90	12.44	400	0.32	0.89	2.15	200
		$PM_{2.5}$	0.00	3.5	86.9	NA	0.00	3.3	7.6	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	October, 2016	SO_2	0.00	1.70	69.16	900	0.95	1.70	5.79	300
		NO_X	0.00	1.24	30.51	400	0.46	1.24	3.35	200
		NO_2	0.00	0.91	12.48	400	0.43	0.92	1.97	200
		$PM_{2.5}$	0.00	6.7	27.6	NA	0.00	6.7	8.9	25
	November, 2016	SO_2	0.00	2.50	5.24	900	2.02	2.50	2.89	300
		NO_X	0.00	1.56	22.04	400	0.39	1.56	4.49	200
		NO_2	0.00	1.33	13.12	400	0.30	1.33	3.89	200
		$PM_{2.5}$	0.00	7.1	113.9	NA	0.00	7.1	13.5	25
	December, 2016	SO_2	0.00	4.70	141.12	900	1.07	4.70	25.64	300
		NO_X	0.00	2.79	73.65	400	0.51	2.79	14.22	200
		NO_2	0.00	1.95	31.41	400	0.30	1.95	7.82	200
		$PM_{2.5}$	0.00	0.8	37.5	NA	0.00	6.8	11.8	25
	January, 2017	SO_2	0.00	5.12	155.04	900	0.66	5.10	41.20	300
		NO_X	0.00	2.70	51.93	400	0.68	2.70	22.32	200
		NO_2	0.00	1.78	25.69	400	0.40	1.78	12.88	200
		$PM_{2.5}$	0.00	7.5	65.6	NA	0.00	7.5	10.7	25
	February, 2017	SO_2	0.00	6.09	136.51	900	1.58	6.09	55.75	300
		NO_X	0.00	3.52	88.40	400	0.47	3.52	35.18	200
		NO_2	0.00	2.31	38.18	400	0.40	2.31	18.01	200
		$PM_{2.5}$	0.00	6.6	24.3	NA	0.00	6.6	10.4	25
	March, 2017	SO_2	0.00	2.66	37.04	900	1.81	2.65	7.02	300
		NO_X	0.00	1.25	22.66	400	0.40	1.24	3.16	200
		NO_2	0.00	0.98	12.44	400	0.20	0.98	2.00	200
		$PM_{2.5}$	0.00	6.9	173.8	NA	0.00	6.9	23.1	25
MAMS	January, 2015	SO_2	0.00	6.86	190.74	900	1.20	6.85	74.12	300
		NO_X	0.00	3.61	67.78	400	0.73	3.61	28.60	200
		NO_2	0.00	2.18	32.34	400	0.62	2.18	10.84	200
		$PM_{2.5}$	0.0	4.3	20.8	NA	0.0	4.3	10.0	25
	February, 2015	SO_2	0.00	11.07	168.39	900	1.03	11.02	60.87	300
		NO_X	0.00	4.77	130.25	400	0.60	5.11	27.87	200
		NO_2	0.00	2.65	93.81	400	0.50	2.96	17.22	200
		$PM_{2.5}$	0.0	6.1	36.4	NA	0.0	6.0	15.3	25

Location	Month	Contaminant	Hourly Concentrations (ug/m³)			Hourly AAQS (ug/m³)	Daily Concentrations (ug/m³)			Daily AAQS (ug/m³)
			Min	Mean	Max		Min	Mean	Max	
	March, 2015	SO_2	0.00	4.16	81.60	900	1.14	4.15	21.19	300
		NO_X	0.00	2.46	43.07	400	0.74	2.46	8.68	200
		NO_2	0.00	1.76	28.41	400	0.61	1.76	5.27	200
		$PM_{2.5}$	0.0	4.8	46.2	NA	0.0	4.8	9.6	25
	April, 2015	SO_2	0.00	3.82	106.10	900	0.72	3.82	20.90	300
		NO_X	0.00	1.94	30.35	400	0.66	1.94	6.71	200
		NO_2	0.00	1.41	14.13	400	0.62	1.41	3.62	200
		$PM_{2.5}$	0.0	5.9	27.9	NA	0.0	5.9	9.4	25
	May, 2015	SO_2	0.00	3.05	113.78	900	0.37	3.04	19.47	300
		NO_X	0.00	1.81	52.71	400	0.65	1.80	10.95	200
		NO_2	0.00	1.25	27.76	400	0.48	1.24	5.48	200
		$PM_{2.5}$	0.0	7.3	67.8	NA	0.0	7.4	12.6	25
	June, 2015	SO_2	0.00	2.51	24.36	900	1.29	2.51	4.75	300
		NO_X	0.00	1.87	90.23	400	0.68	1.88	10.34	200
		NO_2	0.00	1.09	32.87	400	0.41	1.09	3.48	200
		$PM_{2.5}$	0.0	5.2	27.9	NA	0.0	5.2	8.8	25
	July, 2015	SO_2	0.00	2.67	48.30	900	1.49	2.67	13.62	300
		NO_X	0.00	1.51	96.51	400	0.62	1.51	6.07	200
		NO_2	0.00	1.03	29.14	400	0.44	1.03	2.49	200
		$PM_{2.5}$	0.0	6.9	32.1	NA	0.0	6.9	14.2	25
	August, 2015	SO_2	0.00	1.85	6.68	900	0.41	1.84	2.40	300
		NO_X	0.00	1.58	21.57	400	0.58	1.60	5.00	200
		NO_2	0.00	1.10	10.01	400	0.24	1.12	3.13	200
		$PM_{2.5}$	0.0	8.3	42.2	NA	0.0	8.3	12.5	25
	September, 2015	SO_2	0.00	1.44	22.28	900	0.58	1.45	3.15	300
		NO_X	0.00	3.24	36.25	400	0.93	3.24	8.02	200
		NO_2	0.00	0.94	18.15	400	0.29	0.94	2.93	200
		$PM_{2.5}$	0.0	6.1	50.6	NA	0.0	6.1	9.9	25
	October, 2015	SO_2	0.00	4.63	107.68	900	0.29	4.63	39.49	300
		NO_X	0.00	2.01	37.53	400	0.59	2.01	11.87	200
		NO_2	0.00	1.19	16.62	400	0.36	1.19	5.33	200
		$PM_{2.5}$	0.0	2.9	67.0	NA	0.0	2.9	6.1	25
	November, 2015	SO_2	0.00	3.84	114.35	900	0.55	3.82	40.55	300
		NO_X	0.00	1.80	40.33	400	0.44	1.79	13.26	200

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
		NO_2	0.00	1.16	19.40	400	0.47	1.15	5.98	200
		$PM_{2.5}$	0.0	2.5	19.7	NA	0.0	2.4	6.3	25
	December, 2015	SO_2	0.00	4.62	185.39	900	0.43	4.61	59.59	300
		NO_X	0.00	2.80	56.19	400	0.71	2.80	18.31	200
		NO_2	0.00	1.61	23.11	400	0.37	1.61	6.67	200
		$PM_{2.5}$	0.0	2.9	23.5	NA	0.0	2.9	8.8	25
	January, 2016	SO_2	0.00	2.74	84.55	900	0.35	2.72	11.51	300
		NO_X	0.00	2.81	48.23	400	0.60	2.77	8.46	200
		NO_2	0.00	1.96	46.15	400	0.34	1.94	7.15	200
		$PM_{2.5}$	0.0	2.4	14.8	NA	0.0	2.4	4.3	25
	February, 2016	SO_2	0.00	5.33	154.02	900	0.48	5.33	37.32	300
		NO_X	0.00	3.67	62.09	400	0.75	3.61	21.44	200
		NO_2	0.00	2.29	33.77	400	0.50	2.26	12.43	200
		$PM_{2.5}$	0.0	4.2	53.5	NA	0.0	4.2	8.5	25
	March, 2016	SO_2	0.00	8.57	193.77	900	1.50	8.51	80.78	300
		NO_X	0.00	4.19	107.00	400	0.58	4.18	33.82	200
		NO_2	0.00	2.31	46.33	400	0.39	2.32	15.54	200
		$PM_{2.5}$	0.0	3.7	34.3	NA	0.0	3.7	12.5	25
	April, 2016	SO_2	0.00	4.95	108.82	900	0.46	4.95	56.09	300
		NO_X	0.00	2.47	61.74	400	0.39	2.47	26.28	200
		NO_2	0.00	1.53	33.69	400	0.25	1.52	13.29	200
		$PM_{2.5}$	0.0	4.0	35.9	NA	0.0	3.9	12.7	25
	May, 2016	SO_2	0.00	2.94	30.16	900	0.20	2.95	7.37	300
		NO_X	0.00	0.98	11.61	400	0.39	0.97	2.38	200
		NO_2	0.00	0.78	6.12	400	0.33	0.78	1.44	200
		$PM_{2.5}$	0.0	2.9	162.9	NA	0.0	2.8	11.0	25
	June, 2016	SO_2	0.00	5.00	34.62	900	3.72	5.00	5.91	300
		NO_X	0.00	0.98	6.84	400	0.48	0.98	1.70	200
		NO_2	0.00	0.73	4.28	400	0.28	0.73	1.29	200
		$PM_{2.5}$	0.0	4.1	36.1	NA	0.0	4.1	8.7	25
	July, 2016	SO_2	0.00	2.17	74.47	900	0.51	2.17	21.91	300
		NO_X	0.00	1.50	22.53	400	0.60	1.50	6.28	200
		NO_2	0.00	0.87	8.73	400	0.27	0.87	2.53	200
		$PM_{2.5}$	0.0	6.3	19.2	NA	0.0	6.3	10.4	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	August, 2016	SO_2	0.00	1.30	17.23	900	0.44	1.31	3.39	300
		NO_X	0.00	1.02	13.64	400	0.28	1.01	2.55	200
		NO_2	0.00	0.67	9.05	400	0.16	0.67	1.54	200
		$PM_{2.5}$	0.00	3.7	105.4	NA	0.00	3.7	11.0	25
	Septembe r, 2016	SO_2	0.00	1.53	31.92	900	0.26	1.50	6.77	300
		NO_X	0.00	3.03	43.41	400	0.57	3.04	6.14	200
		NO_2	0.00	0.99	16.56	400	0.31	0.99	1.98	200
		$PM_{2.5}$	0.00	3.2	123.7	NA	0.00	3.2	8.1	25
	October, 2016	SO_2	0.00	3.20	83.84	900	1.57	3.19	11.39	300
		NO_X	0.00	1.42	21.08	400	0.45	1.42	3.78	200
		NO_2	0.00	0.84	8.77	400	0.24	0.84	2.06	200
		$PM_{2.5}$	0.00	3.9	70.4	NA	0.00	3.9	6.4	25
	Novembe r, 2016	SO_2	0.00	2.12	21.85	900	0.58	3.17	14.92	300
		NO_X	0.00	1.61	27.63	400	0.39	1.64	5.46	200
		NO_2	0.00	1.23	20.24	400	0.24	1.11	2.70	200
		$PM_{2.5}$	0.00	3.2	123.4	NA	0.00	2.2	6.7	25
	Decembe r, 2016	SO_2	0.00	3.17	73.90	900	0.58	3.17	14.92	300
		NO_X	0.00	1.64	37.02	400	0.39	1.64	5.46	200
		NO_2	0.00	1.11	17.20	400	0.24	1.11	2.70	200
		$PM_{2.5}$	0.00	2.2	57.4	NA	0.00	2.2	6.7	25
	January, 2017	SO_2	0.00	3.14	77.29	900	0.62	3.52	15.92	300
		NO_X	0.00	2.13	59.92	400	0.43	2.09	10.53	200
		NO_2	0.00	1.55	28.33	400	0.27	1.36	4.50	200
		$PM_{2.5}$	0.00	4.0	21.2	NA	0.00	4.3	11.5	25
	February, 2017	SO_2	0.00	3.50	149.43	900	0.62	3.52	15.92	300
		NO_X	0.00	2.08	111.52	400	0.43	2.09	10.53	200
		NO_2	0.00	1.35	41.81	400	0.27	1.36	4.50	200
		$PM_{2.5}$	0.00	4.3	80.4	NA	0.00	4.3	11.5	25
	March, 2017	SO_2	0.00	9.35	197.17	900	0.32	9.32	87.40	300
		NO_X	0.00	4.91	81.00	400	0.32	4.89	29.46	200
		NO_2	0.00	2.66	43.72	400	0.20	2.65	13.75	200
		$PM_{2.5}$	0.00	4.9	120.9	NA	0.00	4.9	16.3	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	**Mean**	**Max**		**Min**	**Mean**	**Max**	
Lawrence Pond	January, 2015	SO_2	0.00	3.81	70.07	900	0.65	3.81	25.98	300
		NO_X	0.00	2.88	51.23	400	0.91	2.88	13.99	200
		NO_2	0.00	2.53	37.19	400	0.85	2.53	11.00	200
		$PM_{2.5}$	0.0	4.5	13.5	NA	0.0	4.5	8.2	25
	February, 2015	SO_2	0.00	6.12	88.27	900	0.50	6.12	26.21	300
		NO_X	0.00	3.47	38.02	400	0.69	3.47	12.89	200
		NO_2	0.00	3.01	28.88	400	0.74	3.01	9.76	200
		$PM_{2.5}$	0.0	5.9	19.9	NA	0.0	5.9	11.6	25
	March, 2015	SO_2	0.00	3.62	180.18	900	0.74	3.60	16.30	300
		NO_X	0.00	2.50	79.94	400	0.69	2.49	7.82	200
		NO_2	0.00	2.09	42.51	400	0.54	2.08	6.33	200
		$PM_{2.5}$	0.0	5.1	20.4	NA	0.0	5.0	9.5	25
	April, 2015	SO_2	0.00	3.26	85.82	900	0.52	3.26	12.70	300
		NO_X	0.00	2.43	49.73	400	1.07	2.43	7.18	200
		NO_2	0.00	1.91	30.01	400	0.90	1.91	5.69	200
		$PM_{2.5}$	0.0	4.5	21.3	NA	0.0	4.5	8.5	25
	May, 2015	SO_2	0.00	2.21	50.69	900	0.62	2.21	8.10	300
		NO_X	0.00	2.11	26.11	400	1.00	2.11	4.72	200
		NO_2	0.00	1.94	17.81	400	0.94	1.94	4.07	200
		$PM_{2.5}$	0.0	4.8	16.8	NA	0.0	4.8	11.7	25
	June, 2015	SO_2	0.00	1.81	28.62	900	0.45	1.81	5.66	300
		NO_X	0.00	1.90	12.21	400	1.08	1.90	3.16	200
		NO_2	0.00	1.58	8.07	400	0.92	1.57	2.69	200
		$PM_{2.5}$	0.0	3.2	15.0	NA	0.0	3.2	6.0	25
	July,2015	SO_2	0.00	2.51	30.63	900	1.30	2.51	7.36	300
		NO_X	0.00	1.93	16.44	400	1.18	1.93	4.14	200
		NO_2	0.00	1.65	10.20	400	0.99	1.65	3.17	200
		$PM_{2.5}$	0.0	3.3	128.5	NA	0.0	3.3	12.2	25
	August, 2015	SO_2	0.00	1.47	14.12	900	0.73	1.47	4.38	300
		NO_X	0.00	2.04	19.72	400	1.37	2.04	5.26	200
		NO_2	0.00	1.56	10.28	400	0.99	1.56	3.49	200
		$PM_{2.5}$	0.0	3.0	15.8	NA	0.0	3.0	7.5	25
	September, 2015	SO_2	0.00	1.69	17.11	900	0.69	1.68	4.02	300
		NO_X	0.00	2.20	17.27	400	0.66	2.18	4.43	200

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
		NO_2	0.00	5.52	17.83	400	0.58	5.49	8.80	200
		$PM_{2.5}$	0.0	2.9	12.8	NA	0.0	2.9	5.8	25
	October, 2015	SO_2	0.00	3.07	72.95	900	0.90	3.07	14.62	300
		NO_X	0.00	3.69	31.96	400	0.70	3.69	8.54	200
		NO_2	0.00	1.46	21.76	400	0.41	1.46	5.11	200
		$PM_{2.5}$	0.0	2.7	10.6	NA	0.0	2.7	4.9	25
	Novembe r, 2015	SO_2	0.00	2.62	73.08	900	0.25	2.62	20.05	300
		NO_X	0.00	1.93	35.50	400	0.76	1.92	10.06	200
		NO_2	0.00	1.60	28.86	400	0.60	1.59	7.99	200
		$PM_{2.5}$	0.0	2.5	11.4	NA	0.0	2.5	5.4	25
	Decembe r, 2015	SO_2	0.00	2.67	45.22	900	0.78	2.70	16.81	300
		NO_X	0.00	1.86	20.34	400	0.77	1.88	6.67	200
		NO_2	0.00	1.42	17.51	400	0.50	1.43	5.09	200
		$PM_{2.5}$	0.0	3.2	14.6	NA	0.0	3.2	6.9	25
	January, 2016	SO_2	0.00	5.82	75.87	900	2.36	5.82	20.11	300
		NO_X	0.00	3.11	55.12	400	0.63	3.12	12.82	200
		NO_2	0.00	2.57	38.91	400	0.55	2.57	10.45	200
		$PM_{2.5}$	0.0	4.3	14.6	NA	0.0	4.3	7.2	25
	February, 2016	SO_2	0.00	4.29	52.72	900	1.24	4.29	14.02	300
		NO_X	0.00	3.09	49.91	400	0.57	3.09	11.10	200
		NO_2	0.00	2.55	40.56	400	0.46	2.55	8.94	200
		$PM_{2.5}$	0.0	3.6	15.8	NA	0.0	3.6	8.4	25
	March, 2016	SO_2	0.00	5.69	93.61	900	0.31	5.74	20.07	300
		NO_X	0.00	2.87	46.76	400	0.72	2.86	11.76	200
		NO_2	0.00	2.33	37.70	400	0.52	2.33	9.37	200
		$PM_{2.5}$	0.0	3.2	16.7	NA	0.0	3.2	8.7	25
	April, 2016	SO_2	0.00	4.47	149.50	900	0.67	4.47	18.61	300
		NO_X	0.00	3.06	79.11	400	0.69	3.06	9.84	200
		NO_2	0.00	2.26	47.38	400	0.40	2.26	7.37	200
		$PM_{2.5}$	0.0	3.7	93.8	NA	0.0	3.7	9.5	25
	May, 2016	SO_2	0.00	3.00	51.64	900	0.85	3.02	6.04	300
		NO_X	0.00	1.28	17.61	400	0.48	1.28	2.99	200
		NO_2	0.00	1.07	12.05	400	0.42	1.07	2.36	200
		$PM_{2.5}$	0.0	2.3	19.6	NA	0.0	2.3	5.2	25

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	Mean	Max		Min	Mean	Max	
	June, 2016	SO_2	0.00	1.36	25.33	900	0.25	1.35	4.65	300
		NO_X	0.00	1.23	15.50	400	0.47	1.23	2.75	200
		NO_2	0.00	0.91	10.76	400	0.24	0.91	2.15	200
		$PM_{2.5}$	0.0	1.8	15.3	NA	0.0	1.8	6.6	25
	July, 2016	SO_2	0.00	1.62	28.91	900	0.28	1.62	6.42	300
		NO_X	0.00	1.39	10.26	400	0.56	1.39	2.88	200
		NO_2	0.00	1.11	7.09	400	0.44	1.11	2.18	200
		$PM_{2.5}$	0.0	2.4	14.7	NA	0.0	2.3	7.6	25
	August, 2016	SO_2	0.00	1.62	22.01	900	0.18	1.62	3.83	300
		NO_X	0.00	1.27	14.16	400	0.52	1.27	2.87	200
		NO_2	0.00	0.93	10.47	400	0.34	0.93	2.14	200
		$PM_{2.5}$	0.00	2.2	27.7	NA	0.00	2.2	5.1	25
	Septembe r, 2016	SO_2	0.00	1.33	18.20	900	0.18	1.40	4.17	300
		NO_X	0.00	4.32	17.62	400	0.68	4.19	8.79	200
		NO_2	0.00	1.20	13.23	400	0.39	1.18	2.59	200
		$PM_{2.5}$	0.00	2.3	37.9	NA	0.00	2.3	5.1	25
	October, 2016	SO_2	0.11	2.58	95.13	900	0.49	2.58	16.23	300
		NO_X	0.00	1.81	40.47	400	0.51	1.81	7.59	200
		NO_2	0.00	1.50	23.91	400	0.53	1.50	5.23	200
		$PM_{2.5}$	0.00	3.5	17.8	NA	0.00	3.5	5.7	25
	Novembe r, 2016	SO_2	0.00	2.15	48.17	900	1.01	2.15	6.07	300
		NO_X	0.00	1.83	27.69	400	0.68	1.83	4.77	200
		NO_2	0.00	1.53	23.64	400	0.49	1.53	4.27	200
		$PM_{2.5}$	0.00	3.5	40.0	NA	0.00	3.5	7.3	25
	Decembe r, 2016	SO_2	0.00	2.06	55.26	900	0.14	2.06	10.70	300
		NO_X	0.00	1.95	41.13	400	0.60	1.96	5.98	200
		NO_2	0.00	1.56	27.31	400	0.43	1.56	4.55	200
		$PM_{2.5}$	0.00	3.9	14.4	NA	0.00	3.9	6.3	25
	January, 2017	SO_2	0.00	2.72	55.51	900	0.75	2.72	11.53	300
		NO_X	0.00	2.00	29.64	400	0.61	2.00	6.45	200
		NO_2	0.00	1.65	25.82	400	0.45	1.65	5.88	200
		$PM_{2.5}$	0.00	4.8	73.3	NA	0.00	4.8	7.8	25
	February, 2017	SO_2	0.00	2.39	67.52	900	0.46	2.39	11.18	300

Location	Month	Contaminant	Hourly Concentrations (ug/m^3)			Hourly AAQS (ug/m^3)	Daily Concentrations (ug/m^3)			Daily AAQS (ug/m^3)
			Min	**Mean**	**Max**		**Min**	**Mean**	**Max**	
		NO_X	0.00	1.89	35.32	400	0.52	1.89	5.97	200
		NO_2	0.00	1.55	28.70	400	0.40	1.55	5.08	200
		$PM_{2.5}$	0.00	4.0	20.3	NA	0.00	4.0	7.3	25
	March, 2017	SO_2	0.00	4.85	88.11	900	0.24	4.80	34.44	300
		NO_X	0.00	3.41	45.47	400	0.22	3.39	17.33	200
		NO_2	0.00	2.41	38.23	400	0.26	2.40	13.03	200
		$PM_{2.5}$	0.00	5.8	19.9	NA	0.00	5.8	10.7	25