

APPENDIX Q  
RAMBOLL AIR QUALITY MODELLING REPORT

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# MEMORANDUM

Subject EverWind Clean Ammonia and Hydrogen Project  
Air Quality Assessment

Project # 324000771

Client Strum Consulting

Date November 11, 2022

To Natasha Myers and Shawn Duncan

From Biljana Cosic, PhD, and Mike Jammer, PEng

## 1. Introduction

This memorandum documents the methodology and results of the Air Quality Screening carried out in support of the Environmental Assessment (EA) submissions by Strum Consulting (Strum) for Phase 1 of the proposed EverWind Fuels, Clean Ammonia and Hydrogen Project in Point Tupper in the Municipality of the County of Richmond, Nova Scotia (the Project). The proposed Facility will produce hydrogen through electrolysis of demineralized water and nitrogen through cryogenic distillation of air which will be used to synthesize ammonia. The ammonia production plant and the ammonia storage system will require dedicated flare stacks to control any off-gassed ammonia from the process and the storage area. While the engineering work on the siting and sizing of the flares is still in the conceptual design stage Hatch has prepared a preliminary flare evaluation report "Preliminary Flare Load and Emissions Estimate" (Hatch Report).<sup>1</sup> The objective of that analysis was to develop preliminary estimates on the flare loads and emissions from the two sources for this assessment.

The emission estimates used in the dispersion modelling are preliminary based on conceptual engineering (FEL1) and are neither a conservative upper bound nor representative of final project emissions. The preliminary emission estimates are likely to change through further project development and engineering study, however they represent the best information currently available. The modelling will need to be revisited in the future as the engineering progresses, and refined emission estimates become available. It was noted that as the engineering advances the configuration of the flares may also change. For instance a single flare may be utilized instead of two. The modelling results presented in this memo reflect the uncertainty in the emission estimates and source configuration, therefore this study is considered to be a screening level assessment only.

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<sup>1</sup> Hatch (2022). EverWind Fuels, Point Tupper Green Ammonia Project Phase 1. Preliminary Flare Load and Emissions Estimate. October 6.

The purpose of this screening assessment is to use these preliminary emission estimates to evaluate the potential impact from the two flare sources and how estimated ground-level concentrations compare to the Nova Scotia Air Quality Regulations Schedule A: Maximum Permissible Ground Level Concentrations.<sup>2</sup> The technical approach is based primarily on the information provided in the Hatch Report. Additional references and sources of information that Ramboll relied on to develop the model and evaluate the impact of the Project on air quality include: EverWind Project Description Report prepared by Strum,<sup>3</sup> Prefeasibility Report<sup>4</sup> and Consequence Impact Assessment Report,<sup>5</sup> both prepared by Hatch, and information obtained through direct communication with Strum and Hatch.

The methodology and key findings from the assessment are summarized in the following sections.

## 2. Technical Approach

Nova Scotia Air Quality Regulations do not provide specific guidance on the development of air emissions and preferred air dispersion modelling approach. In preparation of this assessment Ramboll followed guidance from other regulatory agencies in the United States and Canada such as the U.S. Environmental Protection Agency (US EPA) and Ontario Ministry of the Environment, Conservation and Parks (MECP).

### 2.1 Flare Load Profiles and Emission Estimates

The anticipated releases from the Process Flare and the Storage Flare during regular operations and upset conditions are described in more detail in the Hatch Report. Briefly, under normal operating conditions the Process Flare will have some continuous release, primarily low-pressure off-gas associated with inert gas purging. However, the flare will be designed to handle potential upset events with much larger volumes of ammonia such as outlet loads from pressure relief safety valves. The likelihood and frequency of such unplanned releases cannot be predicted with confidence but for the purpose of the screening assessment Hatch proposed a scenario of one upset event a year with a duration of 15 minutes for the Process Flare. In addition to the continuous and intermittent process releases the Process Flare emissions would be also due to burning of pilots which are expected to represent a small portion of the overall flare emissions.

In terms of the ammonia storage flare system, there will be no ammonia releases during normal operations since the vapours from the tank are recycled back to the ammonia plant or compressed and liquified in the local boil off-gas handling system. However, the flare will be designed to handle large ammonia loads due to unplanned events such as boil-off system

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<sup>2</sup> Nova Scotia Department of Environment and Climate Change, Schedule A—Maximum Permissible Ground Level Concentrations. Available at: [https://www.novascotia.ca/Just/Regulations/regs/envairqt.htm#TOC1\\_1](https://www.novascotia.ca/Just/Regulations/regs/envairqt.htm#TOC1_1)

<sup>3</sup> Strum (2022). EverWind Hydrogen and Ammonia Production Facility, Project Description, prepared by Strum. May 19.

<sup>4</sup> Hatch (2022). EverWind Fuels, Point Tupper Green Ammonia Project Phase 1. Prefeasibility Report (FEL1). July 26.

<sup>5</sup> Hatch (2022). Consequence Impact Assessment, Fuel Green Ammonia & Hydrogen Plant. May 5.

failures or power outages. For the purpose of this preliminary assessment Hatch proposed to assume an upset event in the storage system occurs once a year with a duration of one hour. Both flare stacks will need fuel to assist the complete combustion of ammonia. Therefore the Storage Flare will also have some continuous but low release due to the burning pilots.

Table 1 shows the material loads in the Process Flare and Storage Flare estimated by Hatch, see also Appendix A. The mass loads and the heating values of individual components shown in Table 2 were used to calculate the total heat release rates of the flares, one of the inputs into the screening model.

Table 1. Estimated mass loads into the Flares<sup>1</sup>

Process Flare								
Description		Plant Source	Mass Flow (kg/hr)					
			N <sub>2</sub>	Ar	H <sub>2</sub>	NH <sub>3</sub>	H <sub>2</sub> O	C <sub>3</sub> H <sub>8</sub>
Continuous Loads	Continuous purge	Nitrogen system	35					
	LP Off-gas	Ammonia synloop inert purge	8.9	0.8	1.2	14		
	Compressor Dry Gas Seals	Synloop compressors	30		6.5	0.13		
	Pilots (Hydrogen)	Flare pilot			2.8			
	Pilots (Propane)	Flare pilot						7.8
Intermittent Loads (short-term peak)	103-J Suction Vent		20,708		4,467	91		
	105-J Final Stage PSV		9.2		1.1	18,544		
Storage Flare								
Description		Plant Source	Mass Flow (kg/hr)					
			N <sub>2</sub>	Ar	H <sub>2</sub>	NH <sub>3</sub>	H <sub>2</sub> O	C <sub>3</sub> H <sub>8</sub>
Continuous Loads	Continuous purge	Nitrogen system	5.0					
	Pilots (Hydrogen)	Flare pilot			2.8			
	Pilots (Propane)	Flare pilot						7.8
Intermittent Loads (short-term peak)	Ammonia Vaporization	Storage Tanks				3,000		

<sup>1</sup> Adapted from Hatch Report, Table 2-2 and Table 2-4

Table 2. Low Heating Values<sup>1</sup>

Component	Low Heating Value (MJ/kg) <sup>1</sup>
	<b>MJ/kg</b>
<b>H<sub>2</sub></b>	120
<b>NH<sub>3</sub></b>	18.9
<b>C<sub>3</sub>H<sub>8</sub></b>	46.4

<sup>1</sup> Adopted from Hatch Report, Table 2-1

The corresponding long-term (continuous) and short-term peak (intermittent) emission rates from the Process Flare and the Storage Flare estimated by Hatch are presented in Table 3, see also Appendix A. Emission estimates were developed for nitrogen oxides (NO<sub>x</sub>), ammonia (NH<sub>3</sub>), and carbon monoxide (CO). Due to the negligible amounts of sulfur in the type of fuels considered for pilots (hydrogen and/or commercially available propane), sulfur dioxide emissions were assumed to be negligible and are not evaluated in this study. Particulate matter (PM) emissions are estimated by Ramboll using the US EPA AP-42 emission factor for landfill flares.<sup>6</sup>

<sup>6</sup> USEPA (1998). Municipal Solid Waste Landfills, AP-42 Chapter 2.4., Tables 2.4-4 and 2.4-5. Available at: <https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf>

Table 3. Estimated Emission Rates for the Flares<sup>1,2</sup>

Process Flare						
Contaminant	Continuous		Intermittent		Continuous + Intermittent	
	tonne/yr	kg/hr	tonne/yr	kg/hr	tonne/yr	kg/hr
NH <sub>3</sub>	2.4	0.28	0.093	93	2.5	93
C <sub>3</sub> H <sub>8</sub>	1.3	0.15	0.0	0.0	1.3	0.15
NO <sub>x</sub>	1.2	0.13	0.031	31	1.2	31
CO	3.8	0.43	0.053	53	3.8	53
PM	0.025	0.0029	0.0	0.0	0.025	0.0029
Storage Flare						
Contaminant	Continuous		Intermittent		Continuous + Intermittent	
	tonne/yr	kg/hr	tonne/yr	kg/hr	tonne/yr	kg/hr
NH <sub>3</sub>	0.0	0.0	0.060	60	0.060	60
C <sub>3</sub> H <sub>8</sub>	1.2	0.16	0.0	0.0	1.4	0.16
NO <sub>x</sub>	0.20	0.02	0.017	17	0.22	17
CO	1.4	0.16	0.013	13	1.4	14
PM	0.025	0.0029	0.0	0.0	0.025	0.0029
Total Emissions						
Contaminant	Continuous		Intermittent		Continuous + Intermittent	
	tonne/yr	kg/hr	tonne/yr	kg/hr	tonne/yr	kg/hr
NH <sub>3</sub>	2.4	0.28	0.15	153	2.6	153
C <sub>3</sub> H <sub>8</sub>	2.7	0.31	0.0	0.0	2.7	0.31
NO <sub>x</sub>	1.4	0.15	0.048	48	1.4	48
CO	5.2	0.60	0.066	66	5.3	67
PM	0.051	0.0058	0.0	0.0	0.051	0.0058

<sup>1</sup> Adapted from Hutch Report, Table 2-3 and Table 2-6 (see Appendix A)  
<sup>2</sup> Propane emissions were not modelled, they were used to estimate ozone increment.

## 2.2 Dispersion Modelling

Screening analysis was carried out using the SCREEN3 model developed by US EPA.<sup>7</sup> The model is approved for regulatory modelling in numerous jurisdictions in the USA and in Canada including in Ontario.<sup>8</sup> The model can predict downwind short-term concentrations (1-hr average) from a single source for a range of wind speeds and stability classes. SCREEN3 can model only one emission source at a time and the two flares were modelled individually. Their individual modelled impacts are then superimposed by summing results in a conservative manner, assuming that the intermittent releases from both flares occur simultaneously, that is in the same day and in the same hour.

### 2.2.1 Modelled Source Parameters and Emission Rates

The final feasibility flare studies have not been completed and flare parameters (flare stack height and burner design load) are estimated based on the preliminary and conservative assumptions that Process Flare is 70 feet high and Storage Flare is 30 feet height. In SCREEN3 flares stacks are characterized by two input parameters which include flare stack height and flare heat load which are used by the model to estimate the effective flare stack height and effective stack diameter.

Both Process Flare and Storage Flare have two modes of operation, continuous and intermittent. During intermittent release when emissions are highest, the heat loads will also be at their maximums, which will result in different dispersion characteristics of the flares relative to those during continuous operations. To account for that variability in emission rates and dispersion characteristics, separate runs were performed for each operating mode (intermittent and continuous). The complete list of SCREEN3 input parameters that were used to model the Process Flare and the Storage Flares are presented in Table 4.

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<sup>7</sup> USEPA (1995). SCREEN3 Model User's Guide, September. Available at:  
<https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/screen3/screen3d.pdf>

<sup>8</sup> MOECC (2017). Air Dispersion Modelling Guideline for Ontario, Version 3.0, February. Available at:  
<https://www.ontario.ca/document/guideline-11-air-dispersion-modelling-guideline-ontario-0>

Table 4. Modelled Source Parameters and Emission Rates

Emissions	Flare Stack Height <sup>1</sup> (m)	Total Heat release Rate (cal/s)	NO <sub>x</sub> (g/s)	NH <sub>3</sub> (g/s)	CO (g/s)	PM <sup>2</sup> (g/s)
Scenario						
Process Flare						
Intermittent	21.3	5.90E+7	8.61	25.9	14.6	0
Continuous	21.3	1.32E+5	3.65E-2	7.68E-2	0.120	8.04E-4
Storage Flare						
Intermittent	9.14	3.79E+6	4.72	16.7	3.73	0
Continuous	9.14	4.63E+4	6.35E-3	0	4.53E-2	8.04E-4
<sup>1</sup> Minimum stack height of 70 feet for the Process Flare and 30 feet for the Storage Flare provided by Strum. <sup>2</sup> Particulate Matter is assumed to be associated only with hydrocarbons which are assumed not to be present in significant amounts in the intermittent release.						

Estimated NO<sub>x</sub> emissions were modelled conservatively, assuming all NO<sub>x</sub> was released as NO<sub>2</sub> although NO<sub>2</sub>/NO<sub>x</sub> in-stack ratio for these type of combustion sources is expected to be considerably lower than 1.

Ozone is a secondary pollutant which is formed in ambient air in the presence of Non-methane Organic Volatile Compounds (NMVOC) and Nitrogen Oxides (NO<sub>x</sub>) precursors. As such ozone concentrations cannot be modelled using SCREEN3 nor more complex regulatory models such as AERMOD. Ozone concentrations due to the Project were estimated using the U.S. EPA NMOC/NO<sub>x</sub> Point Source Screening Tables<sup>9</sup> where NMOC stands for Non-methane Organic Carbon. In this study, propane is assumed to be the only NMOC species emitted. The screening procedure is used to calculate ozone increment (increase in ozone concentration above an ambient background value) as a function of long-term NMOC emissions and NMOC/NO<sub>x</sub> emission ratios.

### 2.2.2 Source and Building Layout

Figures showing the Project site layout including the extent of the property boundary, the building layout and the preliminary Process Flare and Storage Flare locations within the site are provided in Appendix B.<sup>10</sup> SCREEN3 can incorporate building downwash effect from a single structure for a simple building geometry and the scenario where the stack is located on the building.

<sup>9</sup> U.S. EPA (1988). VOC/NO<sub>x</sub> Point Source Screening Tables by Richard D. Scheffe.

<sup>10</sup> The site layout figures were prepared and provided by Strum.

Both flares will be stand-alone stacks however the proposed location of the Process Flare stack will be within the zone of influence of the Hydrogen (Processing) Plant.<sup>11,12, 13</sup> The building downwash option was therefore used in the modelling of Process Flare and as such it represents a conservative application since the simplified treatment of building downwash by SCREEN3 assumes the stack is located on the building. The Storage Flare is outside of the zone of influence of the Hydrogen Plant and other structures considered in the area therefore the building downwash option was not used for this stack.

Table 5 shows the dimensions of the Hydrogen Plant building that were used as inputs in the modelling of the Process Flare stack.

Table 5. Building Parameters used in the Screening of the Process Flare Stack<sup>1</sup>

Building	Building Height (m)	Minimum Horizontal Building Dimension (m)	Maximum Horizontal Building Dimension (m)
Hydrogen Plant	25.2	223	246
<sup>1</sup> Building dimensions provided by Strum <sup>2</sup> According to the preliminary site layout shown in Attachment B the Process Flare Stack is 121m from the Hydrogen Plant building which is within the zone of influence of the structure building downwash. SCREEN3 building downwash modelling option applied to the flare stack is a conservative representation since it assumes the stack is on the building.			

### 2.2.3 Terrain and Modelled Receptor Distances

SCREEN3 allows consideration of elevated and complex terrain scenarios where “elevated” refers to the situation where terrain elevations exceed stack base elevation, and “complex” terrain refers to the scenario where terrain elevations exceed the stack height. The Project site includes some elevated terrain features which extend further east and south-east off-site as shown in the terrain elevation map in Appendix C.

Some of the off-site formations are higher than the Storage Flare stack height which warrants the use of complex terrain and elevated options for that source, depending on the distance. With respect to the Process Flare the terrain is characterized as elevated. Due to varying nature of the terrain around the facility the flares were modelled for all applicable terrain scenarios (complex, simple elevated, flat) and the results presented in this assessment represent the maximum predicted concentrations for all modelled terrain scenarios.

Concentrations were modelled at a range of distances from the source, between the ambient distance (closest distance of the source to the property boundary) up to 5,000 meters from the

<sup>11</sup> A building or structure influence zone represents wind direction-specific distance from the building within which building wake effects are assumed to occur and is estimated as a function of the building dimensions and projections relative to incoming wind front

<sup>12</sup> U.S. EPA (1985). Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations). Available at: <https://www.epa.gov/sites/default/files/2020-09/documents/gep.pdf>

<sup>13</sup> U.S. EPA (1995). User's Guide to the Building Profile Input Program. Available at: <https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/bpip/bpipd.pdf>

source. Ambient distance of the Process Flare and the Storage Flare is 329 m and 240 m, respectively as shown in the source layout figures in Appendix B. The maximum distance of 5,000 m was set to be sufficiently large to find the maximum between the Facility property boundary and the closest residential receptors around the site which are located approximately between 2,500 m and 5,000 m from the site as shown in the figure in Appendix D.

For comparison with the Schedule A Maximum Permissible Ground Level Concentrations Limits, concentrations at all distances were modelled at ground level (0 m flagpole). The final modelled concentrations to be compared with Schedule A limits represent the maximum concentrations predicted within the entire modelled receptor grid.

#### 2.2.4 Meteorological Data and Dispersion Options

SCREEN3 uses screening meteorological data with a range of stability classes and wind speeds to identify the worst-case meteorological conditions resulting in highest ground level concentrations. The modelling was conducted using the rural option. SCREEN3 allows evaluation of the fumigation phenomenon that may occur at or near the shore of an ocean or large water bodies. The option was not used since Ontario MOECP dispersion modelling guidance recommends that fumigation option be used only for stacks taller than 50 meters<sup>14</sup>

#### 2.2.5 Modelling of Averaging Periods Longer than One Hour

SCREEN3 model predicts worst-case 1-hr average concentrations.<sup>15</sup> Maximum concentrations for longer periods such as 8-hour, 24-hour, and annual averaging periods are estimated by multiplying the predicted maximum 1-hour concentrations by conversion factors presented in Table 6. These empirical factors account for the variation in meteorological conditions such wind speed and stability over longer periods. Individual contaminants were modelled using averaging periods consistent with those stated in Schedule A of the regulation.

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<sup>14</sup> MOECC (2017). Air Dispersion Modelling Guideline for Ontario, pp. 57-58. Available at: [https://files.ontario.ca/admgo-id50\\_aoda\\_v2b.pdf](https://files.ontario.ca/admgo-id50_aoda_v2b.pdf).

<sup>15</sup> SCREEN3 can also predict 24-hour concentrations for complex terrain scenarios only. SCREEN3 Model User's Guide, p. 44.

Table 6. SCREEN3 Conversion Factors to Estimate “worst-case” concentrations for longer averaging periods<sup>16,17</sup>

Averaging Period	Multiplier
8-hour	0.7
24-hour	0.4
Annual	0.08

### 2.2.6 Treatment of Varying Source Parameters

Since different emission modes (intermittent and continuous) are associated with different emission rates and flare dispersion parameters, the maximum 1-hour concentrations for the two modes of operation are modelled separately. These concentrations represent the “worst-case” 1-hour average concentrations for the respective scenarios. The “worst-case” concentrations estimated on 1-hour basis will be obviously associated with the intermittent release events. The “worst-case” concentrations estimated for longer averaging periods such as 24-hour and annual bases are functions of both intermittent and continuous operations, given that intermittent releases are assumed to last at most one hour per year. To estimate the “worst-case” 24-hour concentration, 1-hour concentrations for the intermittent and continuous scenarios were first weight-averaged to account for the relative duration of each operation mode in the longer averaging period.<sup>18</sup> The weight-averaged concentration is then converted to the worst-case 24-hour concentration using factors from Table 6.

### 2.2.7 Estimating Total Combined Impact from Two Sources

SCREEN3 can only model individual sources. To estimate the total combined impact from the Process Flare and Storage Flare, their respective worst-case 1-hour, 8-hour, 24-hour, and annual concentrations are added assuming that the maximum impacts from the two sources occur at the same time and at the same location. This results in a conservative estimate of combined emissions for both sources.

## 3. Modelling Results

The maximum predicted concentrations for 1-hour, 8-hour, 24-hour, and annual average period are presented in Table 7 and compared with the applicable Schedule A limits.<sup>19</sup> The predicted concentrations for all contaminants are well below the permissible limits with 1-hour NO<sub>x</sub> having the highest percent of the limit at 18%. The predicted maximum 1-hour NO<sub>x</sub> concentration is representative of the upset conditions occurring simultaneously at the Processing Plant and the Ammonia Storage Area. The maximum predicted 24-hour NH<sub>3</sub> concentration at 9% of the limit

<sup>16</sup> USEPA (2021). AERSCREEN User’s Guide, p. 3. Available at:

[https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/aerscreen/aerscreen\\_userguide.pdf](https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/aerscreen/aerscreen_userguide.pdf)

<sup>17</sup> MOECC (2017). Air Dispersion Modelling Guideline for Ontario, Section 4.4. Available at: [https://files.ontario.ca/admgo-id50\\_aoda\\_v2b.pdf](https://files.ontario.ca/admgo-id50_aoda_v2b.pdf)

<sup>18</sup> In addition to Schedule A limits the summary table includes Ontario Ambient Air Quality Criteria for NH<sub>3</sub> and PM<sub>2.5</sub>.

<sup>19</sup> SCREEN3 can also predict 24-hour concentrations for complex terrain scenarios only. USEPA (1995). SCREEN3 Model User’s Guide, September. p. 44.

is based on the same assumption, that the Process Plant and the Ammonia Storage Area upsets occurred on the same day.

Table 7. Summary of Modelled Concentrations

Contaminant	Averaging Period	Schedule A Maximum Permissible Ground Level Concentration ( $\mu\text{g}/\text{m}^3$ )	Maximum Modelled Concentration ( $\mu\text{g}/\text{m}^3$ )	Percent of Limit
Carbon Monoxide (CO)	1 hour	34600	121	0.35%
	8 hours	12700	36	0.28%
Nitrogen Dioxide (NO <sub>2</sub> )	1 hour	400	73	18%
	Annual	100	0.76	0.76%
Ammonia (NH <sub>3</sub> ) <sup>1</sup>	24 hours	100	9.1	9.1%
Ozone (O <sub>3</sub> )	1 hour	160	(i)	(i)
Total Suspended Particulate (TSP)	24 hours	120	0.20	0.17%
	Annual	70*	0.040	0.057%
Particulate Matter Fine Fraction (PM <sub>2.5</sub> ) <sup>1</sup>	24 hours	27	0.20	0.74%
	Annual	8.8	0.040	0.45%

<sup>1</sup> Ontario Ambient Air Quality Criteria. Available at <https://www.ontario.ca/page/ontarios-ambient-air-quality-criteria>  
\* Based on geometric mean  
(i) Insignificant. Estimated Project NMOC emissions at 3 tons/year (short tons per year) are significantly below the minimum screening threshold of 50 tons/year therefore the estimated ozone increment is considered insignificant. For reference, for a hypothetical facility at the minimum screening level, that is with NMOC emissions of 50 tons/year (nearly 16 times that of estimated for the Project) and NMOC/NO<sub>x</sub> ratio of 1.9 (the same ratio as estimated for the Project) the screening ozone increment would have been 11  $\mu\text{g}/\text{m}^3$  or 7% of the Schedule A limit. Total Project NMOC emissions are assumed to be equal to total NMVOC or the propane emissions from flare pilots.

Note that the predicted concentrations are due to the Process Flare and Storage Flare emissions only, they do not account for the potential contribution from other existing sources of emissions at the Project site. The predicted concentrations also do not include the contribution of the ambient background. Background concentrations for some of the contaminants can be estimated using monitoring data from the Port Hawkesbury Airport located approximately 10 kilometres north west from the Project site presented in Appendix E. Data from the most recent five-year period show that 1-hour O<sub>3</sub> background concentration of approximately 134  $\mu\text{g}/\text{m}^3$  is at the highest present (84%) of the Schedule A limit of 160  $\mu\text{g}/\text{m}^3$ . It is followed by 1-hour NO<sub>2</sub> which is at 28% of its limit of 400  $\mu\text{g}/\text{m}^3$ . The maximum predicted concentrations presented in Table 7 suggest that under the operating scenarios considered the Project alone or cumulatively is not expected to contribute to the exceedance of the applicable Schedule A limits.

#### 4. Conclusions

The assessment indicates that even with the conservative approach the predicted impacts due to the Project sources will be well below applicable limits in Schedule A. Of the parameters modelled 1-hour NO<sub>x</sub> was at the highest percent of the limit (18%) assuming the intermittent release occurs simultaneously at the Processing Plant and the Ammonia Storage Area. The longer averaging periods are more indicative of continuous operations with the maximum percent of limit less than 10% for NH<sub>3</sub> and less than 1% for all other modelled contaminants. It should be underlined that this evaluation is based on conceptual-level engineering and screening level assessment, and it should be revisited in the future as the Project emissions and source configurations become better defined.

APPENDIX A  
FLARE LOADS AND EMISSION RATE ESTIMATES

Estimated mass load into process flare (Hatch Report, Table 2-2)

Description	Plant Source	Temperature	Mass Flow	Component (mol%) and Molecular Weight (kg/kmol)						
				N <sub>2</sub>	Ar	H <sub>2</sub>	NH <sub>3</sub>	H <sub>2</sub> O	C <sub>3</sub> H <sub>8</sub>	
		°C	kg/hr	28.014	39.948	2.016	17.031	18.016	44.097	
Continuous Loads	Continuous purge	Nitrogen system	20	34.6	100.00%					
	LP Off-gas	Ammonia synloop inert purge	6.9	25	18.36%	1.19%	32.89%	47.56%		
	Compressor Dry Gas Seals	Synloop compressors	30	37	24.97%		74.85%	0.18%		
	Pilots (Hydrogen)	Flare pilot	N/A	2.8			100.00%			
	Pilots (Propane)	Flare pilot	N/A	7.8						100.00%
Intermittent Loads	103-J Suction Vent		30	25,266	24.97%		74.85%	0.18%		
	105-J Final Stage PSV		88	18,554	0.03%		0.05%	99.92%		

Estimated mass load into storage flare (Hatch Report, Table 2-4)

Description	Plant Source	Temperature	Mass Flow	Component (mol%) and Molecular Weight (kg/kmol)						
				N <sub>2</sub>	Ar	H <sub>2</sub>	NH <sub>3</sub>	H <sub>2</sub> O	C <sub>3</sub> H <sub>8</sub>	
		°C	kg/hr	28.014	39.948	2.016	17.031	18.016	44.097	
Continuous Loads	Continuous purge	Nitrogen system	20	5	100.00%					
	Pilots (Hydrogen)	Flare pilot	N/A	2.8			100.00%			
	Pilots (Propane)	Flare pilot	N/A	7.8						100.00%
Intermittent Loads	Ammonia Vaporization	Storage Tanks	33.4	3,000				100.00%		

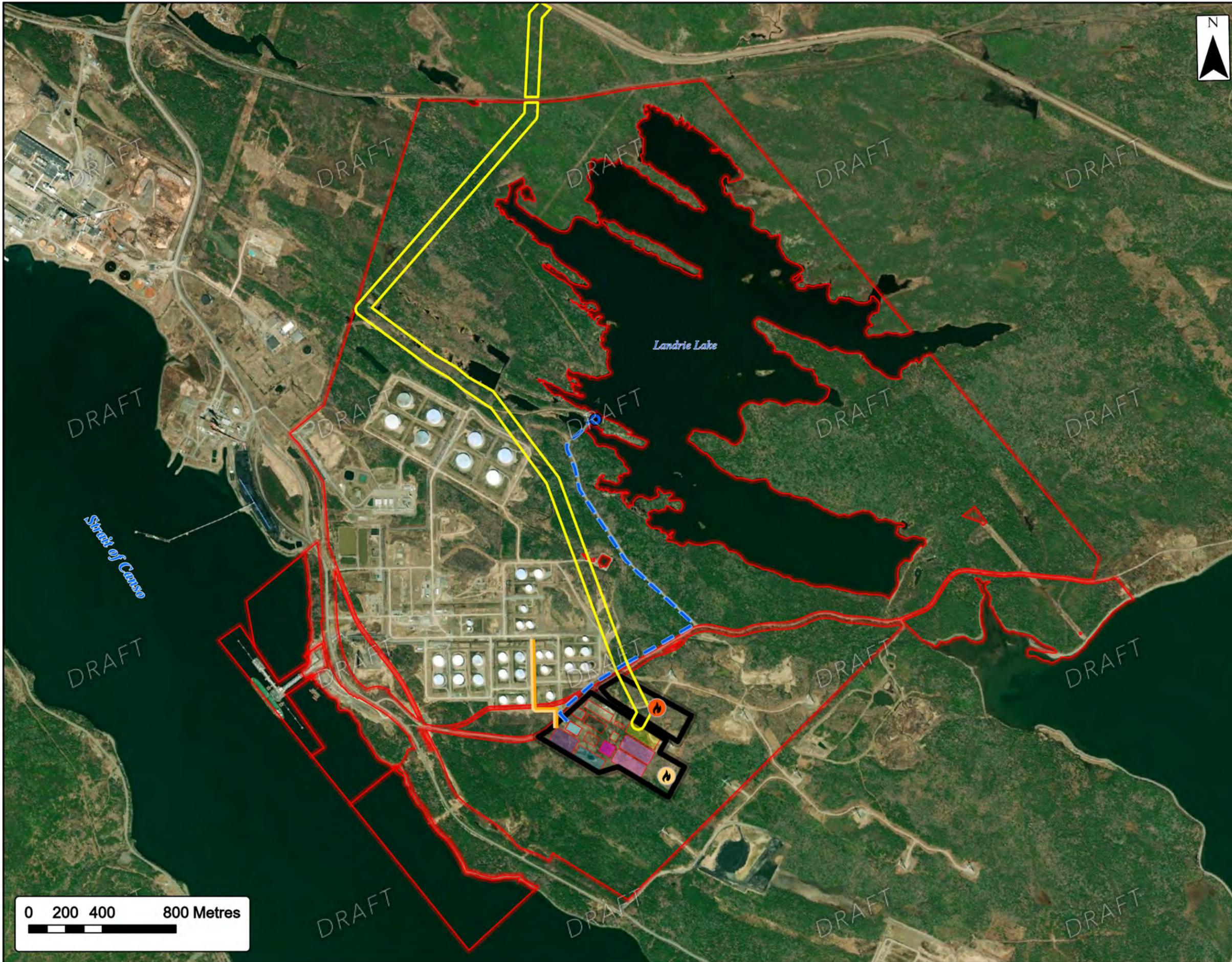
Estimated Emission Rates for Process Flare (Hatch Report, Table 2-3)

Emissions	Continuous emission	(Continuous emission) + (intermittent emission)	(Continuous emission) + (15-minute intermittent emission)
	tonne/yr	kg/min	tonne/yr
H <sub>2</sub>	1.78	1.493	1.80
NH <sub>3</sub>	2.42	6.216	2.52
C <sub>3</sub> H <sub>8</sub>	1.32	0.003	1.32
NO <sub>x</sub>	1.15	2.069	1.18
CO	3.79	3.512	3.85
CO <sub>2</sub>	198.39	0.388	198.39
CH <sub>4</sub>	0.00	0.000	0.00
N <sub>2</sub> O	0.01	0.000	0.01

Estimated Emission Rates for Storage Flare (Hatch Report, Table 2-6)

Emissions	Continuous emission	(Continuous emission) + (intermittent emission)
	tonne/yr	kg/min
H <sub>2</sub>	0.48	0.001
NH <sub>3</sub>	0.00	1.000
C <sub>3</sub> H <sub>8</sub>	1.36	0.003
NO <sub>x</sub>	0.20	0.283
CO	1.43	0.226
CO <sub>2</sub>	203.98	0.388
CH <sub>4</sub>	0.00	0.000
N <sub>2</sub> O	0.01	0.000

APPENDIX B  
SITE LAYOUT AND SOURCE LOCATION



# Industrial Facility

Overview of Components

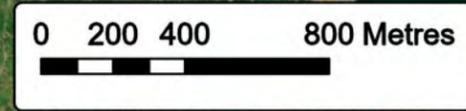


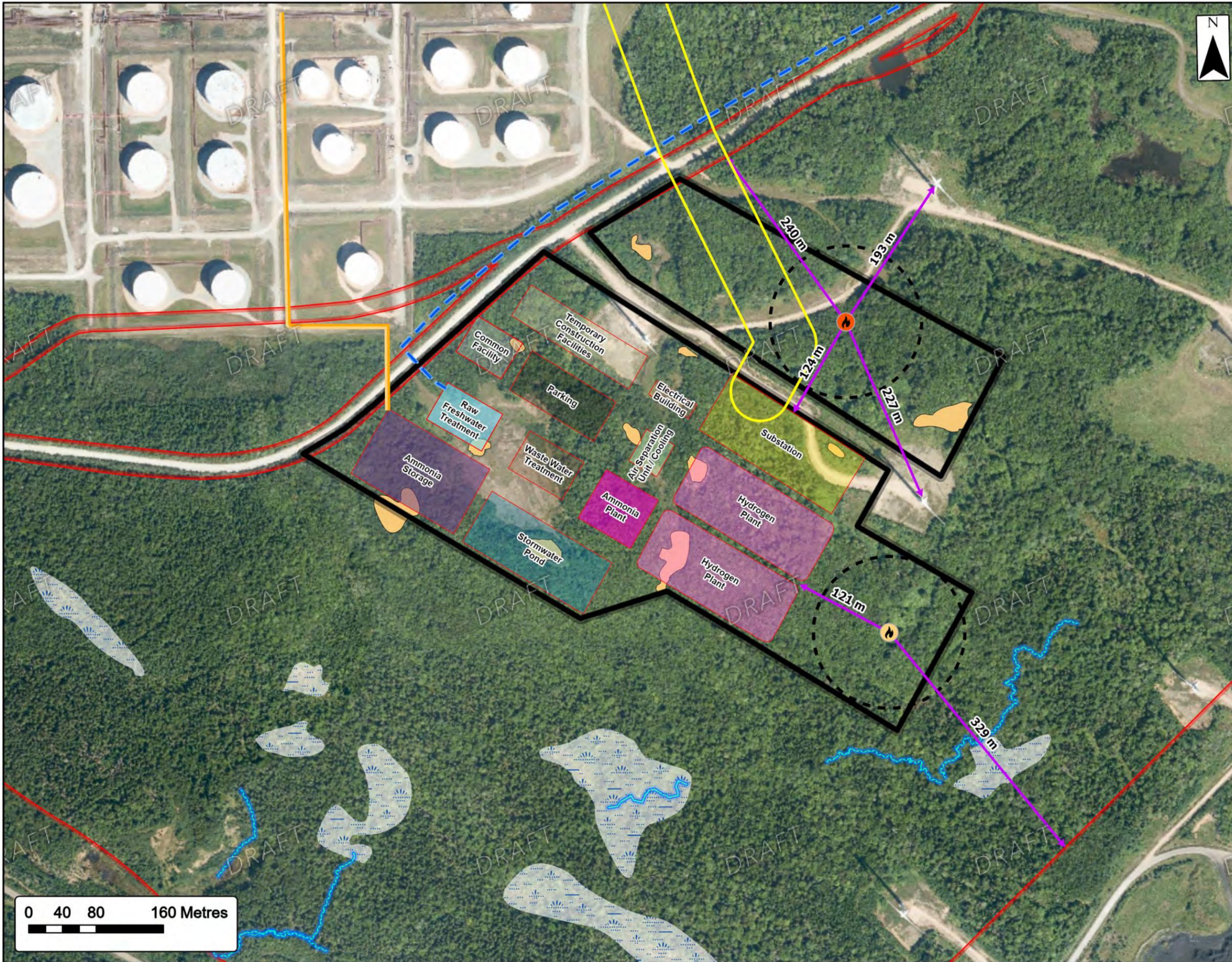
- LLWU Pump Station
- Storage Flare
- Process Flare
- Approx. Pipeline
- Raw Freshwater Pipeline
- Everwind Fuels Property
- Transmission Interconnection Line
- Approximate Facility and Laydown Area



Coordinate System: [NAD83 UTM Zone 20E] Sources: ESRI Basemaps, GeolNOVA, 1:50,000, HERE, Garmin, USGS, IIRCan

Date:	Nov 2022	Project #:	22-8516
Scale:	1:20,000	Drawing #:	<b>1</b>
Drawn By:	P. Opra		
Checked By:	F. Gascon		





# Industrial Facility

Overview of Components and Measurements

- Surveyed Watercourse
- Surveyed Wetland
- Human Influenced Drainage Feature
- Facility Components**
- Storage Flare
- Process Flare
- Approx. Pipeline
- Raw Freshwater Pipeline
- Everwind Fuels Property
- Transmission Interconnection Line
- Approximate Facility and Laydown Area
- Flare Buffer Diameter (180 m)

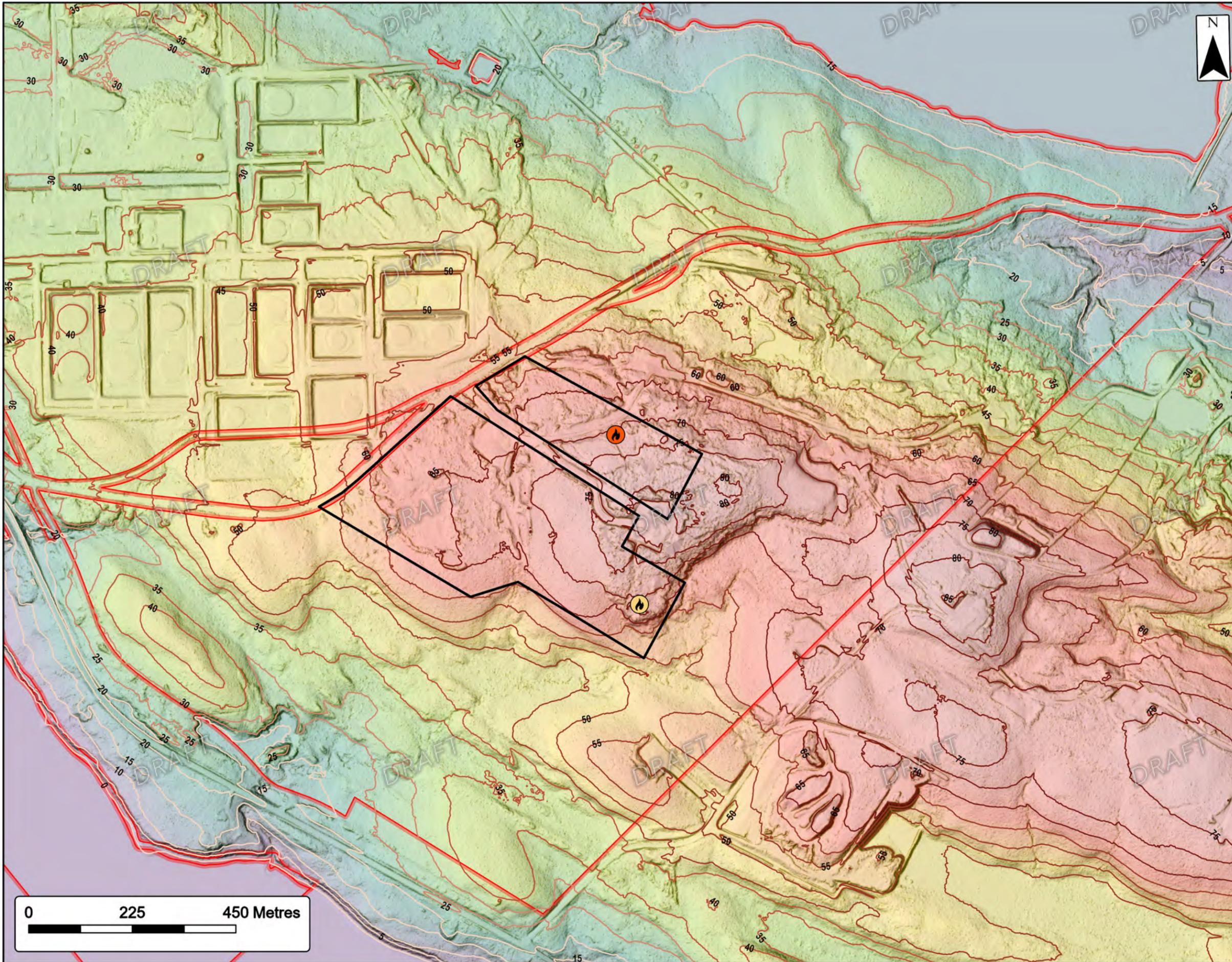


Coordinate System: IAD83 UTM Zone 20E Sources: ESRI Basemaps, GeolNOVA, 1:50,000, HERE, Garmin, USGS, IIRCan

Date:	Nov 2022	Project #:	22-8516
Scale:	1:4,375	Drawing #:	<b>1</b>
Drawn By:	P. Opra		
Checked By:	F. Gascon		

Engineering - Surveying - Environmental  
Bedford - Antigonish - Moncton - St. John's

APPENDIX C  
SITE TOPOGRAPHIC MAP



# Industrial Facility

Overview of Topography



### Facility Components

- Storage Flare
- Process Flare
- Everwind Fuels Property
- Approximate Facility and Laydown Area

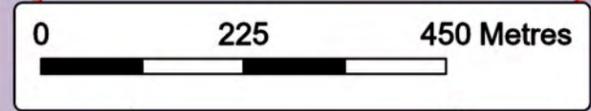


Coordinate System: IAD83 UTM Zone 20E Sources: ESRI Basemaps, GeolNOVA, 1:50,000, HERE, Garmin, USGS, IIRCan

Date:	Nov 2022	Project #:	22-8516
Scale:	1:8,000	Drawing #:	<b>1</b>
Drawn By:	P. Opra		
Checked By:	F. Gascon		



Engineering - Surveying - Environmental  
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APPENDIX D  
LOCATION OF CLOSEST RESIDENCES



**Industrial Facility**  
Proximity Analysis



- Industrial Facility
- Potential Residential Buildings
- Potential Commercial Buildings
- Distance Marker to Potential Residential Building
- 5 km Buffer from Industrial Facility Centroid



Coordinate System: IAD83 UTM Zone 20E Sources: ESRI Basemaps, GeolNOVA, 1:50,000, HERE, Garmin, USGS, IIRCan

Date:	Nov 2022	Project #:	22-8516
Scale:	1:40,000	Drawing #:	<b>1</b>
Drawn By:	P. Opra		
Checked By:	N. Myers		



Engineering - Surveying - Environmental  
Bedford - Antigonish - Moncton - St. John's



APPENDIX E  
AMBIENT CONCENTRATIONS AT PORT HAWKESBURY AIRPORT

Ambient concentrations measured at Port Hawkesbury Airport between 2017 and 2021

Parameter	Averaging Period	O <sub>3</sub> (µg/m <sup>3</sup> )	SO <sub>2</sub> (µg/m <sup>3</sup> )	NO <sub>x</sub> (µg/m <sup>3</sup> )	NO (µg/m <sup>3</sup> )	NO <sub>2</sub> (µg/m <sup>3</sup> )	PM <sub>2.5</sub> (µg/m <sup>3</sup> )
<b>Port Hawkesbury Ambient Monitoring 2017-2021</b>	1 hour	134	160	289	116	111	64.0
	24 hours	93.8	39.3	94.0	31.0	46.3	21.8
	Annual	58.1	1.8	7.7	1.7	5.1	5.5
<b>NS AQS Schedule A (Ontario AAQC)</b>	1 hour	160	900	-	-	400	-
	24 hours	-	300	-	-	(200)	(27)
	Annual	-	60	-	-	100	(8.8)
<b>Percent of: NS AQS (Ontario AAQC)</b>	1 hour	84%	18%	-	-	28%	-
	24 hours	-	13%	-	-	(23%)	(81%)
	Annual	-	3%	-	-	5%	(63%)

APPENDIX R  
HATCH FLARE MEMO

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**EverWind Fuels**  
**Point Tupper Green Ammonia Project Phase 1**  
**Preliminary Flare Load and Emissions Estimate**

2022-10-06	B	Client Review	Jeff Eastick	Mark Tempel Lukito Lau	Michel Carreau	N/A
<b>Date</b>	<b>Rev.</b>	<b>Status</b>	<b>Prepared By</b>	<b>Checked By</b>	<b>Approved By</b>	<b>Approved By</b>
<b>HATCH</b>						<b>Client</b>

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## 1. Introduction

### 1.1 Purpose and Objective

The objective of this memo is to provide EverWind Fuels with technical information requested to support the Environmental Assessment (EA) submission by Strum Consulting (“Strum”) for Phase 1.

The status and maturity of the information provided herein is still based upon conceptual FEL1 level engineering and requires future refinement through further project development and engineering study.

## 2. Flares and Flare Emissions Estimate

### 2.1 Methodology

Flare systems (“flares”) will be required to mitigate/prevent/disperse releases of hazardous off-gases from the ammonia production and storage areas. During the FEL1 study, the ammonia plant technology licensor/vendor, KBR, included the requirement for two (2) flares in the plant design: one (1) flare for the ammonia process plant (the “process flare”) and one (1) flare at the ammonia storage tank (the “storage flare”). During the FEL2 study, and upon completion of additional engineering and review of the flare loads from process equipment in greater detail, it may be shown to be feasible to combine the flares into one flare for cost saving purposes, however, the economic trade-off nor technical feasibility of this approach has not been conducted. For the purposes of this memo, the two flares are considered.

The following sections of this memo describe preliminary flare loads and emissions estimates for the EverWind Fuels Phase 1 process plant to provide an indicative “first pass” of air emissions. These values are estimates and shall not be considered final, nor bounding upper limits for emissions from the flare stacks.

Flare loads have been determined based on a combination of the vendor process design information available at this stage among other assumptions, described in the following sections. Emissions estimates at this time are calculated based on the methodologies described below, subject to further direction and guidance from local regulating authorities in future phases of engineering. It should be noted that the methodology below is for the purposes of evaluating emissions in the context of local air quality, not greenhouse gas (GHG) reporting. For GHG reporting, the relevant local regulations from Climate Change Nova Scotia should be utilized in future project phases. The calculation methodology is as follows:

1. Each flare load is defined and tabulated by mass flow (kg/hr) and mol% ratios of the flow components (equivalent to vol%) (see Table 2-2 and Table 2-4).
2. Mass flow for each individual component is calculated based on total mass flow and mol% ratios.

3. Residual emissions of non-inerts (ammonia, hydrogen, propane) are calculated assuming a destruction efficiency of 98% (Texas Commission on Environmental Quality (TCEQ), 2021)
4. Thermal NOx emissions are calculated based on a thermal NOx emission factor of 0.068 lb/MMBTU and higher heating value (HHV) of all combustible components, as per (US EPA, 1995). If flare flame temperatures are determined to be low in future phases of engineering, actual NOx emissions may be lower than stated, however, this emission factor is applied for the purposes of this estimate.
5. Fuel NOx emissions from combustion of ammonia are calculated on a mass basis of 0.5% kgNOx/kgNH<sub>3</sub> as per (Texas Commission on Environmental Quality (TCEQ), 2021).
6. CO emissions are calculated based on emission factor of 0.5496 lb/MMBTU and lower heating value (LHV) of all combustible components, as per (Texas Commission on Environmental Quality (TCEQ), 2021).
7. CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions from propane combustion are calculated based on the HHV of propane, and stationary combustion emission factors of 59.66 kgCO<sub>2</sub>/GJ, 0.948 gCH<sub>4</sub>/GJ, and 4.267 gN<sub>2</sub>O/GJ (Government of Nova Scotia, Nova Scotia Environment, 2018). Note that this N<sub>2</sub>O emissions estimate will overlap with the NOx emissions and could be considered double counting, however, this conservative approach is applied for now.

Standard reference conditions used in calculations are defined as IUPAC STP: 0°C, 100 kPa. The HHV and LHV values used in calculation are summarized in Table 2-1 on a mass basis.

**Table 2-1 - Heating Values**

Component	LHV (MJ/kg)	HHV (MJ/kg)
Hydrogen	119.96	141.80
Ammonia	18.90	22.50
Propane	46.35	50.35

## 2.2 Fuel Gases

To ensure combustion of the off-gas that exits a flare stack, pilot burners are installed around the circumference of the flare tip. A continuous flow of fuel gas is provided to the pilots which self-aspirate to produce the continuous pilot flame. The fuel gas selected can depend on the application. Natural gas (or LNG), propane, butane, and hydrogen are examples potential fuel gases that could be used and evaluated in the next phase of study.

The fuel gas selected for flare stack pilots at The Point Tupper Green Ammonia Project should consider the following:

- Hydrogen will be continuously produced and compressed to 7 bar(g) by the hydrogen plant which could be made available for pilot flare fuel, depending on plant operating philosophy.

- There is no existing natural gas utility or infrastructure at the site property.
- There is an existing butane storage sphere at site which could potentially offer a supply of butane fuel.
- Use of propane would require a local storage tank/farm and regular delivery of propane from a local supplier.
- The following items will result in carbon or other GHG emissions sources that may require offset mechanisms to achieve true corporate or product carbon neutrality. Depending on legislated or certification requirements concerning carbon intensity of the final green ammonia product, these may or may not be material considerations in project decision making:
  - o Use of hydrocarbon fuels will result in carbon emissions and NOx emissions, depending on flame temperature.
  - o The combustion of all fuel gases including hydrogen will likely result in thermal NOx emissions, depending on flame temperature.
  - o Combustion of ammonia will result in both thermal NOx (depending on flame temperature) and fuel NOx emissions.

For the purposes of this preliminary emissions estimates, both hydrogen and propane pilots are conservatively assumed to be in simultaneous continuous service. Propane is assumed instead of butane as Hatch is unsure whether the butane stored on site is available for project use. During actual plant operation, only one set of pilots should operate on a continuous basis, and therefore the continuous emissions estimates presented in this document should be conservative.

## 2.3 Process Flare

### 2.3.1 Loads

The process flare would be located adjacent to the ammonia plant. The purpose of the process flare is to combust/destroy any harmful off-gases from the ammonia plant. The loads expected to be served by the process flare are summarized in Table 2-2, and are described in further detail below.

**Table 2-2 - Process Flare Load Estimate (Pre-Combustion)**

	Description	Plant Source	Temperature °C	Mass Flow kg/hr	Component (mol%) and Molecular Weight (kg/kmol)					
					N2 28.014	Ar 39.948	H2 2.016	NH3 17.031	H2O 18.016	C3H8 44.097
Continuous Loads	Continuous purge	Nitrogen system	20.0	34.6	100.00%					
	LP Off-gas	Ammonia synloop inert purge	6.9	25.0	18.36%	1.19%	32.89%	47.56%		
	Compressor Dry Gas Seals	Synloop compressors	30.0	37.0	24.97%		74.85%	0.18%		
	Pilots (Hydrogen)	Flare pilot	N/A	2.8			100.00%			
	Pilots (Propane)	Flare pilot	N/A	7.8						100.00%
Intermittent Loads	103-J Suction Vent		30.0	25,266.0	24.97%		74.85%	0.18%		
	105-J Final Stage PSV		88.0	18,554.0	0.03%		0.05%	99.92%		

1. **Low Pressure (LP) Off-gas** – The Haber-Bosch ammonia synthesis process employed by the ammonia plant involves a recirculating ammonia synthesis loop, whereby unconverted syngas is recycled from the condensing system back to the syngas compressor. With this recirculating loop type system, any inert gas impurities, such as Argon, supplied to the synthesis loop from the hydrogen feedstock plant and air separation unit will accumulate over time if not purged from the system. By purging of inert gases, some volume of ammonia, hydrogen, and nitrogen are also purged from the system. This purge flow is continuous and would be routed to a process vent header and to the flare.
2. **Compressor dry gas seals** - The syngas compressor employs dry gas seals whereby leakage is contained and sent to a process vent header, and subsequently to flare. The composition of this load would be nitrogen and hydrogen at the same %mol composition as the compressed syngas. This flow would be continuous.
3. **PSV/Vent Valve Outlets** – During normal plant operation, no continuous venting or PSV discharge is envisaged. However, KBR states that for the purposes of sizing flare systems, a simultaneous venting of the syngas compressor suction vent (25,266 kg/hr) and ammonia refrigerant compressor final stage PSV discharge (18,554 kg/hr) can be considered (43,820 kg/hr total). The composition of these loads were not explicitly provided by KBR in their effluent/emissions summary, however, are identified by Hatch as follows from KBR's PFD and heat and material balance:
  - a. Syngas compressor suction vent has molar composition of 74.85% hydrogen, 24.97% nitrogen, 0.18% ammonia, based on Stream 1.
  - b. Ammonia refrigerant compressor final stage PSV discharge has molar composition of 0.05% hydrogen, 0.03% nitrogen, 99.92% ammonia, as per Stream 9.

PSV/Vent Valve outlet loads are not continuous, and should only occur in plant upset scenarios. During future engineering activities, other smaller intermittent PSV loads will likely be identified, and should be considered at that time.

### 2.3.2 Emissions

The calculated preliminary emissions summary for the process flare (post-combustion) are summarized in Table 2-3. Continuous loads are reported on a tonne/year basis considering 355 operating days (8520 hours) per year. Intermittent loads are reported on a kg/min basis, and include the continuous load. In the absence of more detailed engineering and vendor information (e.g. the total system volume/inventory during a PSV/vent valve release), the duration and frequency of intermittent releases cannot be estimated or determined with a high degree of confidence, beyond stating that during normal plant operation no PSV discharge is envisaged or expected. KBR has stated that they cannot confirm number of occurrences expected per year. This must be assessed in further detail in the next phases of engineering

in conjunction with KBR and EverWind Fuels plant operations through design reviews, HAZOP, risk assessments, and layer of protection analyses (LOPA).

Hatch suggests for preliminary purposes only, consideration of estimated intermittent loads on a once-per-year frequency for a duration of 15 minutes, as more detailed engineering or operational information has not yet been developed. The plant will at a minimum require blowdown once per year for shut-down maintenance purposes, however, this would be at a controlled rate likely less than the intermittent loads stated. Through process engineering design for safety, LOPA, and safety system design, the PSV/vent release frequencies should be on the order of magnitude of 1/10 or 1/100 year occurrences, pending further study.

**Table 2-3 - Process flare emissions estimate summary**

Emission	Continuous emission	(Continuous emission) + (intermittent emission)	(Continuous emission) + (15 minute intermittent emission)
	tonne/yr	kg/min	tonne/yr
H2	1.78	1.493	1.80
NH3	2.42	6.216	2.52
C3H8	1.32	0.003	1.32
NOx	1.15	2.069	1.18
CO	3.79	3.512	3.85
CO2	198.39	0.388	198.39
CH4	0.00	0.000	0.00
N2O	0.01	0.000	0.01

Through preliminary consultation with John Zink (flare system supplier), the flare requires minimum 70ft height and 36" diameter with 3 pilot burners and a velocity seal.

## 2.4 Storage Flare

### 2.4.1 Loads

The loads expected to be served by the storage flare are summarized in Table 2-4, and are described in further detail below.

**Table 2-4 – Storage Flare Load Estimate (Pre-Combustion)**

	Description	Plant Source	Temperature	Load Mass Flow	Component (mol%) and Molecular Weight (kg/kmol)					
			°C	kg/hr	N2	Ar	H2	NH3	H2O	C3H8
					28.014	39.948	2.016	17.031	18.016	44.097
Continuous Loads	Continuous purge	Nitrogen system	20.0	5.0	100.00%					
	Pilots (Hydrogen)	Flare pilot (normal)	N/A	2.8			100.00%			
	Pilots (Propane)	Flare pilot (backup)	N/A	7.8						100.00%
Intermittent Loads	Ammonia vaporization	Storage tanks	- 33.4	3,000.0				100.00%		

During normal plant operation, vapours generated within the storage tanks are recycled to the ammonia plant chiller for recondensing. Furthermore, local to the storage tanks, there is a boil-off gas system that performs similar function. In the event that neither of these recondensing systems are in operation, vapours generated within the tank may require flaring. A preliminary estimate of vapour loading to the flare was provided by KBR for (2) x 41,000 m3 tanks at 3,200 kg/hr. The vapour loading was also independently estimated by Hatch for (1) x 50,000 m3 tank based on the conditions/scenarios described below, as the Phase 1 project design basis is for (1) x 50,000 m3 tank. These scenarios are not exhaustive

in determination of the vapour loading rate to the flare, however, serve to provide preliminary indication. During future phases of engineering detailed vent calculations should be calculated in conjunction with the tank vendor/designer (i.e.: as per applicable API standards such as API 2000) considering rates of inflow and outflows, various permutations of concurrent operations, flashing, and risks associated with utility failure (e.g. power, cooling water). Flare loading will also depend on the relative locations between the plants and tanks, length of pipelines, quality of insulation, ambient atmospheric conditions, size of marine cargo vessel, among other factors not considered here.

The current project phase (Phase 1) includes one 50,000 m<sup>3</sup> useable volume double-walled refrigerated storage tank to support up to 600 tNH<sub>3</sub>/day ammonia production. It should be noted that the project vision includes a Phase 2 plant expansion, where up to 100,000 m<sup>3</sup> of total storage volume and an additional 2,400 tNH<sub>3</sub>/day of ammonia production is envisaged by EverWind Fuels. These additional storage tanks and ammonia plants are not included within the scope of Phase 1, however, the engineering and design of the ammonia storage flare system should consider allowance and additional design capacity for the future plant expansion. Consideration of additional loads from Phase 2 may drive an increased boil-off gas system design capacity, increased flare design capacity (if a single common flare is to serve both 50,000 m<sup>3</sup> ammonia tanks), and increased pilot fuel consumption. Alternatively, a second boil-off gas system and flare stack may be developed for the second 50,000 m<sup>3</sup> tank, or the Phase 1 boil-off gas system and flare be replaced with higher capacity equipment to support Phase 2. Loads associated with Phase 2 have not been estimated.

1. Vapour from tank boil off – vapour will be generated within the tank through ambient heat transfer through tank walls and other thermal effects. The boil-off rate due to these effects is estimated based useable tank and loadout line volume, density of saturated liquid ammonia at atmospheric pressure of 99.6 kPa, and an assumed 0.05% mass per day design boil-off rate. Through additional engineering, the tank boil off rate shall be evaluated in further detail considering tank and piping geometry, insulation type, insulation thickness, as per API 2000.

In the event that a second 50,000 m<sup>3</sup> tank is to be developed in Phase 2, this load may approximately double.

2. Vapour displacement and flashing from liquid tank filling with tank at atmospheric pressure – when the ammonia plant product line transfers new liquid to the tank, vapour in the tank will be displaced by the new liquid, and vapour will be generated from flashing of the new liquid upon the decrease in pressure. The ammonia plant outlet produces 25,000 kg/hr ammonia at conditions of -33.4°C and 5 bar(a), which upon entry to the tank will displace vapour and can flash to local atmospheric pressure, 99.6 kPa(a) (0.996 bar(a)). From the ammonia plant outlet to the storage tanks, there will be some ambient heat gain through pipe insulation. Ammonia delivery conditions to the tank considered for flashing calculation is assumed as -28.4°C (a 5°C temperature rise from plant discharge temperature due to ambient heat gain) and 5 bar(a).

It should be noted that in the event that additional 2,400 MTPD of ammonia production is developed in Phase 2, this load would increase approximately linearly with production.

3. Atmospheric pressure change – If the storage tank is at its maximum allowable internal operating pressure and the atmospheric pressure drops rapidly, vapour would be released to prevent an overpressure scenario. The calculation considers vapour release from the tank with nominal volume of 72,000 m<sup>3</sup> (50,000m<sup>3</sup> useable volume) at maximum gauge operating pressure of 300 mmwc and atmospheric pressure drop rate of 2,000 Pa/hr.

In the event that a second 50,000 m<sup>3</sup> useable volume tank is to be developed in Phase 2, this load will approximately double.

Emergency venting due to fire exposure for a double-walled tank is not considered at this time (i.e.: catastrophic emergency scenarios). It is possible that the relief rate from a fire scenario is greater than those of the scenarios above. The calculation of such a value is complex and requires more thorough engineering analysis by the tank designer, and should be evaluated through a quantitative risk assessment (QRA):

*“For a double-wall refrigerated storage tank, the heat input from a fire initially causes the vapors in the space between the walls of a double-wall tank to expand. The heat input also causes the vapors in the roof space of a double-wall tank with suspended-deck insulation to expand; however, it can be several hours before the increased heat input into the stored liquid causes a significantly increased vaporization rate. The venting requirements for handling the increased vaporization can be small compared to the requirements for handling the initial volumetric expansion of the vapors. Because emergency venting for a double-wall refrigerated storage tank is complex, no calculation method is presented here. A thorough analysis of the fire relief for a double-wall refrigerated storage tank, including a review of the structural integrity of unwetted portions of the outer wall, should be conducted.” (API, 2020)*

The flare loads above were calculated using fluid properties of ammonia from AFT Chempak (Version 1.00.1004) database software, and are rounded to the nearest increment of 50 kg/hr. The results of the calculations above are presented in Table 2-5.

**Table 2-5 – Ammonia Vaporization Load Summary**

Condition	Load (kg/hr)
Tank and pipeline boil-off	750
Liquid filling and vapor flashing	500
Ambient pressure drop	1,300
<b>Total</b>	<b>2,550</b>
<b>Consider:</b>	<b>3,000</b>

Based on the calculations above, the preliminary unfactored estimated design flare load to the ammonia storage tank is 2,550 kg/hr, and a rounded 3,000 kg/hr is considered as the

load in the flare emissions calculation. Comparing this figure to the estimated peak load for (2) x 41,000 m<sup>3</sup> tanks from KBR at 3,200 kg/hr, the calculation estimate is considered reasonable and within the correct order of magnitude given the level of current engineering definition. This design load would require simultaneous unavailability of the boil-off gas system (or cooling water system), continued operation of the ammonia production plant, and a rapid ambient pressure drop. Other scenarios including marine cargo vessel loadout, fire or other emergency scenarios must be considered in future phases of engineering once additional information is known.

During normal plant operation, all the vapor loads described in Table 2-5 would be continuously collected and re-condensed by the ammonia plant chiller and boil-off gas system such that no regularly occurring continuous off-gas load should be sent to the storage flare.

## 2.4.2 Emissions

The calculated preliminary emissions summary for the storage flare (post-combustion) are summarized in Table 2-6. Storage flare continuous loads are reported on a tonne/year basis with 365 operating days (8760 hours) per year, and are only due to pilots. Intermittent loads are reported on a kg/min basis, and include the continuous load. The intermittent loads would not be regularly occurring loads. Similar to the process flare, this must be assessed in further detail in the next phases of engineering in conjunction with the storage tank designer and EverWind Fuels plant operations through design reviews, HAZOP, risk assessments, and layer of protection analyses (LOPA). Through process engineering design for safety, LOPA, and safety system design, emergency back-up power systems, the PSV/vent release frequencies should be on the order of magnitude of 1/10 or 1/100 year occurrences, pending further study and QRA.

**Table 2-6 - Storage Flare Emissions Summary**

Emission	Continuous emission	(Continuous emission) + (intermittent emission)
	tonne/yr	kg/min
H <sub>2</sub>	0.48	0.001
NH <sub>3</sub>	0.00	1.000
C <sub>3</sub> H <sub>8</sub>	1.36	0.003
NO <sub>x</sub>	0.20	0.283
CO	1.43	0.226
CO <sub>2</sub>	203.98	0.388
CH <sub>4</sub>	0.00	0.000
N <sub>2</sub> O	0.01	0.000

Through preliminary consultation with John Zink (flare system supplier), the flare requires minimum 30ft height and 14" diameter with 2 pilot burners and a velocity seal.

### 3. Next Steps

The information above is indicative based on FEL1 level engineering and preliminary vendor information. In the next phases of engineering (FEL2 and FEL3) the ammonia process vendor and storage tank designer shall provide a detailed flare summary to support the process flare design. It is recommended to revisit the assumptions made in this memo as the design and operational requirements are matured to ensure they are still valid.

In future engineering phases the preferred fuel (hydrogen, propane or others) for the flare pilots will be finalized which will allow for more accurate emissions estimates.

Once engineering definition is sufficiently mature and P&IDs developed, Hatch, EverWind Fuels, and the vendors (where required) shall perform HAZOP studies and LOPA to quantify the risks and probabilities associated with flare loads and emissions, and determine applicable mitigations if/where necessary.

EverWind Fuels and Strum should evaluate the information provided herein against local legislated environmental and air quality requirements prior to engaging the regulator.

### 4. References

- API. (2020). *API Standard 2000, 7th Edition*. American Petroleum Institute.
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## PROFESSIONAL ASSOCIATIONS

- Environmental Services Association of Nova Scotia (ESANS)
- Canadian Land Reclamation Association (former Board Member)
- Halifax Chamber of Commerce
- OTANS member

## AREAS OF SPECIALIZATION

- Project Management
- Environmental Impact Assessment
- Public and Regulatory Consultation
- Permitting
- Infrastructure Planning and Construction
- Environmental Management System
- Natural Resource Inventories

## EDUCATION

- BSc., McGill University, Montreal (1990)

## TRAINING

- M.Eng. (pending), University of New Brunswick, Fredericton
- CEAA Screening Training
- Contaminated Sites Assessment and Clean-up
- EMS and Project Planning
- Conflict Management and Dispute Resolution
- Project Management Bootcamp, 2007
- ISO 14001 Orientation

## RELEVANT EXPERIENCE

Mr. Duncan is the President of Strum Consulting based in Bedford Nova Scotia. Shawn has also worked for both provincial and federal government departments, as well as having senior environmental experience in the private sector for the oil and gas industry. He has worked professionally in the environmental field throughout Canada and internationally for over 30 years. His areas of specialization include project planning and management, environmental impact assessment, infrastructure planning and construction, public consultation and regulatory support.

## REPRESENTATIVE PROJECTS AND ROLES

### NATURAL RESOURCE INVENTORIES AND SURVEYS:

**Environmental Effects Monitoring Programs, Paper Mills, NB – Project Manager:** Involved in the development, design, and implementation of EEM programs for five pulp mills that were required under federal regulations. These programs were multi-year in scope and involved both freshwater and marine systems.

**Assessment of Downstream Fish Migration, NB – Field Coordinator:** Involved in the study of the downstream migration patterns of juvenile blue-backed herring and alewife on the St. John River.

**Fish Habitat Assessments, NS, NB – Program Manager:** Coordinated a fish habitat assessment program that assessed over 500 watercourses that intersected a proposed pipeline corridor, in support of the EIA and provincial and federal permitting.

**Aerial Moose Survey, NB – Program Manager:** Managed and conducted a provincial aerial winter survey for moose, using helicopter.

**Development of Watershed Management Plan, Keswick River, NB – Program Manager:** Developed a watershed management plan for the Keswick River System in conjunction with the federal Department of Fisheries and Oceans.

**Numerous Fisheries and Aquatic Habitat Surveys, NS, NB – Project Manager:** Coordinated a number of freshwater fisheries and aquatic habitat surveys throughout the Atlantic provinces to provide baseline and monitoring data for a number of projects and developments.

**Identification of Fish Habitat Improvement Opportunities, NB – Project Manager:** Identified particularly beneficial opportunities for fish habitat improvement in New Brunswick, and determined strategies for project implementation.

**Development of Fisheries Management Plans, Recreational Fisheries Developments, NB – Technical Support:** Involved in the preparation of fisheries management plans to provide improved recreational salmonid fishing on private landholdings.

**Tropical Ecology, Bellairs Institute, Barbados – Field Assistant:** Attended a field course on tropical ecology and participated in research surveys of mangrove environments, reef ecosystems, and marine fisheries.

**Fish Behavioural Study, St. Andrews, NB – Field Assistant:** Conducted a two-month study underwater survey to observe the behaviour of juvenile Pollock under induced threat from predation.

**Marine Benthic Habitat Surveys, NS, NB – Field Assistant:** Conducted a number of marine benthic habitat and sampling surveys for the federal government to support dredging or wharf construction activities.

#### **ENVIRONMENTAL ASSESSMENTS:**

**Sydney Tar Ponds Environmental Impact Statement, Sydney, NS – Manager:** Mr. Duncan managed the EIS for the cleanup, which involved managing a large team of professionals, working closely with the proponent and their engineering consultant to prepare the 7-volume EIS for submission to federal and provincial regulators. Components included public and regulatory consultation, environmental baseline field work and human and ecological risk assessments. He also provided testimony during the three week public hearing process as part of a joint review panel.

**Environmental Impact Assessment, Keltic Petrochemical and LNG Facilities, NS – Project Manager:** Mr. Duncan acted as Project Manager for the preparation of a provincial EIA and a federal CSR for this combined petrochemical and LNG project. Managed a large consulting team and coordinated consultation with the public, stakeholders, and the regulatory agencies. Shawn also acted as panel lead at the 8-day provincial hearings that were part of the NS review process.

**Fundy Tidal Energy Project, NB – Senior Technical Reviewer:** Mr. Duncan provided senior technical input and senior review for the combined federal and provincial EA that was required as part of the Fundy Tidal Energy Project.

**Environmental Assessment, NB DoT, Route #11, NB – Senior Reviewer:** Mr. Duncan acted as the senior reviewer for a provincial EA for a new 4 lane highway in northern NB. This Project also included compliance with the federal CEA Act and required a number of natural resource surveys.

**Federal Comprehensive Study Report, Hamilton Harbour Clean-up, ON – Project Manager:** Mr. Duncan was the Project Manager and Senior Technical Reviewer for the federal CSR that was required as part of the Randle Reef Project in Hamilton Harbour.

**Environmental Impact Assessment, 25 MW Windfarm, Canso, NS – Project Manager:** Mr. Duncan conducted the environmental impact assessment for a windfarm and associated infrastructure. Components included public and regulatory consultation, environmental baseline field work, turbine site selection, and environmental impact assessment.

**Joint Federal-Provincial Environmental Assessment (Comprehensive Study) for the Black Point Quarry Project, Erdene Resource Development Corp, NS – Project Director:** Mr. Duncan was the Project Director responsible for senior review and client management for the environmental assessment project and EA scoping; scoping and coordination of field studies; regulatory and public consultation plans; and report preparation.

**Environmental Impact Assessment, Power Generating Facilities, Barbados – Project Manager:** Mr. Duncan was the Project Manager for the environmental impact assessment for a 250 MW power production facility and associated transmission line. Options that were considered for the facility fuel design included low-speed diesel engines and natural gas engines. Components included public and regulatory consultation, environmental baseline field work, and environmental impact assessment.

**Environmental Assessment, Maritimes & Northeast Pipeline, Mainline Expansion, NS, NB – Project Manager:** Mr. Duncan provided project management and development of the federal CEEA screenings for four compressor stations. This involved detailed site selection, field surveys and public, regulatory, and First Nations consultation programs.

**Environmental Impact Assessment, Terminal and Pipeline Facilities, Barbados – Project Manager:** Mr. Duncan prepared the EIA for a petroleum terminal facility and associated transmission pipelines. The existing bulk storage facilities were relocated from a coastal location in Oistins to a location near the airport. Components included public and regulatory consultation, environmental baseline field work, and pipeline route selection.

**Environmental Impact Assessment, Windfarm, Barbados – Project Manager:** Mr. Duncan conducted the Environmental Impact Assessment for a windfarm near Lamberts, Barbados. The project consisted of eleven 900 kW wind turbines. The EIA included public and regulatory consultation, environmental baseline field work, and environmental impact assessment.

**Environmental Impact Assessment, Prison Facility, Barbados – Project Manager:** Mr. Duncan prepared the Environmental Assessment for a new prison facility in Dodds, St. Philip. The previous prison was destroyed by fire and therefore there was an accelerated timeline to build a new facility to house the inmates. The EIA was completed ahead of schedule.

**Environmental Impact Assessment, Natural Gas Pipeline Route, Country Harbour, Nova Scotia to St. Stephen, New Brunswick – Assessor:** Mr. Duncan participated in the technical aspects of the corridor selection and environmental impact assessment of a 558 km pipeline, which included providing input on the definition of VECs, prediction of environmental effects, identification and analysis of design and route alternatives, socioeconomic impacts, contingency planning and compensation.

#### **ENERGY RELATED EXPERIENCE:**

**Regulatory Support and Joint Public Review, Sable Offshore Energy and Maritimes & Northeast Pipeline – Technical Support:** Mr. Duncan participated in, and provided environmental support to expert witness panel members testifying before a Joint Public Review Panel which included representatives of the National Energy Board.

**Detailed Route Assessment and Hearings Maritimes & Northeast Pipeline – Technical Support:** Mr. Duncan conducted a detailed analysis for the routing of the detailed 25 m easement for the mainline 30-inch pipeline. He also provided technical support for a detailed regulatory review of this easement through a NEB panel review process.

**Environmental Protection Plan, Maritimes & Northeast Pipeline – Management/Technical Support:** Mr. Duncan provided management and technical support for the development of an environmental protection plan for construction of 550 km of 30 inch natural gas transmission pipeline. Construction practices and protection measures were outlined in the EPP which would minimize potential impacts to the receiving environment.

**Maritimes & Northeast Pipeline – Construction Supervisor:** For the construction of the M&NP mainline and the Halifax lateral, Mr. Duncan fulfilled the role of construction supervisor. He provided supervision of a team of 20 environmental inspectors to oversee the implementation of environmental commitments and regulatory requirements during construction activities.

**Duke Energy, Environment, Health and Safety Audit, Natural Gas Distribution and Processing Facilities, Fort Nelson, British Columbia, and Northwestern Ontario – Lead Assessor:** Mr. Duncan conducted an EH&S compliance audit of distribution pipeline facilities in Ontario, and a gas processing facility in Fort Nelson. He verified compliance with applicable provincial and federal legislation and/or permits related to environmental and health and safety requirements for these types of facilities.

**Comprehensive Study, Halifax Lateral, Maritimes & Northeast Pipeline – Management/Technical Reviewer:** Mr. Duncan provided management support and technical review of a comprehensive EIA for the construction and operation of 120 km of 12 inch natural gas pipeline into Halifax. Shawn also acted as the construction supervisor to oversee the implementation of required environmental measures.

**Pipeline Evaluation and Coastal Mapping, Orimulsion Pipeline, NB – Project Manager:** Mr. Duncan was involved in the evaluation of an Orimulsion pipeline and the development of a coastal mapping for use in contingency and spill response planning for the transportation of Orimulsion. The Orimulsion was being transported to the NB Power generating station in Dalhousie New Brunswick.

## **ENVIRONMENTAL MANAGEMENT:**

**Sydney Tar Ponds Remediation – Project Director and Regulatory Manager:** Mr. Duncan fulfilled these senior roles during the Detailed Design of the Sydney Tar Ponds Clean-up and for the ongoing Construction Administration and Oversight for this Project.

**Inventory of Fish Processing Facilities, Environment Canada, Atlantic Provinces – Project Manager:** Managed a project that compiled and evaluated data and information of fish processing facilities in the Maritimes with the intent to evaluate waste treatment procedures for these operations.

**Acid Rock Mitigation and Construction Response Plan, Maritimes & Northeast Pipeline – Technical Support:** Participated in the development and implementation of a unique approach to the handling of acid rock during the planning and construction of the pipeline. A construction response plan (CRP) was developed in conjunction with regulators that addressed the identification, handling, and disposal of acid rock encountered during construction. In addition, the CRP outlined mitigation and risk analysis procedures that were developed for treatment of acid rock to be left on-site.

**Environmental Evaluation and Management, Canadian International Development Agency, India – Technical Support:** Assisted CIDA and the government of India in identifying hazardous waste streams and developing treatment strategies.

**Environmental Sensitivity Atlas, Baie de Chaleur, NB – Assessor:** Collected environmental information for the Baie de Chaleur region and used it to produce environmental sensitivity mapping for the region to support spill response planning.

**Inland Waters and Coastal Oceanographic Information Network, NB – Technical Support:** Provided technical support for a project to develop and apply an environmental information system for the Bay of Fundy and Chaleur Bay regions. The system combines metafiles, a knowledge-based system and a geographical information system. It is used both for EIAs of proposed projects and contingency planning and to identify development opportunities.

**Corporate EMS, Industrial Client – Project Manager:** Developed and provided implementation guidance for a corporate environmental management system that closely followed the requirements as set out in the ISO 14001 CSA standard.

**Environmental Performance Evaluation Training, India – Technical Support:** Provided technical input and conducted training to environmental professionals in India to provide an overview of EPE and the requirements under the ISO 14031 CSA standard.

**Wilderness Recreation Potential Assessment, Halifax, NS – Project Manager:** Prepared an assessment of the potential for wilderness recreational use of a forest area that will be bisected by the proposed Highway #113.

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## PROFESSIONAL ASSOCIATIONS

- Environmental Professional
- Project Management Professional

## AREAS OF SPECIALIZATION

- Regulatory Permitting, Monitoring, & Compliance
- Environmental Management Systems
- Project Management
- Large Scale Infrastructure Projects
- Phased Environmental Site Assessment
- Spill Response & Remediation
- Water Quality Assessments and Monitoring
- Environmental Liability Assessments

## RELEVANT EXPERIENCE

Ms. Myers is a seasoned Environmental Manager with 15 years of experience working on environmental projects across Canada. Ms. Myers joined Strum Consulting in 2020 and was previously employed as an Environmental Manager at the Keeyask (Hydroelectric) Generating Station construction project (Manitoba). Prior to that, Ms. Myers was an Environmental Advisor for ConocoPhillips at the Surmont Phase 1 & 2 Oil Sands Developments (Alberta) and an Environmental Consultant for upstream oil and gas facilities located in British Columbia, Alberta, and Saskatchewan.

Ms. Myers has extensive experience conducting phased environmental assessments on upstream oil and gas sites and has worked on over 300 properties across British Columbia, Alberta, and Saskatchewan. This experience includes project management on all phases of environmental site assessment, environmental monitoring, remediation, risk assessment, and management of contaminated sites. Ms. Myers specializes in soil and groundwater remediation programs and the mitigation and management of legacy facility and wellsite locations including remediation of saline, hydrocarbon, sulfur, metal, glycol, and polycyclic aromatic hydrocarbons (PAH) impacts.

More recently, Ms. Myers has been responsible for the development and implementation Environmental Management Systems for large-scale infrastructure projects. This involved supporting all areas of environmental permitting, monitoring, and compliance components for groundwater, surface water, air quality, soil quality, erosion mitigation, vegetation/wildlife management, hazardous and non-hazardous waste management, spill response, remediation, and decommissioning aspects of large-scale infrastructure works.

Ms. Myers has also been involved as an advisor ensuring environmental compliance and providing lessons-learned to help minimize environmental impacts during initiating and planning stages of large-scale construction work. She has been instrumental in developing emergency response plans, has participated in Incident Command Center situations, is familiar with remote supply-chain challenges (associated with sampling and response materials for environmental activities) and is well-versed in logistical and planning initiatives for environmental components of pre-construction and operational site development.

## EDUCATION

- Bachelor of Science, University of Calgary, Calgary, AB (2008)
- Bachelor of Arts, University of Calgary, Calgary, AB (2008)

## TRAINING

- Wetlands Identification (2020)
- EnviroTech (2020)
- Wildlife Awareness & Safety Training (2019)
- Communication, Negotiation & Conflict Resolution Workshop (2018)
- Upping Your Game in Contaminated Sites (2017)
- Aboriginal Awareness Training (2016)
- Ecological Risk Assessment, Theory & Practice (2013)
- Introduction to Vascular Plant Identification Workshop (2013)
- RemTech (2012, 2014)

## PUBLICATIONS

- Nudibranch Diversity and Microhabitat at Sepping Island in Barkley Sound, BC. BMSC, 2007
- Sex Ratios of Native Minnow Populations: How Common are Gender-Benders? University of Calgary, Directed Studies Project, 2008

## REPRESENTATIVE PROJECTS AND ROLES

**EverWind Fuels, NS, 2022-ongoing – Environmental Lead:** Development of an Environmental Assessment for the construction of a green hydrogen and ammonia production facility. Assessment of applicable environmental constraints (including federal, provincial and municipal considerations), coordination of environmental surveys and development of valued environmental components associated with air quality, geology, surface water, groundwater, marine, wetland, flora and fauna, SOCI, avifauna, bats, fish and fish habitat, and socioeconomic considerations.

**Melford Atlantic Gateway, NS, 2020-ongoing – Environmental Lead:** Coordination and submission of over 30 watercourse alteration applications associated with the project's proposed construction of a terminal and associated rail line. Development of a comprehensive Environmental Management Plan, incorporating regulator feedback and project requirements for Air Quality & Dust, Avian, Blasting, Emergency Response & Contingency Planning, Erosion & Sediment Control, Freshwater Ecology, Spill Prevention and Response, Contingency Planning, Terrestrial Habitat and Wildlife Protection, Waste Management, Water Well Surveys, and Greenhouse Gas.

**Request for Proposal (RFP) Process, Multiple Wind Farm Sites, NS, 2022 – Environmental Manager:** Coordination and management of the environmental submission component for multiple Request for Proposal preliminary environmental screening documents associated with wind farm developments across Nova Scotia. Content included preliminary desktop and field data review of climate change, geology, surface water, groundwater, wetland, flora and fauna, SOCI, avifauna, bats, fish and fish habitat, noise, shadow flicker, visual impacts, socioeconomic and air quality considerations and preliminary VECs assessment; as per the requirements of the Nova Scotia Rate Based Procurement May 2022 Request for Proposal process. Of the five approved wind farm developments, three of them were Strum clients.

**Keeyask Hydroelectric Generating Station, MB, 2018-2020 – Environmental Manager:** Developed and implemented the environmental management plan for a construction workforce of over 1,800 personnel while meeting Client needs and ensuring compliance with Provincial and Federal regulations during construction of a hydroelectric dam. Responsible for providing environmental leadership during the installation of a seven-unit Powerhouse/Service Bay complex, seven-bay Spillway, construction of 23 km of dykes, drilling and blasting operations, use and operation of seven quarries, hazardous and non-hazardous waste management, spill response and remediation, air, water, and soil quality monitoring, wildlife management, and ongoing environmental training activities.

**Keeyask Hydroelectric Generating Station, MB, 2016-2017 – Spill Response Coordinator:** Spill Response Team Lead and technical advisor for high-risk environmental work including in-water work, blasting operations, water-up events, batch plant cleanouts and maintenance activities. Responded to and trended spill data for over 2,500 pieces of heavy and mobile equipment, responding to and remediating over 500 large (>1,000 litres) and small (<1 litre) scale on-site releases.

**Hazardous Waste Storage and Transfer Facility, MB, 2016 – Project Manager:** Oversaw the development and design of a provincially permitted Hazardous Waste Storage and Transfer Facility managing over 1,200 chemicals at a large-scale infrastructure project site. Designed pad and site layout, coordinated associated work groups (cranes, electrical, ironworkers, and earthworks), installed 24-hour surveillance, developed controlled access points and created site-specific mini disposal locations with associated collection program that were installed across site. Staff education was completed once facility was operational to ensure compliance with provincial and federal regulations.

**Surmont Phase 2 Oil Sands, AB, 2014-2015 – Environmental Advisor:** Supported and performed environmental compliance and monitoring assessments during construction of the Surmont 2 SAGD bitumen recovery facility. Assisted with wetland identification and protection, well-pad and pipeline right-of-way development and monitoring, pipeline and winter-works (i.e., ice road) development and monitoring, industrial water use tracking and reporting, ambient air quality monitoring, wildlife management and reporting, spill response and remediation, invasive species and weed management programs, and reclamation and revegetation activities.

**Surmont Phase 1 Oil Sands, AB, 2014-2015 – Environmental Advisor:** Supported on-going environmental monitoring and compliance activities at an operational SAGD bitumen recovery facility. Responsibilities included field coordination, data assessment and reporting for monthly and annual air quality monitoring program; annual industrial runoff control system monitoring, groundwater monitoring, vegetation management and monitoring, erosion and sediment control plans, spill response, and remediation activities.

**Assessment and Risk Management of Legacy Sour Gas Facility, AB, 2011-2014 – Field Lead:** Completed initial inspection and assessment of the site. Completed drilling assessment and delineation of historic tank farm and flare pit including glycol, metal, PAHs, and saline sources of contamination. Developed and designed regulator-approved soil and groundwater remediation plan, including culvert water collection and disposal system as well as a large-scale dig and dump operation (>\$1.5-million-dollar budget). Developed and implemented a site-specific, regulator-approved remedial action plan to prevent impacts to nearby ecological receptors and continue long-term remediation and monitoring program.

**Long Term Soil and Water Monitoring Programs, SK) 2011-2014 – Program Manager:** Planning, coordination, assessment, analysis, and reporting to SPIGEC of various long-term soil and groundwater monitoring programs at upstream oil and gas sites. Trend analysis of soil and groundwater quality and submission of remedial action plans for in-situ plumes or contaminated source material.

**Environmental Monitoring Program – Sour Gas Processing Plant, AB, 2009-2014 – Program Coordinator:** Coordinated the various aspects of an on-going environmental monitoring program at a Sour Gas Processing Plant located in Northern Alberta. Responsibilities included project management, field coordination, data assessment, and reporting for monthly and annual air quality monitoring; annual industrial runoff control system monitoring, annual domestic wastewater release monitoring, annual groundwater monitoring, annual soil monitoring, and annual soil management programs.

**Sulphur Base Pad Remediation, Sour Gas Processing Plant, AB, 2009-2014 – Project Coordinator / Environmental Scientist:** Managed and coordinated the on-going environmental remediation and soil monitoring program at a Sour Gas Processing Plant former Sulphur Base Pad located in Northern Alberta. Responsibilities included assessment and review of historical test data, conducting and coordinating field program, assessment of obtained SAR values, and management of chemical application (lime) to treat and neutralize highly acidic soils.

**Long Term Soil and Water Monitoring Programs, AB, 2009-2014 – Program Manager:** Planning, coordination, assessment, analysis, and reporting to AER of various long-term soil and groundwater monitoring programs at upstream oil and gas sites. Trend analysis of soil and groundwater quality and submission of remedial action plans for in-situ plumes or remaining source material.

**Environmental Assessment – Chemical Manufacturing Plant, AB, 2013 – Environmental Scientist:** Completed Phase I & Phase II Environmental Site Assessment and subsequent soil and groundwater monitoring program for an operational chemical manufacturing plant in Medicine Hat, AB. Project responsibilities include assessing historical test data, conducting and coordinating the field program, assessing site data for petroleum hydrocarbons, metals, PAHs, and inorganic chemicals in soil and groundwater, and report writing.

**Assessment and Remediation of a Pipeline Release, AB, 2012 – Field Lead:** Responded to a loss of 10,000 litres of crude oil/condensate/salt/produced water due to internal corrosion of a multiphase pipeline on private land (agricultural). Participated in an Incident Command Center, coordinated and developed contaminant containment strategies, directed remediation activities, conducted soil sampling, and supervised reporting for the successful regulatory closure through local government agencies.

**Assessment and Remediation of a Pipeline Release, AB, 2012 – Project Coordinator:** Performed office-based support for a loss of 3,000 litres of crude oil/salt/produced water due to construction damage of a multiphase pipeline on private land (agricultural). Supported fieldwork activities through coordination of locates, equipment, contaminant disposal and sampling supplies; compiled, and submitted report for the successful regulatory closure through local government agencies.

**Fugitive Emissions Management Program (AB), 2010-2012 – Program Coordinator:** Coordinated the identification, tracking, assessment, and repair of all fugitive emissions sources at multiple oil and gas sites for various clients across Alberta; per the requirements of AER Directive 060. Organized emissions surveys and screening assessments, tracked, managed, and verified the status of needed repairs and was responsible for the reporting and record keeping obligations for all fugitive emissions management program requirements.



**Lyndsay Eichinger, BSc., MREM**  
Environmental Scientist  
Total Experience: 5 years

## AREAS OF SPECIALIZATION

- Environmental Reporting and Permitting
- Wetland and Watercourse Assessment
- Wildlife Surveying and Assessment
- Remediation and Reclamation
- Environmental Emergency Response
- Dangerous Goods Assessment

## RELEVANT EXPERIENCE

Miss Eichinger first joined the Strum team in 2020 as an Environmental Intern, while working towards her Masters of Resource and Environmental Management degree at Dalhousie. While studying at Dalhousie, Lyndsay specialized in remediation, environmental assessment, and natural resource management in Nova Scotia. Lyndsay also obtained her Bachelor of Science degree in 2019 from the University of British Columbia where she specialized in Earth and Environmental Science with a minor in Economics.

During her graduate studies, Lyndsay conducted a desktop study on the Boat Harbor Remediation Project, producing a technical review paper evaluating the cost-effectiveness of the different remedial components and technologies considered by the project. This paper has since been published in the journal Remediation titled: Review of remedial options for the Boat Harbour remediation project in Nova Scotia, Canada.

Lyndsay is active in conducting environmental assessments, wetland delineations, watercourse assessments, bat surveys, and other ecological studies. She has conducted significant fieldwork across large projects in remote locations. She is knowledgeable with provincial and federal regulations, working closely with senior staff preparing reports and regulatory submissions. Lyndsay is experienced working with multi-disciplinary teams through the Dalhousie Faculty of Management, in the Management Without Borders and Tri-Course class-structures, beyond her time with Strum.

Lyndsay held a previous position with RAM Environmental Response as a HAZMAT Responder based in the BC interior. Her role was fast-paced and multidisciplinary, working in tandem with senior management on emergency response planning and remediation teams on site. Lyndsay has responded to an array of emergency situations involving dangerous goods, such as train derailments and fuel spills, all requiring coordination between clients, contractors, first responders, and government parties. She has a strong background in safety protocols, erosion control implementation, response tactics, and emergency remediation measures for a variety of contaminants. Lyndsay is well practiced in remote travel along with ATV, snowmobile, and 4x4 use.

## REPRESENTATIVE PROJECTS AND ROLES

**Environmental Assessment Registration and Environmental Protection Plan, NL, 2022 – Junior Environmental Professional:** Completed reporting requirements for the submission of an EA Registration Document and associated Environmental Protection Plan for a transmission line decommissioning project located in Newfoundland and Labrador.

**Ellershouse Wind Farm Environmental Risk Assessment, NS, 2022 – Junior Environmental Professional:** Conducted a desktop study to characterize environmental risk, mitigation, and management measures for a wind farm located in Ellershouse, NS. This report was then used to inform constraints analysis and Project design features.

**Windsor Forks Wetland Compensation Project, NS, 2021-2022 – Junior Environmental Professional:** Completed reporting requirements for the final year of wetland monitoring and assessment for a constructed wetland.

## EDUCATION

- Masters of Resource and Environmental Management (MREM) - Dalhousie University, Halifax, NS (2021)
- Bachelor of Science - University of British Columbia (2019)

## TRAINING

- ATV Certification (2022)
- RPAS Pilot Certification (2022)
- BICO – Search and Rescue Program (2022)
- Electrofishing Certification (2021)
- Standard First Aid and WHMIS (2021)
- Stream Gauging Training from UBC (2019).
- Environmental Impact Assessment Certificate received from the Centre for Environmental Assessment Research at UBC (2019).
- Derailment Response - CP Railway (2018)
- Railway Safety Training (2018)
- Transportation of Dangerous Goods (2018)

**Weavers Mountain Wind Farm Moose Tracking Surveys, NS, 2022 – Junior Environmental Professional:**

Participated in field assessments for winter wildlife, with a focus on mainland moose and other species at risk. This involved walking predetermined transects through various habitats to identify and document evidence of wildlife such as tracks, scat, and browsing.

**GWRR Watercourse Alteration Approval and Fish Surveys, NS, 2021 – Junior Environmental Professional:**

Conducted electrofishing / fish salvage for an emergency watercourse alteration along a section of railway. This involved the capture, identification, documentation, and release of fish from the impacted section of the watercourse.

**Mahone Bay Well Installation and Monitoring, NS, 2021 – Junior Environmental Professional:** Groundwater well installs were completed at a construction site in Mahone Bay, NS along with vegetation transects to characterize the sites environmental features.

**Pirate Harbour Wind Farm Project, NS) 2021-Present – Junior Environmental Professional:** Participated in field assessments and Environmental Assessment report writing for a wind farm located in NS. Field surveys were conducted for wildlife, birds, wetlands, and watercourses. Environmental Assessment related documents such as field survey assessments, consultation, and background research were also completed.

**Mersey Wind Farm Project, NS, 2021 – Junior Environmental Professional:** Participated in field assessments and Environmental Assessment report writing for a wind farm located in NS. Field surveys were conducted for wildlife, birds, wetlands, and watercourses. Environmental Assessment related documents such as field survey assessments, consultation, and background research were also completed.

**Melford Atlantic Gateway Project, NS, 2020-Present – Junior Environmental Professional:** Completed various reporting and background research requirements such as consultation documents, engagement record keeping, and the development of a wetland compensation plan.

**Higgins Mountain Wind Farm Project, NS, 2020-Present – Environmental Technician:** Conducted watercourse, wetland, fish/fish habitat, wildlife and avian assessments all contributing to the environmental assessment for the establishment of a windfarm. Involved in Environmental Assessment development, planning, and finalization.

**L8001 and L8005 Transmission Line, NS, 2020 – Environmental Technician:** Participated in wetland and watercourse assessments, Wildlife surveys, and rare plant and lichen surveys, along the linear corridor spanning 100kms from the NS/NB border to Onslow, NS.

**Shellfish Harvesting and the Persistent Threat of Sewage Pollution, NS, 2020 – MREM Tri-course project:** Working in a multi-disciplinary team to assess the threat of sewage pollution on the shellfish industry of Nova Scotia, including the biophysical, socio-political, law and policy aspects of the greater issue of pollution in the near shore environment. This involved research into government programs, policies and regulations, as well as different stakeholders in the industry.

## PROFESSIONAL ASSOCIATIONS

- Association of Professional Engineers of Nova Scotia (Engineer-in-Training)

## AREAS OF SPECIALIZATION

- Industrial Approvals
- Computer-Aided Design
- Hydrogeology
- Water Treatment

## RELEVANT EXPERIENCE

Frank Gascon is an Engineer-in-Training with a Bachelor's Degree in Environmental Engineering from Dalhousie University in Halifax, NS. Since his employment with Strum, he has been involved in project management, engineering design, environmental monitoring, groundwater assessments, hazard assessments, project reporting and regulatory compliance.

Frank has worked directly with Nic Strum, Mechanical Engineer, to design solid waste transfer stations, waste audits, long-term monitoring and regulatory permitting for large Solid Waste and Waste to Energy Facilities. Additionally, he has gained valuable experience from Bruce Strum, Senior Hydrogeologist, concerning groundwater assessments for potable groundwater supply development, evaluation and treatment of water quality issues, and review of factors that contribute to the degradation of groundwater resources at residential sites.

Before working with Strum, Frank researched the management and disposal of municipal drinking water treatment plant waste residuals in the Northwest Territories.

## REPRESENTATIVE PROJECTS AND ROLES

- **Dartmouth Municipal Compost Facility Environmental Monitoring Program, Dartmouth, NS, 2021 - Present – Junior Engineer:** Monitoring groundwater and surface water sampling, data compilation, data analysis, and regulatory reporting.
- **Municipal Compost Facility Leachate Handling System, Dartmouth, NS, 2021 - Present – Junior Engineer:** Design, specification, and industrial approval amendment.
- **Level II Groundwater Assessments, Multiple Locations, NS, 2021 - Present – Junior Engineer:** Supervise well installation, pump testing (i.e., step and constant), sampling, analysis of aquifer characteristics, groundwater modelling, and regulatory reporting.
- **Groundwater Geothermal Cooling Systems, Wolfville, NS, 2021 - Present – Junior Engineer:** Withdrawal flow monitoring, water level monitoring, equipment inspection, water quality sampling, data compilation, data analysis, and regulatory reporting.
- **Groundwater Geothermal Heating and Cooling System Review and Permitting, Wolfville, NS, 2021 - Present – Junior Engineer:** Withdrawal flow monitoring, water level monitoring, equipment inspection, water quality sampling, data compilation, data analysis, and regulatory reporting.
- **Production Field Centre Hazardous Materials Assessment, Sheet Harbour, NS, 2021 – Junior Engineer:** Hazardous Materials inventory, coordinate sampling, data analysis, and reporting.

## EDUCATION

- Bachelor of Engineering (Environmental), Dalhousie University, Halifax, NS (2020)
- Civil/Mining Technician, Collège Boréal, Sudbury, ON (2010)

## TRAINING

- Standard First Aid & CPR
- Excavation and Trenching
- Confined Spaces

- **Green House Gas Inventory Audit, Parrsboro, NS, 2021 – Junior Engineer:** Green House Gas auditing for Fisheries and Oceans Canada (DFO) application.
- **Air Quality Improvement Design, Labrador, NL, 2021 – Junior Engineer:** Design, specification, stack testing, data analysis, and construction of ventilation improvements.
- **Drinking and Wastewater Treatment Plant System Assessments, Baddeck, NS, 2021 – Junior Engineer:** Assess water and wastewater infrastructure, establish an asset inventory, and reporting.
- **Municipal Groundwater Withdrawal Compliance, Pictou, NS, 2021 – Junior Engineer:** Review pumping rates and withdrawal volumes, spatial interferences, sustainability concerns, data analysis, and regulatory compliance.
- **Registered Potable Groundwater Supply Assessment, Cape Breton, NS, 2021 – Junior Engineer:** Review design specifications, well logs, water quality, data compilation, data analysis, and regulatory compliance.

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## PROFESSIONAL AFFILIATIONS

- Association of Professional Geoscientists of Nova Scotia

## AREAS OF SPECIALIZATION

- Project Management
- Phase I/II/III Environmental Site Assessments
- Remedial Action Plans
- Environmental Monitoring
- Geotechnical/Environmental Drilling
- Contaminated Site Assessment & Management
- Environmental Risk Assessment & Management
- Wetland/Watercourse Delineation & Alteration
- Avian Surveys
- Wildlife Tracking

## EDUCATION

- Bachelor of Science, Honors (Geology), St. Mary's University, Halifax, NS (2020)
- Bachelor of Engineering Technology, (Environmental), Cape Breton University, Sydney, NS (2014)

## TRAINING

- First Aid/CPR (2022)
- WHMIS (2018)
- Maxxam Lab Ops Boot Camp (2015)
- MCFT Wetland Delineation Training

## RELEVANT EXPERIENCE

Mr. Wagner joined the Assessment and Remediation group of Strum Consulting in spring 2015. Assisting in field operations of on-going projects, Drew has gained experience in a number of job specific tasks relating to the consulting services offered by the Strum team. Working as a field coordinator for the first four years of his career, he developed valuable skills including drilling supervision, emergency spill response, bird identification, Hazmat/mould assessments, and various sampling techniques. More recently, Mr. Wagner has gained experience in the management of various projects including phased environmental assessments, watercourse/wetland alterations, environmental impact assessments (EIAs), environmental monitoring, risk assessment, and contaminated sites management.

Prior to working with Strum, Mr. Wagner gained similar experience with other consulting firms in the environmental sector.

## REPRESENTATIVE PROJECTS AND ROLES

**Windfarm Impact Assessments, NS, 2015-Present – Environmental Scientist:** Completed coordination and field assessments for windfarm projects including wildlife tracking, bird surveys, nest searches, watercourse/wetland delineation, bat surveys, and plant/lichen identification.

**Wetland/Watercourse Alterations, NS, 2019-Present – Environmental Scientist:** Delineation, data collection, reporting, and management of wetland and watercourse alteration projects for both domestic and commercial clients.

**Bat Surveys, NS, 2021 – Environmental Scientist:** Surveyed project area for potential bat roosting habitat and determined the presence/absence of bats through visual and acoustic surveys.

**Nest Searches, NS, 2020 – Environmental Scientist:** Surveyed proposed project areas for the presence of nesting birds. Collected field data and reported on the findings.

**Domestic Fuel Oil Spill Remediation, NS, NB, NL, 2019 - Present – Project Manager:** Coordination and supervision of remedial excavation of contaminated soils as well as groundwater monitoring well, and subfloor air sampling port installations on multiples sites, to assess the extent of contamination in groundwater and bedrock.

**Groundwater Monitoring, NS, 2015-2018 – Field Coordinator:** Conducted groundwater monitoring and sampling on various projects ranging from residential to large scale industrial sites including organic landfills and power transfer stations.

**Monitoring Well Abandonment, NS, 2015-2018 – Field Coordinator:** Execution of proper well abandonment procedures to conserve aquifer integrity and prevent groundwater contamination.

**Quarterly Groundwater Monitoring Event, NS, 2017 – Field Coordinator:** Sampling of both groundwater monitoring wells and remote wooded area surface water bodies for a variety of parameters. Sampling procedures included field filtration and preservation, as well as recording on the spot chemical and physical parameters including PH, temperature, conductivity, TDS, and dissolved oxygen.

**Carcass Survey, NS, 2015-2018 – Field Coordinator:** Completed carcass surveys of multiple windfarms located throughout Nova Scotia. Surveys included ground searches of turbine footprints, proper documentation and logging of search results, and practicing safe handling procedures in dealing with wildlife found.

**Waste Audit, NS, 2016 – Field Coordinator:** Assisted in projects relating to the collection and auditing of various waste streams of government buildings throughout Atlantic Canada.

**Drilling Supervision, NS, 2015-2016 – Field Coordinator:** Coordinated drilling of boreholes and installation of monitoring wells for multiple projects. Included sample collection, borehole logging, well development, surveying of well locations and determining hydraulic gradient and hydraulic conductivity.

**Subfloor/Soil Vapour Air Sampling, NS, 2015 – Field Coordinator:** Numerous soil vapour and subfloor air sampling tasks, completed installation and helium shroud tests while practicing proper sample handling procedures.

**Groundwater Monitoring, Multiple IOC Mine Properties, Labrador, NL, 2016 – Field Technician:** Work involved seasonal programs conducted at multiple IOC Mine properties in Labrador, NL. This monitoring program was to assist IOC with regulatory compliance and reporting. These field programs consisted of locating existing monitoring wells, conducting well condition assessments, purging wells, collecting groundwater samples, and shipping samples from a remote field location to the laboratory for analysis. This project also required extensive mine safety training and daily interaction on site with heavy mine vehicles and operations.

**Regulated (Hazardous) Materials Survey, NS, 2015 – Field Coordinator:** Sampled various building materials for hazardous substances in commercial buildings. Samples were transported to a private laboratory for asbestos, lead, and metals analysis.

**Surveying, NS, 2015 – Field Coordinator:** Assisted survey crews in locating and recording x-y-z coordinates for a GIS software program. GPS locates included manholes, catch basins, storm drains, culverts, fire hydrants, and industrial/ residential curb side shut off valves.

**Moose Survey, NS, 2015 – Field Coordinator:** Participated in winter snow tracking and fall pellet group surveys. Included hiking various terrains and inspecting designated survey areas for animal sign including pellets, tracks, possible grazing or bedding areas, to identify animal types and diversity.

## AREAS OF SPECIALIZATION

- Baseline Study Data Collection and Analysis
- Wildlife Assessment
- Ecological Forestry and Agriculture
- Benthic Invertebrate Analysis

## RELEVANT EXPERIENCE

Ms. Schultz joined the Strum team in 2022 as an Environmental Scientist upon completing her coursework for her Masters of Resource and Environmental Management degree at Dalhousie. While studying at Dalhousie, Ms. Schultz specialized in a number of different areas of natural resource management in Nova Scotia, such as forestry, agriculture, and wetlands. She obtained her Bachelor of Science degree in 2019 from the University of Manitoba in the department of biological sciences where she specialized in ecology and environmental sciences. Her honours thesis focused on the ecological application of double-stranded RNA-based pesticides to control flea beetles in canola cropping systems in Manitoba. This project incorporated both field-based sample collection and lab-based sample preparation using techniques in molecular biology.

During her graduate studies, Ms. Schultz worked on a number of large projects, collaborating with multidisciplinary teams to contribute to local issues. As her final MREM Research Project, she produced GIS and statistics-based recommendations for the Nova Scotia Department of Natural Resources and Renewables regarding identification of old-growth forest locations in the province. Through the Dalhousie Faculty of Management's 'Management Without Borders' course, Ms. Schultz helped develop recommendations for pest control in the Municipality of the District of Argyle. She also developed an understory vegetation sampling protocol to be used in the Acadia Research Forest by the Canadian Forestry Service.

Ms. Schultz's most recent work experience includes contributing to a research project on bat activity hosted by a global non-profit organization by conducting statistical analysis on acoustic data. Ms. Schultz held a previous position with Nova Scotia Department of Lands and Forestry as a summer intern while completing her graduate studies. This role required remote field work to carry out the provincial old-growth scoring protocol, and desktop GIS-based work to plan and navigate to study locations. Prior to this internship, Ms. Schultz held a position with Agriculture and Agri-Foods Canada as a Junior Policy Analyst. In this role, she focused on the development of the Clean Fuel Standard, which included significant correspondence with agricultural stakeholders and a major deliverable of a jurisdictional scan of clean fuel regulations across the world.

Ms. Schultz is active in conducting ecological studies to contribute to a variety of environmental assessments. She has conducted significant fieldwork across large projects in remote locations, in both Nova Scotia and Manitoba. She is knowledgeable with provincial and federal regulations, working closely with senior staff preparing reports and regulatory submissions.

## REPRESENTATIVE PROJECTS AND ROLES

**Environmental Effects Monitoring Program, Halifax International Airport Authority, NS, 2022-Present – Environmental Scientist:** Conducting preliminary research and planning for benthic macroinvertebrate sample collection following CABIN protocol to be completed in June 2022.

## EDUCATION

- Masters of Resource and Environmental Management (MREM) - Dalhousie University, Halifax, NS (2022)
- Bachelor of Science (Hons.) - University of Manitoba (2019)

## TRAINING

- Wetland Delineation Training – Maritime College of Forest Technology (2022)
- Backpack Electrofishing – Canadian Rivers Institute (2022)
- Pilot Certificate for Small Remotely Piloted Aircraft System (RPAS), Visual line-of-sight (VLOS) – Transport Canada (2022)
- WHMIS (2022)
- Wilderness First Aid and CPR "C" – St. John's Ambulance (2022)

**Environmental Assessment, Higgins Mountain Wind Farm, NS, 2022-Present – Environmental Scientist:** Reporting on terrestrial habitat and flora at the Project site in support of an in-progress Environmental Assessment.

**Environmental Assessment, Weavers Mountain Wind Farm, NS, 2022-Present – Environmental Scientist:** Collecting winter and spring wildlife data and reporting on winter wildlife tracking and fall and winter avian surveys for an Environmental Screening Report.

**Environmental Assessment, Mersey River Wind Farm, NS, 2022-Present – Environmental Scientist:** Collecting winter and spring wildlife data.

**Environmental Assessment, Pirate Harbour Wind Farm, NS, 2022-Present – Environmental Scientist:** Collecting winter and spring wildlife data.

**Environmental Assessment, Melvin Lake, NS, 2022-Present – Environmental Scientist:** Collecting winter and spring wildlife data.

**Environmental Study, Apitamkiejit Wind Farm, NS, 2022 – Environmental Scientist:** Reporting on winter wildlife tracking and winter avian surveys for an Environmental Screening Report.

**Environmental Assessment, Blueberry Acres Wind Farm, NS, 2022 – Environmental Scientist:** Reporting on winter wildlife tracking and fall and winter avian surveys for an Environmental Screening Report.

**Environmental Assessment, Red Spruce Wind Farm, NS, 2022 – Environmental Scientist:** Reporting on fall migration avian surveys for an Environmental Screening Report.

**Environmental Study, L8005 Transmission Line, NS, 2022 – Environmental Scientist:** Collecting winter wildlife data.

**Environmental Assessment, Ross Bay Junction, NF, 2022 – Environmental Scientist:** Identifying previously collected benthic macroinvertebrate samples and preparing a report and data summary on the diversity and abundance of species present on the Project site.

## AREAS OF SPECIALIZATION

- Stakeholder Management & Engagement
- Community Development
- Intercultural Communication
- Data Management and Analysis
- Digital Communications
- Qualitative Research
- Political Affairs

## RELEVANT EXPERIENCE

Ms. Morrison joined the Strum team in 2022. She is an experienced facilitator and community organizer with an interdisciplinary academic background. She has lived and worked in six provinces and brings this regional perspective to her work. Her diverse professional experience has fostered strong interpersonal and teamwork skills; she excels in communication, collaboration, and research.

During graduate studies, Ms. Morrison focused on environmental health, environmental racism, and First Nation consultation. She worked as a Qualitative Research Intern with the *Atlantic Policy Congress of First Nation Chiefs Secretariat*. In this role, she participated in the Atlantic consultation session for *Indigenous Circle of Experts Pathway to Canada Target 1* (protecting 17% of terrestrial areas and inland waters by 2020). She also prepared a summary and index of all First Nations' submissions to the federal review of the *Canadian Environmental Assessment Act* and *National Energy Board*. These findings were compiled into a formal report to inform member decision-making.

Prior to joining Strum, Courtney worked various political roles in Alberta, Nova Scotia, and Newfoundland & Labrador. In Alberta, she worked in both government and opposition, and represented the Minister of Health at stakeholder consultation sessions for the *Mental Health Services Protection Act*. In Nova Scotia, she managed a federal campaign (South Shore–St. Margarets). In Newfoundland & Labrador, she worked as a regional organizer and supported Indigenous and Inuk candidates running in Fortune Bay - Cape La Hune, Happy Valley-Goose Bay, and Torngat Mountains. In these roles, Courtney has gained experience developing outreach strategies and managing stakeholder, public, and Indigenous relations.

## REPRESENTATIVE PROJECTS AND ROLES

**Mersey Wind Farm, NS, 2022-Present – Community Engagement Coordinator:** Supporting client with public open house, including ad design for local newspaper, tracking public engagement.

**Laconia Wind Farm, NS, 2022-Present – Community Engagement Coordinator:** Tracking public/stakeholder engagement.

**Tusket Wind Farm, NS, 2022-Present – Community Engagement Coordinator:** Tracking public/stakeholder engagement.

**Everwind Fuels Green Hydrogen Project, NS, 2022-Present – Community Engagement Coordinator:** Built tracker for public/stakeholder engagement.

**Elmsdale (ELCO) Biochar Plant, NS, 2022-Present – Community Engagement Coordinator:** Supporting client with presentation to town council.

## EDUCATION

- Continuing and Professional Education, Change Leadership, University of Alberta, Edmonton, AB (2020)
- Master of Resource and Environmental Management, Dalhousie University, Halifax, NS (2018)
- Bachelor of Arts (Sustainability and Sociology), Dalhousie University, Halifax, NS (2013)

## TRAINING

- Standard First Aid, CPR, and AED (2022)
- WHMIS Certificate (2022)
- RBC Sustainability Leadership Certificate (2013)

## AREAS OF SPECIALIZATION

- Marine Hydrographic Surveys
- Bathymetric Surveys
- Single Beam Sonar Surveys
- Multibeam Sonar Surveys
- Marine Benthic and Water Sampling
- Underwater Video
- Geographic Information Systems (GIS)

## COMPUTER EXPERIENCE

- Operating Systems: Windows, OSX, Linux
- Survey Software: HYPACK
- Seismic Software: SonarWiz, Coda
- GPS Software: Trimble Office, Waypoint GPS Processing, GravNav and GravNet
- GIS Software: ArcGIS, GRASS GIS
- CAD Software: AutoCAD Civil 3D
- Image Processing: Surfer, CARIS HIPS and SIPS
- Misc. Software: Grapher, Microsoft Office, Global Mapper, SonarPro

## EQUIPMENT EXPERIENCE

- GPS Equipment: Assorted Trimble and equipment for autonomous, differential, static, and RTK surveying (Pro XR, 4600, 4800, 5700/5800), Leica RTK, differential static and total stations
- Surveying Equipment: Knudsen BP320 echosounder, SSS Klein 595 and 3000, Teledyne Reson T20P multibeam, Teledyne Reson 7125 multibeam, Odom MB1 and MB2, Integrated Marine Acoustic Profiling System, Magnetometer, and various GPR equipment.
- Misc. Equipment: RBR XR620 CTD Probe and Tide Gauge, Eckman and Van Veen Grab Samplers, Underwater Camera, CNAV 0183 NMEA GPS receivers

## RELEVANT EXPERIENCE

Mr. Savelle is a Marine Surveyor and a GIS Specialist with Strum working in our Environmental Science Group. His area of speciality is in Marine Geomatics and conducting bathymetric and topographic surveys. He has extensive experience in surveying marine benthic surfaces and shorelines, obtaining overlapping hydrographic (multibeam, single beam and side scan sonar) data, data collection positioning and navigation, data processing and compilation, plotting and reporting of results. Matt also has experience collecting conventional total station data, RTK and static GPS data, and has been responsible for project set up, establishing GPS control points, and boat mobilization.

## REPRESENTATIVE PROJECTS AND ROLES

**Marine Survey for Offshore Oil & Gas Support Facilities, Sheet Harbour (NS), 2020** – Detailed marine surveys were conducted as part of the planning and permitting process for a marine facility used to support the offshore oil and gas industry. Bathymetric and multibeam sonar surveys were completed to provide a detailed bottom profile and water depths in areas of Sheet Harbour that will be used for large vessel movements. This information will be used to determine proper clearances for vessels and to determine if additional dredging is required. In addition to collecting this survey information, digital video was captured to document the types of marine habitat in the area to support applications for federal approvals.

## EDUCATION

- Centre of Geographic Sciences (COGS), Lawrencetown, Nova Scotia Advanced Diploma in Marine Geomatics (2010)
- Saint Mary's University, Halifax, Nova Scotia Bachelor of Science Degree (BSc) (2009), major in Biology and Minor in Geography

## TRAINING

- Marine Basic First Aid.
- St. John Ambulance, Level A CPR
- St. John Ambulance, Canadian East Coast Offshore Fitness Certificate
- Med A1 Offshore Survival Systems,
- WHMIS

**Chedabucto Bay Marine Surveys for Aquaculture Facilities (NS), 2020** – As part of the detailed siting of marine aquaculture facilities, bathymetric and single beam sonar surveys were completed to provide a detailed bottom profile and water depths in multiple areas of St. Marys Bay. In addition to collecting this survey information, digital video was captured along predetermined transects to document marine habitats, and benthic sediment samples were collected with a Van Veen grab for analysis. Marine survey data was processed to generate detailed digital bottom profiles.

**St. Marys Bay Marine Surveys for Aquaculture Facilities (NS), 2019-2020** – As part of the detailed siting of marine aquaculture facilities, bathymetric and single beam sonar surveys were completed to provide a detailed bottom profile and water depths in multiple areas of St. Marys Bay. In addition to collecting this survey information, digital video was captured along predetermined transects to document marine habitats, and benthic sediment samples were collected with a Van Veen grab for analysis. Marine survey data was processed to generate detailed digital bottom profiles.

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## AREAS OF SPECIALIZATION

- Remote Sensing
- Geographic Information Systems (GIS)
- LiDAR
- Photogrammetry
- Location, spatial, and data analytics
- Geoprocessing, Model Building, and automation
- Database management
- Geomorphology

## COMPUTER EXPERIENCE

- Operating Systems: Windows, macOS
- GPS Software: Garmin BaseCamp, Trimble Geospatial
- GIS Software: ArcGIS Suite, QGIS, Global Mapper
- Remote Sensing Data Processing: Trimble Inpho, POSPac MMS, LAStools
- Other Software: CoreDRAW X7
- Scripting: Python 2 & 3, SQL

## EDUCATION

- Master of Science in Applied Geomatics, Acadia University, Wolfville, NS (2021)
- Advanced Diploma in Geographic Information Systems (GIS), Centre of Geographic Sciences (COGS), Lawrencetown, NS (2020)
- Bachelor of Science, Major in Geology Saint Mary's University, Halifax, NS (2019)

## TRAINING

- Standard First Aid and WHMIS (2022)
- RPAS Pilot Certification (2021)
- Over 200 hours ESRI Academy Training (2019 – Present)

## RELEVANT EXPERIENCE

Mr. Opra is a GIS Specialist with Strum working in our Environmental Science Group. Mr. Opra specializes in Geomatics analysis and automation. He has extensive experience in implementing workflows for data analysis and processing. This experience includes trajectory processing, processing single and dual channel LiDAR data, photogrammetry, and automation of geospatial data analysis with both vector and raster data. In addition, Mr. Opra is experienced in operating a RPAS for data collection.

During his graduate studies, Mr. Opra focused on the application of remote sensing technologies in exploration geology. He investigated LiDAR as an effective means to visualize topography and in further detail, geomorphological features such as folds and glacial structures. He explored the advantages of both RPAS and airplane-acquired LiDAR while reviewing various software for processing and analysis. Mr. Opra helped support the project's RPAS surveys in Trafalgar, Nova Scotia and processed the data to produce high resolution terrain models.

Prior to and following his research contribution, Mr. Opra worked in academia as an advisor, then in the industry as a Geospatial Data Analyst and as a Remote Sensing Analyst. In academia, he assisted with an Honours thesis in developing a geospatial model to automatically detect sinkholes based on LiDAR data. He also assisted in a Master's thesis by mapping legacy gold mine tailings, and developing a survey grid for sampling. As a geospatial data analyst, he helped create new data products using multispectral imagery for precision agriculture. Through working on various LiDAR and Photogrammetry projects based throughout the Caribbean, USA, and Canada, Mr. Opra was able to apply automation to photogrammetry procedures and LiDAR processing. His commitment to data quality assurance and control, allowed him to develop a deeper understanding of how data is affected by environmental and human factors. His experience in both geology and environmental science allows him to have a strategic approach for geospatial analysis in environmental consulting.

Due to the multidisciplinary nature of Geomatics, Mr. Opra developed the ability to anticipate, identify, and solve diverse geospatial problems. Mr. Opra continues to research advancements in technology to build on and develop efficient procedures for data analysis and collection.

## REPRESENTATIVE PROJECTS AND ROLES

**EverWind Fuels Green Hydrogen Project, NS, 2022 - Present - Geomatics Specialist:** Spearheaded geospatial analysis, supported external inquiries, and integrated environmental and socioeconomic factors in the assessments.

**Wind Farm Projects, NS, 2022 - Present - Geomatics Specialist:** Streamlining field data collection, developed in house habitat modelling, tracking applications, and performing geospatial data analysis.

**Sinkhole Delineation Automation, NS, 2021 - 2022 - Advisor:** Assisted in the development of a model within ArcGIS Pro for automating detection and delineation of sinkholes in the Karst prone areas.

**LiDAR and Orthoimagery Data Production, Caribbean, USA, and Canada, 2021 - 2022 - Remote Sensing Analyst:** Trajectory processing, LiDAR processing, automation, and creation of data products from inception to delivery.

**Epiphytic Lichens as Spatial Biomonitors of Airbourne Mercury and Arsenic, 2019 - Research Intern:** Used GPS to map historical mining sites, and designed survey grids for Lichen collection.

**Multispectral Vineyard Imagery Data Production, California, USA, 2020 - Geospatial Data Analyst:** Assisted with the development of new proprietary geospatial products for precision agriculture.

**Provenance and Diagenesis of Sandstones in the Deep Wells Annapolis G-24, Balvenie B-79, Crimson F-81, Weymouth A-45, and Newburn H-23, Scotian Basin, offshore NS, 2017 - 2018 - Research Assistant:** Creation of graphic models and diagrams using data captured by a scanning electron microscope (SEM) to further research efforts in understanding the geology of the Scotian Basin.

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**Education:** Master of Arts – History, Saint Mary’s University, 2011  
Bachelor of Arts – History and Social Anthropology, Dalhousie University, 1998

**Permits:** Nova Scotia Heritage Research Permits held since 2008  
Newfoundland and Labrador Historic Resources Impact Assessment Permits held since 2011  
Parks Canada Agency - Research and Collection Permits held since 2017

**Affiliations:** Saint Mary’s University, Adjunct Professor, Department of Anthropology (2014-Present)  
Acadia University, Part-time Professor, Department of History and Classics (2017)

Archaeological Land Trust of Nova Scotia (Director: 2006-Present; Secretary/Treasurer: 2011-2017)  
Association of Professional Archaeologists of New Brunswick (2013-Present; Secretary: 2018-2021)  
Canadian Archaeology Association (Vice President: 2020-Present)  
Gorsebrook Research Institute, Saint Mary’s University (External Director: 2020-Present)  
Nova Scotia Archaeology Society (Director: 2004-2008; 2015-2016; President: 2005-2007; 2016-2018)  
Royal Nova Scotia Historical Society (Director: 2010-2013; Vice President: 2013-2017; President: 2017-2020)

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## EMPLOYMENT HISTORY

### *Saint Mary’s University, Halifax, Nova Scotia*

2020 Adjunct Professor, Department of Anthropology

### *Parks Canada, Indigenous Affairs & Cultural Heritage Directorate, Halifax, Nova Scotia*

2019-2020 Collections Specialist (SI-2) – responsible for the creation of an archaeological inventory/database of all Indigenous material cultural from Nova Scotia National Historic Sites/Parks held in the Parks Canada collection, report writing, and photography.

2018 Collections Specialist (SI-2) – responsible for the creation of an archaeological inventory/database of all Indigenous material cultural from Prince Edward Island National Historic Sites/Parks held in the Parks Canada collection, report writing, and photography.

### *Acadia University, Wolfville, Nova Scotia*

2017 Part-time Professor, Department of History and Classics

### *Boreas Heritage Consulting Inc., Halifax, Nova Scotia*

2013-Present Principal and Senior Archaeologist/Historian providing archaeological, historical and heritage consulting services to public and private sector clients.

### *Parks Canada, Indigenous Affairs & Cultural Heritage Directorate, Halifax, Nova Scotia*

2017 Archaeological Assistant (GT-1) – responsible for the creation of an archaeological inventory/database of all Indigenous material cultural from New Brunswick National Historic Sites/Parks held in the Parks Canada collection, report writing, photography, and conservation.

***Stantec Consulting, Churchill River, Newfoundland & Labrador***

2015-2017 Senior Archaeologist/Field Team Lead for Stage 3 Mitigation of Muskrat Falls Hydroelectric Project, Labrador, involved in all aspects of archaeological assessment and mitigation, including: research, implementation of field and lab work, artifact analysis, and report writing. This project required working in remote areas of Labrador, directing large field crews, and working closely with Innu and other Indigenous peoples.

***Cultural Resource Management Group Limited, Halifax, Nova Scotia***

2006-2013 Staff Archaeologist and Historian involved in all aspects of archaeological assessment and mitigation, including project management, research, implementation of field and lab work, and report writing.

***Parks Canada, Halifax, Nova Scotia***

2004 Archaeological Site and Laboratory Assistant, Beaubassin & Fort Lawrence National Historic Sites.

***Private Consultant***

2003-2006 Provided archaeological and historical research services to private sector consulting firms in Nova Scotia.

***Jacques Whitford Environment Limited, Dartmouth, Nova Scotia***

1993 Field Technician and Archaeological Assistant involved in various aspects of environmental assessment.

***Parks Canada, Halifax, Nova Scotia***

1992 Field Archaeologist and Laboratory Assistant, Fort Anne National Historic Site.

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**REPRESENTATIVE PROFESSIONAL EXPERIENCE**

- 2021 Project Manager for Gaspereau Lake Reservoir Archaeological Mitigation, for Nova Scotia Power Inc.
- Principal Investigator for Archaeological Impact Assessment of Acadia Wharf Extension, for Develop Nova Scotia
- Principal Investigator for Archaeological Impact Assessment of Blandford to Tancook Ferry Terminals, for NS Department of Transportation
- Principal Investigator for Archaeological Impact Assessment of Peggy's Cove Revitalization, for Develop Nova Scotia
- 2020 Project Manager for Archaeological Impact Assessment of installation of electric charging stations at Ardgowan National Historic Site, Prince Edward Island, for Parks Canada
- Project Manager for Archaeological Impact Assessment of George's Island National Historic Site, for Parks Canada
- Project Manager for Geophysical Survey of Shubenacadie Residential School, for Confederacy of Mainland Mi'kmaq
- Principal Investigator for Archaeological Assessment of Deep Panuke Jackup Gas Production Field Centre (PFC) Platform, for RJMI Ltd.
- 2019 Project Manager and Lead Researcher for Chignecto Isthmus Indigenous Knowledge Study (Archaeology), for Mi'gmawe'l Tplu'taqnn Incorporated
- 2018 Project Manager for Archaeological Impact Assessment of PEI National Park – Morrison Cottage Infrastructure Removal, for Parks Canada
- Principal Investigator for Geophysical Investigation of the Garrison Graveyard at Fort Anne National Historic Site, for Parks Canada
- Project Manager/Senior Archaeologist for Geophysical Investigation of Chapel Island at Potlotek First Nation;

for Potlotek First Nation

Project Manager/Senior Archaeologist for Archaeological Impact Assessment of Kejimikujik Multi Use Trail in Kejimikujik National Park/National Historic Site, for Parks Canada

Project Manager for Hydro Asset Study, for Nova Scotia Power Incorporated

Project Manager/Senior Archaeologist for Archaeological Resource Impact Assessment PID 15308448, in Cape Breton Regional Municipality, for Eskasoni First Nation

Project Manager/Senior Archaeologist for Archaeological Impact Assessment of Halifax Citadel National Historic Site in Halifax Regional Municipality, for Parks Canada

Archaeological Assistant for 2018 Archaeological Survey & Geophysical Investigation of Sable Island National Park Reserve, for Parks Canada

2017 Project Manager for Archaeological Impact Assessment of PEI National Park Project FII 1427, for Parks Canada

Principal Investigator for Geophysical Investigation of Elsdale Anomaly at Halifax Citadel National Historic Site, in Halifax Regional Municipality, for Parks Canada

Principal Investigator for Archaeological Salvage Operation at Canso Islands National Historic Site in Canso, in Guysborough County, for Parks Canada

Project Manager/Historian/Archaeologist for Archaeological Impact Assessment of Halifax Citadel National Historic Site in Halifax Regional Municipality, for Parks Canada

Archaeological Assistant for 2017 Archaeological Survey of Sable Island National Park Reserve, for Parks Canada

Project Manager/Senior Archaeologist for Archaeological Resource Impact Assessment of Ellershouse Windfarm, in Hants County, for Strum Consulting

Project Manager for Archaeological Impact Assessment of Kouchibouguac Force Main Realignment, in Kouchibouguac National Park, New Brunswick, for Parks Canada

Principal Investigator for Archaeological Resource Impact Assessment of Big Moon Tidal Demonstration Site, in Cape Split, Kings County, for Strum Consulting

2016 Field Team Lead for Stage 3 Mitigation of Muskrat Falls Hydroelectric Project, Labrador, for Stantec

Senior Archaeologist/Historian for Archaeological Overview Assessment of Halifax Citadel National Historic Site in Halifax Regional Municipality, for Parks Canada

Project Manager/Senior Archaeologist for Archaeological Screening and Reconnaissance of Cow Bay Road-Grand Lake Road in Cape Breton Regional Municipality, for Nova Scotia Department of Natural Resources

2015 Field Team Lead for Stage 3 Mitigation of Muskrat Falls Hydroelectric Project, Labrador, for Stantec

Principal Investigator for Archaeological Monitoring of geotechnical drilling at Upper Lake Falls, Mersey River Hydro System in the Region of Queens Municipality, for Nova Scotia Power Incorporated

Project Manager/Historian for Archaeological Monitoring of site preparation for Horizontal Directional Drilling Pad location at Cape Ray, Newfoundland and Labrador, for NSP Maritime Link Inc. / Emera Newfoundland and Labrador

Project Manager/Historian for Archaeological Screening and Reconnaissance of the Mersey Hydro System Redevelopment in the Region of Queens Municipality, for Nova Scotia Power Incorporated

Project Manager/Historian for Archaeological Screening and Reconnaissance of Eon Wind – Ketch Harbour Wind Farm in Halifax Regional Municipality, for Strum Environmental

Project Manager for Archaeological Monitoring of tree clearing for Maritime Link - Onslow to Springhill Transmission Line near Debert, for Nova Scotia Power Incorporated

2014 Principal Investigator for Archaeological Shovel Testing of Maritime Link – Onslow to Springhill Transmission Line – Debert Area in Colchester County, for Nova Scotia Power Incorporated

Project Manager for Archaeological Screening, Reconnaissance and Shovel testing of Haddock Harbour in Richmond County, for Glenn Group

Project Manager for Archaeological Screening, Reconnaissance and Shovel Testing of Lower Lake Falls Reservoir in Queen’s County, for Nova Scotia Power Incorporated

Project Manager for Archaeological Screening and Reconnaissance of Van Dyke Blueberry (PID 70036504) in Queens County

Project Manager for Archaeological Shovel Testing of Town Point (PID 01302165) in Antigonish County

Project Manager for Archaeological Screening and Reconnaissance of Eon Wind Farms in Queen’s County and Halifax Regional Municipality, for Strum Consulting

Project Manager for Archaeological Screening and Reconnaissance of Maritime Link - Onslow to Springhill Transmission Line, for Nova Scotia Power Incorporated

Project Manager for Archaeological Screening and Reconnaissance of Northumberland Rock Quarry Expansion in Antigonish County, for Alva Construction

Principal Investigator for Archaeological Screening and Reconnaissance of Hardwood Lands Community Wind Project in Hants County, for Strum Environmental

Principal Investigator for Archaeological Monitoring of Upper Broad River Bridge Replacement in Queens County, for Nova Scotia Department of Internal Services

Project Manager for Archaeological Monitoring of Sandy Lake drawdown in Halifax Regional Municipality, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Testing of Castor’s River, Newfoundland

Project Manager for Archaeological Screening and Reconnaissance of Chedabucto Aggregates Quarry Expansion in Guysborough County, for Strum Environmental

Project Manager for Archaeological Screening, Reconnaissance and Testing of Mink Lake Dam Refurbishment in Yarmouth County, for Nova Scotia Power Incorporated

Project Manager for Archaeological Screening, Reconnaissance and Testing of PID 25223686 in Cumberland County

Project Manager for Archaeological Screening, Reconnaissance and Testing of PID 50001007 in Inverness County

Principal Investigator for Archaeological Screening and Reconnaissance of Crowdis Bridge Replacement in Inverness County, for Nova Scotia Department of Transportation and Infrastructure Renewal

2013 Principal Researcher/Historian for Historical Research Report on the “Formation of the Jewish Legion at Fort Edward during WWI”, for Parks Canada

Project Manager for Archaeological Screening and Reconnaissance of proposed Dufferin Mine Expansion in Halifax Regional Municipality, for Ressources Applaches

Project Manager for Archaeological Testing of proposed Neives Dam Replacement in Annapolis County, for Nova Scotia Power Incorporated

Project Manager for Stage 2 Archaeological Assessment of proposed subdivision in Happy Valley-Goose Bay, Labrador, for Goose Bay Capital Corp. Inc.

Principal Investigator for Archaeological Testing of the Thibodeau Village/Shawbrook Farm site in Hants County;

2012 Principal Investigator for Archaeological Testing of the Shawbrook Farm site in Hants County

Principal Investigator for Archaeological Testing of the Donahue Dam Refurbishment project in Guysborough County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Testing of the Cooks Brook Pit Expansion project in Halifax Regional Municipality, for Gallant Aggregates Limited

Principal Investigator for the Archaeological Testing of Highway 103 Connector Road in Halifax Regional Municipality, for Nova Scotia Department of Transportation and Infrastructure Renewal

2011 Principal Investigator for Archaeological Screening, Reconnaissance and Strategic Testing of the Cape Ray, Newfoundland component of the *Maritime Link* project, for Emera Newfoundland and Labrador

Field Supervisor for Archaeological Survey of Lawlors Island Quarantine Facility in Halifax, Nova Scotia

Principal Investigator for Archaeological Screening and Reconnaissance of the Cape Breton Grounding Site components of the *Maritime Link* project, for Emera Newfoundland and Labrador

Field Supervisor and Principal Researcher for Archaeological Screening and Reconnaissance of the Newfoundland component of the *Maritime Link* project, for Emera Newfoundland and Labrador

Field Supervisor and Principal Researcher for Archaeological Screening and Reconnaissance of the Cape Breton component of the *Maritime Link* project, for Emera Newfoundland and Labrador

Principal Investigator for Archaeological Monitoring of the Provincial Law Courts Parking Lot Replacement in Halifax Regional Municipality, for Department of Transportation and Infrastructure Renewal

Principal Investigator for Comparative Evaluation of archaeological potential assessment of the Greater Sydney Area Wastewater Collection Project in Cape Breton Regional Municipality, for Cape Breton Regional Municipality

Principal Investigator for Archaeological Screening, Reconnaissance and Testing of the proposed Ingramport Cellular Tower Site in Halifax Regional Municipality, for GENIVAR

Principal Investigator for Archaeological Reconnaissance of the Falls Lake Refurbishment in Hants County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Screening and Reconnaissance of McNab's Bridge, Hay Cove Bridge, Soldiers Bridge, Sutherlands Culvert and Thorn Culvert, in Richmond County, for Nova Scotia Department of Transportation and Infrastructure Renewal

Principal Investigator for Archaeological Screening and Reconnaissance of the Aberdeen Transmission Line and Substation Expansion in Inverness County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Monitoring of the Shoreline Stabilization Project at Malagawatch, Inverness County, for Dillon Consulting Limited and the Assembly of Nova Scotia Mi'kmaq Chiefs

Principal Investigator for Archaeological Assessment of the Northeast Nova Scotia Correctional Facility in Pictou County, for Nova Scotia Department of Transportation and Infrastructure Renewal

Principal Investigator for Archaeological Screening and Reconnaissance of the Raynardton and Alders Bridge

Replacement projects in Yarmouth County, for Nova Scotia Department of Transportation and Infrastructure Renewal

Principal Investigator for Archaeological Screening and Reconnaissance of the Antigonish Wind Project in Antigonish County, for Nova Scotia Power Incorporated

2010 Principal Investigator for Archaeological Screening and Reconnaissance of the Donahue Dam Refurbishment project in Guysborough County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Screening and Reconnaissance of the Baddeck Landfill Expansion project in Victoria County, for the Municipality of the County of Victoria

Principal Investigator for Archaeological Screening and Reconnaissance of the Ten Mile Lake Dam project in Halifax Regional Municipality, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Screening and Reconnaissance of the Marshall Falls Dam project in Halifax Regional Municipality, for Nova Scotia Power Incorporated

Principal Investigator for the Archaeological Monitoring of soil sampling at the Halifax Armoury in Halifax, for Defence Construction Canada

Principal Investigator for the Archaeological Assessment of proposed Highway 103 Connector Road alignments in Halifax Regional Municipality, for Nova Scotia Department of Transportation and Infrastructure Renewal

Principal Investigator for the Archaeological Screening and Reconnaissance of the Stillwater Later Bridge Replacement project, for Halifax Regional Municipality

Principal Investigator for Archaeological Screening and Reconnaissance of the Lower Cove Wind Project in Cumberland County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Screening and Reconnaissance of the Loganville Wind Project in Colchester County, for Nova Scotia Power Incorporated

Principal Investigator for Archaeological Screening and Reconnaissance of the Nuttby I & II Wind Projects in Colchester County, for Nova Scotia Power Incorporated

2009 Principal Researcher for Archaeological Assessment of proposed Highway 113 alignment in Halifax Regional Municipality, for Nova Scotia Department of Transportation and Infrastructure Renewal

Field Archaeologist and Principal Researcher for Archaeological Assessment of the Ferrona Bridge Replacement Project in Pictou County, for Nova Scotia Department of Transportation and Infrastructure Renewal

Principal Researcher for Archaeological Assessment of the Hawthorne Farm Site within a proposed mine expansion area in Gays River, Nova Scotia, for Acadian Mining

Principal Investigator for the Archaeological Monitoring of subterranean electrical duct installation at CFB Stadacona in Halifax, for Department of National Defence

Field Director for Stage 2 and Stage 3 Archaeological Assessments of Talbot Wind Farm, in Chatham-Kent, Ontario, for Renewable Energy Systems - *Reports on file with Ontario Ministry of Tourism, Culture and Sport*

2008 Principal Investigator for Archaeological Screening and Reconnaissance of the Fifteen Mile Stream Development in Halifax Regional Municipality, for Nova Scotia Power Incorporated

Principal Researcher for Archaeological Assessment of Highway 101 Twinning in Kings County, for Nova Scotia Department of Transportation and Infrastructure Renewal

Field Supervisor and Principal Researcher for Archaeological Screening, Reconnaissance and Testing of Great Barren Dam Safety Remedial Works in Yarmouth County, for Nova Scotia Power Incorporated

Field Archaeologist and Principal Researcher for Archaeological Screening and Reconnaissance of the Ardoise Development Property in Hants County, for Environmental Design and Management Limited

Field Archaeologist and Principal Researcher for Archaeological Screening and Reconnaissance of the Sandy Lake Development Property in Halifax Regional Municipality, for Armco Capital Incorporated

Field Supervisor and Principal Researcher for Archaeological Screening and Reconnaissance of the Beaver Dam, Getty, Northeast Expansion, Smithfield, and Cape Breton Barite development properties, all proposed mine expansion areas in Nova Scotia, for Acadian Mining Corporation

Field Archaeologist and Principal Researcher for Archaeological Screening and Reconnaissance of proposed harbour improvements at Margaree Harbour, Inverness County, for Public Works and Government Services Canada

Principal Researcher for Assessment of the Touquoy Gold Project – Moose River Heritage Preservation in Halifax Regional Municipality, for Atlantic Gold

2007 Field Supervisor and Principal Researcher for Archaeological Investigations of the Dartmouth Turbine Chamber, part of the Shubenacadie Canal System and Starr Manufacturing complex in Dartmouth, for Halifax Regional Municipality & the Shubenacadie Canal Commission

Field Director and Principal Researcher for the Monitoring and Mitigation of features identified during construction of Founders Corner Condominiums in Halifax Regional Municipality, for Nova New England Group

Field Archaeologist for the Archaeological Mitigation of the Sinkhole Site, a Precontact habitation site within a proposed mine expansion area in Colchester County, for ScoZinc Limited

Principal Researcher and Field Archaeologist for Archaeological Reconnaissance and Testing of proposed Highway 104 corridor and interchange areas between Port Hawkesbury and Port Hastings, Cape Breton, for Department of Transportation and Infrastructure Renewal

Principal Researcher for Archaeological Assessment of Lot 209, Palaeo Subdivision in Debert, Colchester County, for Department of Transportation and Public Works

2006 Field Archaeologist during search for the Portobello Turbine Chamber, part of the Shubenacadie Canal System in Waverly, for Halifax Regional Municipality & the Shubenacadie Canal Commission

Field Archaeologist for Archaeological Screening, Reconnaissance and Testing of proposed Miller's Creek gypsum quarry expansion in Hants County, for Fundy Gypsum Company

Field Archaeologist for the Archaeological Reconnaissance of Wrights Lake and Coon Pond in Halifax Regional Municipality, for Nova Scotia Power Incorporated

Field Archaeologist for the Archaeological Assessment of construction related activities at McGowan Headpond Main Dam on the Medway River in Queens County, for Nova Scotia Power Incorporated

2005 Field Archaeologist for Archaeological Testing of proposed Lingan Wind Turbine #2 site in Cape Breton County, with CRM Group

Field Archaeologist and Archaeological Monitor of proposed Port Hawkesbury/Port Hastings Sewage Treatment Plant site in Inverness County, with CRM Group

Archaeological Monitor during construction of Balmoral Pump Station and connecting pipe system at Point Pleasant Park in Halifax Regional Municipality, with CRM Group

Field Archaeologist for partial excavation and documentation of a 19<sup>th</sup> century shipwreck (BdCv-51) in Woodside, Nova Scotia, with CRM Group

Archival Research for "Crafting an Identity: Occupational Therapy in Nova Scotia, 1950-1972", in Halifax, Nova Scotia, for Saint Mary's University and Associated Medical Services Inc.

- 2004 Archaeological Site and Laboratory Assistant for Archaeological Testing of Beaubassin and Fort Lawrence National Historic Sites in Cumberland County, for Parks Canada
- Field Archaeologist and Artifact Processor for Archaeological Mitigation of the Maritime Museum Combined Sewage Overflow Chamber in Halifax Regional Municipality, with CRM Group
- 2003 Field Archaeologist for Archaeological Assessment of Highway 101 structure construction areas in Yarmouth County, with CRM Group
- Field Archaeologist for Archaeological Assessment of a proposed quarry expansion area in Colchester County, with CRM Group
- 1993 Field Technician and Archaeological Assistant for Jacques Whitford Environment Limited, Dartmouth, Nova Scotia
- 1992 Field Archaeologist and Laboratory Assistant for Archaeological Excavation of Charlesfort site at Fort Anne National Historic Site in Annapolis County, for Parks Canada

### PUBLICATIONS AND PRESENTATIONS

- Beanlands, Sara 2018 "The Training of the Jewish Legion in Windsor, Nova Scotia, During the First World War," *Journal of the Royal Nova Scotia Historical Society*, Vol. XXI (2018).
- Beanlands, Sara 2012 "The Reverend Professor Andrew Brown: An Academic Reassessment," *The University of Edinburgh Journal*, Vol. XLV, No.4 (2012).
- Erickson, Paul & Jonathan Fowler, eds. 2010 "Neighbours in Time," in *Underground Nova Scotia: Stories of Archaeology*. Halifax: Nimbus Publishing.
- Reid, John G et. al. 2009 "Is There a Canadian Atlantic World?" *International Journal of Maritime History*, Vol. XXI, No. 1 (2009).
- MacIntyre, April & Sara Beanlands 2008 "History of Sale: The Treasure Trove Act in Nova Scotia," In *Preprints of the 15th Triennial Meeting, New Delhi, 22-26 September 2008*.
- Beanlands, Sara 2006 "The Rev. Dr. Andrew Brown: Nova Scotia's Elusive Historian," *Journal of the Royal Nova Scotia Historical Society*, Vol. IX (2006).
- 2019 "Merging UAV Data with Subsurface Ground Penetrating Radar for Archaeological Investigations", Nova Scotia Community College AGRG-COGS *Sensors High and Low: Measuring the Reality of Our World Conference*, Middleton, Nova Scotia
- "Archaeology and Species at Risk Research in Kespukwitk", with Jeff Purdy, *Kespukwitk Two-Eyed Seeing Gathering*, Bear River First Nation, Nova Scotia
- "What Lies Beneath: An Acadian Ancestry Project", Kings Theatre, Annapolis Royal, Nova Scotia
- 2018 "Sandy Banks (FgCg-01): The Archaeology of a Hudson's Bay Company Fur Trade Post in Central Labrador", with Fred Schwarz et al., *Council for Northeastern Archaeology Conference*, Halifax, Nova Scotia
- "A Typological analysis of the Stone Pipes of the Isthmus of Chignecto, Eastern Canada", with Eric Tremblay et al., *Council for Northeastern Archaeology Conference*, Halifax, Nova Scotia
- "The Elsdale Anomaly: Geophysics and the Search for Fort Luttrell", *Council for Northeastern Archaeology Conference*, Halifax, Nova Scotia
- "The Training of the Jewish Legion at Fort Edward", *Royal United Services Institute of Nova Scotia*, Royal Artillery Park, Halifax, Nova Scotia
- "The Jewish Legion in Windsor", *Atlantic Mayors Congress*, Windsor, Nova Scotia

- “Voices of the Landscape”, *Landscape of Cultures Festival*, Grand Pré National Historic Site, Nova Scotia
- 2017 “Landscape in Memory: What Time is it in Fort Lawrence?”, *Nova Scotia Archaeology Society*, Halifax, Nova Scotia
- “The Training of the Jewish Legion at Fort Edward during the First World War”, *Royal Nova Scotia Historical Society*, Halifax, Nova Scotia
- 2016 “Unearthing our History”, *West Hants Historical Society Heritage Banquet*, Windsor, Nova Scotia
- “Thibodeau Village: Community Engagement, Archaeology, and the Discovery of an Acadian Past in a Nova Scotia Planter Landscape”, *Genealogical Association of Nova Scotia*, Dartmouth, Nova Scotia
- “John Reid’s Influence on Historical Archaeology in Nova Scotia”, *Practicing History in the 21<sup>st</sup> Century Symposium*, Saint Mary’s University, Halifax, Nova Scotia
- 2015 “An Early African-Nova Scotian Burial Ground in Hammonds Plains”, *Black Canadian Studies Conference*, Dalhousie University, Halifax, Nova Scotia
- “Preserving the Memory of Historical Public Space in Halifax Regional Municipality”, *Public Space, History and Memory Symposium*, Saint Mary’s University, Halifax, Nova Scotia
- “Thibodeau Village: Community Engagement, Archaeology, and the Discovery of an Acadian Past in a Nova Scotia Planter Landscape”, *Evenings at Government House Lecture Series*, for the Lieutenant Governor of Nova Scotia, Government House, Halifax, Nova Scotia
- 2013 “Re-layering the Cultural Landscape”, *Nova Scotia Heritage Conference*, Liverpool, Nova Scotia
- “Unravelling the 3D Cultural Landscape within a Tablet Interface”, *European Archaeology Association*, Pilsen, Czech Republic
- 2012 “Rev. Dr. Andrew Brown and the Removal of the French Inhabitants of Nova Scotia”, *Monument-Lefebvre National Historic Site*, Memramcook, New Brunswick
- 2011 “The Brown Manuscripts: An 18<sup>th</sup> Century Approach to Understanding Acadia”, *Histoire de l’Acadie: New Approaches*, Saint Mary’s University, Halifax, Nova Scotia
- “Bayonets, Bottles and Beads: An Overview of Archaeological Sites in the Chignecto”, *Tantramar Heritage Trust*, Sackville, New Brunswick
- 2010 “Finding Acadia in Planter Oral Tradition”, *Colchester Historical Society*, Truro, Nova Scotia
- “An Introduction to Industrial Archaeology”, *Industrial Heritage Nova Scotia*, Halifax, Nova Scotia
- “The Brown Manuscript: An 18<sup>th</sup> Century Account of the Acadian Deportation”, *Causerie: Grand-Pré*, Place des Arts Père Anselm Chaisson, Cheticamp, Nova Scotia
- “Removal of the French Inhabitants of Nova Scotia by Lieut. Governor Lawrence & His Majesty’s Council in October 1755”, *Tantramar Heritage Trust*, Sackville, New Brunswick
- 2009 “The Brown Manuscript and the Scottish Enlightenment”, *Atlantic Canada Studies Conference*, University of Prince Edward Island, Charlottetown, Prince Edward Island
- 2008 “New Perspectives on the Idea of a ‘Canadian’ Atlantic World”, *International Workshop on Material Culture Dimensions of the Asia-Atlantic Comparison and on the ‘Canadian’ Atlantic World*, Halifax, Nova Scotia
- 2006 “Thibodeau Village”, *Confederation of Association of Acadian Families*, Lafayette, Louisiana
- “Thibodeau Village”, *Acadian Memorial*, St. Martinville, Louisiana
- “If the Land Could Speak”, *Grand-Pré National Historic Site*, Wolfville, Nova Scotia

- “Andrew Brown and the Acadians”, *Société Historique Acadienne*, Université de Moncton, Moncton, New Brunswick
- 2005 “An Enlightened Mind in Nova Scotia: The University of Edinburgh’s Andrew Brown - Nova Scotia’s First Historian”, *University of Edinburgh*, Centre of Canadian Studies, Edinburgh, Scotland
- “The Rev. Dr. Andrew Brown: Nova Scotia’s Elusive Historian”, *Royal Nova Scotia Historical Society*, Halifax, Nova Scotia

#### **SCHOLARSHIPS AND AWARDS**

- 2017 Volunteer Service Award (Municipality of the District of West Hants & the Town of Windsor)
- 2013 Nova Scotia Museum Research Grant (Cultural History)
- 2006/2007 Mary Jackson-Hinch and Joseph Hinch Research Award (St. Mary’s University)
- 2006 Honorary Citizenship to the City of Lafayette, Louisiana for contributions to Acadian Society
- 2005/2006 St. Mary’s University Graduate Award Scholarship
- St. Mary’s University Faculty of Graduate Studies and Research Fellowship
- 2005 Associated Medical Services Hannah Studentship
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#### **TRAINING AND CERTIFICATES**

Certified Emergency First Aid CPR Level A.  
Wilderness First Aid  
WHMIS

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# BILJANA COSIC

## Senior Managing Consultant

Dr. Biljana Cosic is a Managing Consultant with over fifteen years of consulting and research experience in the field of environmental science and engineering with a focus on emission development, air dispersion modelling, process chemistry and thermodynamics, and statistical data analysis. Ms. Cosic is a dispersion modelling expert and has used models including CALPUFF, AERMOD, SCICHEM, BLP, CAL3QHC and other screening models for environmental assessments and to provide regulatory support to the clients in various jurisdictions including the United States, Canada and the Nordics. She has worked on air quality projects for the clients in government, power generation, mining, base metal smelting, oil & gas, and chemical manufacturing sectors. Ms. Cosic has co-authored a number of peer-reviewed publications on topics ranging from fundamental environmental science to those on the development of emission inventories and specialized application of air dispersion models.



## CAREER

2010-present

**Managing Consultant, Ramboll Canada Inc.**

2008-2010

**Air Quality Specialist, Golder Associates Ltd.**

2005-2008

**Postdoctoral Fellow, Waterloo Centre for Atmospheric Sciences,  
University of Waterloo, Waterloo, Canada**

2004-2005

**Visiting Scholar, Rensselaer Polytechnic Institute, NY**

2000

**Visiting Researcher, Combustion Research Facility, Sandia  
National Laboratory, Livermore, CA**

1996-2004

**Graduate Research Assistant, Rensselaer Polytechnic Institute, NY**

## EDUCATION

2004

**PhD, Chemical Engineering**

Rensselaer Polytechnic Institute, Troy, NY

1995

**BSc, Chemical and Biochemical Engineering**

University of Belgrade, Belgrade, Serbia

## CONTACT INFORMATION

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## SELECTED PROJECT EXPERIENCE

2018-present

**Litigation support: Evaluation of historical PCB use and releases in different industrial sectors United States**

Managed a multi-year litigation project on behalf of an expert witness involving reconstruction and estimation of historical polychlorinated biphenyls (PCBs) use and emissions in facilities from different industrial sectors including power transmission & distribution and metal refining. Reviewed facility records and technical literature on historical application, consumption, and disposal of PCB-based materials in respective facilities. PCB chemical and thermodynamic properties were considered in developing estimates of the most likely pathways and partitioning of PCBs emissions between different media (air, liquid or solid waste).

2019-present

**Litigation Support: Metal Smelting and Refining Facility, South America**

Managed a litigation project in support of an expert witness which involved evaluation of historic emissions from an integrated copper, lead and zinc smelter. Historic facility operations including production throughputs, process upgrades, source testing, ambient air monitoring data, and literature data on emission factors and the industry practice in the period were reviewed/analysed to evaluate emissions of particulate matter, metals and SO<sub>2</sub>. Oversaw A computational fluid dynamics (CFD) modelling study was carried out to evaluate the impact of complex terrain and building structures on dispersion of smelter emissions and siting of ambient monitors.

2020-present

**Litigation Support: Explosion at a Petrochemical Facility, United States**

Managed a litigation project in support of an expert witness on a case involving an investigation of incidental releases due to multiple explosions and fires at a plant and evaluation of their impact on air quality. The impact is being evaluated using different approaches including the review of ambient monitoring data, meteorological conditions and Doppler radar data to infer the plume path, spatial extent and vertical profiles during the incident.

2020-present

**Environmental Compliance, Surface Iron Mine, Newfoundland and Labrador**

Managed an air quality impact study in support of compliance demonstration for a surface mine and associated processing facility. Emission inventory has been developed for the worst-case scenario which considered process and fugitive emissions from stationary sources, mobile onroad and offroad equipment, and windblown dust. Dispersion modelling conducted using prognostic meteorological model and CALMET/CALPUFF modelling system to assess compliance with applicable provincial air quality standards.

2018-2020

**Evaluation of Air Quality Impacts from Road Tunnels, Multiple Municipalities in Norway**

Technical lead on two independent studies to evaluate air quality impacts associated with operation of proposed road tunnels along the E10-Rv 85 Hålogalandsvegen and E16 Arna-Stanghelle roads in Northern and Western Norway. The proposed roadway and tunnel networks consisted of numerous tunnels and portals extending over large areas and across multiple municipalities. Traffic exhaust and fugitive emissions for the baseline and alternative future scenarios were developed using Norwegian emission inventory guidance. Dispersion modelling was carried out using CALPUFF/CALMET modelling system. A new method was developed to parameterize emissions from tunnel portals to account for the tunnel air flow due to traffic and ventilation. Modelling results were used to assess the project compliance with applicable air quality guidelines and evaluate ventilation requirements in different tunnel segments.

2019-2020

**Dispersion Modelling Regulatory Support, Aggregate Production Facility, Missouri**

Managed a dispersion modelling task for an existing limestone processing plant to support a permit application for a proposed increase in the facility throughput. The facility is characterized by an extensive

trucking network associated with hauling feedstock from a mine, customer traffic, and material movement between different process lines and stockpiles. Worked with the facility to convert the complex traffic logistics into a conservative yet realistic worst-case emission scenario to demonstrate compliance with National Ambient Air Quality Standards (NAAQS). Modelling performed using AERMOD dispersion model. Negotiated with the state regulator the approach for background concentration assessment for PM<sub>10</sub> resulting in a significantly lower value than originally proposed by the agency.

2019-2020

**Litigation Support: Air Quality Impact from a Chemical Manufacturing Facility**

Project manager and technical lead on an air quality study to evaluate the potential impact of ethylene oxide (EtO) emissions from this and other nearby facilities at community-wide ambient air monitoring locations. Analysed ambient air and background monitoring data and spatial distribution of other reported industrial and commercial sources in the area. Carried out analysis of meteorological and ambient air monitoring data and reviewed the canister sample handling and record keeping data to help evaluate the origin of isolated elevated (outlier) samples.

2020

**Air Quality Assessment, Plastic-to-Fuel Pyrolysis Plant, Canada**

Provided technical lead and managed an air permit application effort for a proposed facility that would convert waste plastics to fuels. Ramboll worked closely with the client, technology provider and regulatory agency to develop a realistic operating and emission scenario for the permit application including developing a methodology to estimate emission factors and/or emissions from this type of processes by considering mass balance, physical partitioning and chemical speciation as a function of process conditions and feedstock composition.

2020

**Air Quality Assessment due to Potential Spills, Fires and Explosion, Chemical Storage Facility, United States**

Provided technical support on a project which involved evaluation of emissions and air quality impacts from potential spills, fires and explosions at a chemical storage and blending facility. Carried out screening dispersion modeling using ALOHA and AERSCREEN models. Reviewed and evaluated methods to estimate physical and thermodynamic properties of selected chemicals which represent critical inputs for estimating emissions from accidental releases.

2020

**Evaluation of Accidental Chemical Release, Pulp and Paper Sector, United States** Managed a project to assist a client in pulp and paper sector investigate historic upset events and quantify chlorine gas releases during the events. Provided technical lead for development of methods to quantify emissions from different processes and type of releases using operations data, characterization of pollution control equipment, and data from indoor and outdoor air monitoring networks. Complementary estimation methods were considered and evaluated to validate emission estimates and propose the most optimal methods to quantify accidental releases from various parts of the processes. Excel-based tools were developed to streamline emission estimation in nearly real-time and help the facility monitor compliance.

2018-2019

**Evaluation of Traffic-related Air Quality Impact, Oslo Municipality, Norway**

Technical lead in two separate studies to evaluate the impact of expansion of two hospital complexes and associated traffic emissions on local air quality. The sources considered include traffic on the campus, on surrounding public roads, and emissions from a tunnel portal and a tunnel ventilation stack. Emission inventories were developed for the baseline and future traffic scenarios in accordance with Norwegian emission guidance. Dispersion modelling was carried out using AERMOD model. Predicted concentrations

were used to evaluate long- and short-term impacts from traffic-related emissions at the hospital campus and the surrounding residential areas.

2017-2019

**Air Quality Assessment, Proposed Mining and Processing Facility, Utah**

Project manager and technical lead on a multi-year air quality modelling project for a proposed mining and processing facility to support the National Environmental Policy Act (NEPA) and air permit application. Emission inventories were developed for the construction and operation phase and considered stationary sources, mobile onroad and offroad equipment, and windblown dust, as well as offsite sources associated with the construction of supporting infrastructure (roads, power lines, pipeline). The project site extends over an area of more than 100,000 acres with high spatial and temporal variability in emissions over the project lifetime (~30 years). Developed a semi-quantitative screening method to identify the project phases which would result in the worst-case air quality impacts for each pollutant and averaging period evaluated. The work was carried out with the oversight from federal and state agencies including the United States (U.S.) Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Utah Division of Air Quality (UDAQ).

2019

**Evaluation of the Fate of PFOA Airborne Emissions, Paint Spraying Facility, United States**

Key technical resource in dispersion modeling effort to assess air quality against the Protective Action criterion for PFOA. Another goal was to evaluate relative contribution of gas-phase and particulate deposition pathways of Per- and polyfluoroalkyl substances (PFOA). Reviewed and evaluated published PFOA thermodynamic properties used in deposition modeling PFOA. In case of deposition parameters with high uncertainty sensitivity analysis was conducted. The results were used to evaluate the potential partitioning of mass deposited in close range (e.g. facility rooftop, property boundary) as opposed to long-range deposition affecting surrounding communities.

2019

**Ambient Air Monitoring, Building Product Manufacturing, United States**

Managed a project to assist a client develop an ambient air monitoring program for PM<sub>10</sub> and PM<sub>2.5</sub>. Carried out dispersion modelling to allow 3-D visualization of the concentration profiles and identify the locations most frequently impacted by facility emissions. The result of this analysis and consideration of the impacts from nearby facilities were used to develop recommendations for the optimal monitor siting along the facility property boundary.

2016-2018

**Air Quality and Process Assessment of a Coal-fired Power Plant, Guatemala**

Managed two separate air quality studies for a 300 MW coal-fired power plant in Central America following International Finance Corporation (IFC) guidelines and Equator Principles. In the original scope - conducted in support of an Environmental Impact Assessment - a facility-wide emission estimates were developed and dispersion modelling was conducted to assess compliance with international air quality standards for a proposed 50%-50% coal-petcoke fuel mix. The follow-up study involved a review of current operations and a feasibility assessment of fuel switch to 100% petcoke. Used process data to develop an integrated mass balance to evaluate process chemistry and control efficiencies for current operations. This information was used to estimate the impact of the proposed fuel switch on the facility emissions and compliance with applicable air quality standards.

2018

**Evaluation of Traffic-related Air Quality Impact, Norway**

Technical lead in a study to support land use planning and development efforts in a municipality in Northern Norway. NO<sub>2</sub> and PM<sub>10</sub> emissions from on-road traffic, tunnel, and shipping activities were developed for a baseline and a proposed mixed-use development. Due to unique climate and long winter season, development of particulate matter emissions from road traffic required consideration of the use of studded tires and road salt applications. Modelled concentrations for the present (baseline) scenario were compared to ambient monitoring data to validate the emission estimation and modelling approach.

Predicted impacts for future scenario were used to assess the project compliance with Norwegian Pollution Regulations and Norwegian Guideline for the Treatment of Air Quality in Land Planning.

2017-2018

**Litigation support: Radioactive Waste Storage, United States**

Managed a litigation project which involved estimation and reconstruction of historical emissions of radioactive metal species associated with storage and handling of radioactive waste materials. Historical activity data, physical, chemical and thermodynamic data for radioactive nuclei and their compounds were considered in developing mass balance and estimating likely speciation and partitioning of the species in ambient air and soil.

2017-2018

**Identifying Sources of Hexavalent Chromium Emissions, Power Generation Sector, United States**

Investigated likely sources of hexavalent chromium emissions in a process identified as a source of hexavalent chromium emissions. The integrated nature of the process which consisted of more than ten components did not allow direct testing of emissions from individual components. While the feedstock does not contain chromium, the process equipment is made of different types of Cr-based stainless steel which are exposed to different process conditions. Reviewed process and source testing data and performed chemical, thermodynamic and probabilistic analysis to develop a mass balance for total and hexavalent chromium. Identified the process zones that are most likely sources of hexavalent chromium and provided recommendations for further testing to validate the theoretical analysis.

2011-2018

**Assessment of Construction and Operational Emission Using CalEEMod**

**Various Transit-oriented, Industrial and Commercial Developments in California**

Provided permitting assistance to California-based clients on various commercial, residential, and industrial land use development projects. Developed detailed emission inventories of greenhouse gas (GHG) and Criteria Air Pollutants (CAP) for construction and operational phase using California Emissions Estimation Model (CalEEMod).

2016-2017

**Multimedia Model Development, Electrical Power Research Institute (EPRI), United States**

Key technical resource in the development of a new generation of a multimedia model (TRUE-2) for EPRI. The model is used to assess potential health risks associated with emissions of trace metals from coal-fired power plant stacks and ash impoundments. The model comprises of non-proprietary and publicly available software and tools, including models developed and/or accepted by the U.S. Environmental Protection Agency (EPA). The model integrates AERMOD and SCHICHEM Air Dispersion modules, Surface Water & Sediment, and Groundwater modules to simulate partitioning, transportation, and transformation of contaminants between different media and multiple exposure pathways (e.g. inhalation, dermal exposure, food chain path) to estimate human health risks.

2014-2017

**Environmental Air Assessment and Air Permit Application on a Proposed Grain Terminal, British Columbia**

Modelling lead in an air quality assessment study completed for the Port of Vancouver for a proposed grain terminal. The emission sources considered stationary sources at the facility (e.g. dust collectors, fugitive dust from unloading and loading grain, boilers) as well as mobile sources associated with the facility (e.g. trucks, locomotives, and vessels). Carried out dispersion modelling using CALPUFF model. Developed an approach to address a deficiency in CALPUFF model in the use of building downwash data. The proposed method was accepted by the reviewing agencies and implemented in the regulatory modelling to demonstrate the project compliance with British Columbia air quality objectives.

2011-2017

**Air Quality Assessment – Evaluation of Traffic-related Impacts Using CAL3QHCR Model**

**Various Transit-oriented and Commercial Developments in California**

Developed roadway traffic emissions and performed CAL3QHCR dispersion modelling in support of numerous air quality and human health risk assessment studies to evaluate the impact of project-related traffic at nearby residential and sensitive receptor areas. Vehicular emissions were estimated using

project-specific traffic data and California Air Resource Board EMFAC (Emission Factor) Model. In some cases the predicted concentrations for particulate matter were used to evaluate the need for additional indoor air filtration systems at proposed developments.

2016

**Electric Arc Furnace Mass and Energy Model, Iron and Steel Industry, United States**

Developed an Electric Arc Furnace (EAF) mass and energy model to estimate off-gas parameters during different stages of steel melting and refining. The model was used to assist in evaluation of the ventilation system in two U.S.-based steel making facilities.

2015-2016

**Method to Estimate Thermodynamic Data for Pure Chemicals, Chemical Manufacturing Sector, United States**

Developed a methodology to estimate thermodynamic properties (e.g. vapor pressures) over wide temperature ranges for chemicals without experimental or literature data. The methodology was accepted by regulatory/reviewing agencies in the U.S. and Canada and has been routinely used by Ramboll in developing emission estimates for chemical manufacturing and other type of industrial facilities.

2015-2016

**An Inventory of Transportation Fuels and Technologies in Canada, Natural Resources Canada (NRCan)**

The objective of this project was to compile, review and evaluate for credibility the data relevant to economic and environmental policy making in Canada and individual provinces. Carried out a comprehensive review of the most recent data on transportation fuels and technologies in Canada. The review included all modes of transportation as well as fuel lifecycle information (well to pump and pump to wheels).

2014-2015

**Litigation support: Refinery Flaring Event, United States**

Technical support in a litigation case which involved evaluation of emissions associated with an incidental release. Reviewed process data to estimate emissions for nearly 20 contaminants. Combined analysis of monitoring and dispersion modeling data was carried out to evaluate compliance with applicable air quality standards.

2014-2015

**Litigation support: Aircraft Manufacturing Facility, United States**

Technical support in a litigation case involving evaluation of historical emissions from an aircraft manufacturing facility over a period of several decades. Facility-wide emissions were developed for more than 30 compounds. Took part in various aspects of the project including emission estimation and dispersion modelling. Developed an integrated programming tool to automatize dispersion modelling and analysis of the impacts resulting from a large number of modelling scenarios.

2015

**Identifying Sources of Hexavalent Chromium Emissions, Facility in High Energy Intensity Sector, Canada**

Assisted the client in identifying potential sources of emissions of hexavalent chromium. The process feedstock does not contain chromium although chromium-based refractory brick and stainless steel are building blocks of the equipment used in the facility. Reviewed relevant process information including feedstock, process parameters, historical rebuild, materials, and stack testing data to evaluate the potential of chromium mobilization and oxidation from different process equipment surfaces and identify the process segments most likely to contribute to hexavalent chromium emissions.

2010-2015

**Air Quality Assessment Studies for the Canadian Industrial Sectors, Health Canada**

Technical lead in several independent air quality assessment studies completed to evaluate impacts from different industrial sectors in Canada on local and regional air quality. The sectors evaluated include base metal smelting, petrochemical, cement and fertilizer manufacturing. The studies involved development of comprehensive emission inventories for stationary and mobile sources. CALPUFF/CALMET dispersion modelling system was used to predict concentrations and deposition fluxes which were used as inputs into human health risk assessment. The predicted concentrations and deposition rates were compared with

ambient monitoring data to infer the contribution of the facilities on the local and regional air quality. Developed various computational tools to manage large data sets and facilitate, dispersion modelling, postprocessing and statistical data analysis.

2012-2014

**Litigation support: Pharmaceutical Manufacturing Facility, United States**

Technical support in a multi-year litigation case which involved reconstruction of historical activity data, emissions and cumulative human exposures over a 90-year period from a pharmaceutical facility. Used historical process data and chemical use records to reconstruct emissions of more than 20 compounds. Principal investigator in the reconstruction of hexavalent chromium emissions from cooling towers which were a key driver in the overall exposure risk. Provided support to the expert and legal team including scientific literature review, monitoring data analysis, dispersion modelling, review of expert reports and rebuttals, and technical support to counsellors during expert witness deposition.

2012-2013

**Analysis of the Trends and Spatial Variation in the Composition of Fine Particulate Matter  
Environment Canada**

Technical lead on a study to evaluate the composition, trends, and temporal and spatial variation of PM<sub>2.5</sub> near the Canada-United States border in the period between 2003 to 2010. Ambient monitoring data from the Protective Visual Environmental (IMPROVE) and the National Air Pollution Surveillance (NAPS) programs were analysed to evaluate spatial distribution and temporal trends of PM<sub>2.5</sub> and its components which were then compared to provincial and state emissions trends from NPRI and NEI databases. The analysis considered meteorological effects to infer the impact of regional transport across Canada-US border on ambient air quality.

2011-2012

**Forecasting of Emissions for Onroad Vehicles and Marine Vessels in Canada  
Electric Power Research Institute (EPRI), United States**

The goal of this study was to prepare criteria air contaminant (CAC) and Greenhouse Gas (GHG) emission inventories for onroad vehicles, offroad equipment, marine and air traffic sources in Canada for different electrification penetration scenarios. Developed projections for on-road vehicle activity, fuel consumption, and associated emissions for Canadian provinces for years 2010-2050 for different electrification penetration scenarios based on vehicle activity data such as vehicle population and age distribution, vehicle miles travelled growth rates, sales growth factors, etc. On-road emissions were generated using the vehicle emission estimation model MOVES. Developed a methodology to forecast CAC and GHG emissions for marine vessels in Canadian ports based on the population growths forecast, vessel turnover rates, and phasing in of Emission Control Area (ECA) fuel standards and emission standards for various marine engine categories.

2011-2012

**Evaluation of Historical Trends in Ambient Ozone Concentration, Environment Canada**

Technical lead in Environment Canada's study to evaluate historical trends of ambient ozone concentrations at multiple urban and rural locations in eastern Canada. Performed meteorological adjustment of measured O<sub>3</sub> levels over a 15-year period. Analysed temporal trends of ambient ozone and their statistical significance using parametric and non-parametric statistical diagnostics. Statistical modelling performed using Generalized Linear Model and statistical software R.

2008-2012

**Air Quality Study for Environmental Assessments, Mining Sector**

Technical lead in the air quality assessment studies for several metal mining developments to assess the proposed project compliance with applicable Canadian and/or International Finance Corporation (IFC) standards and guidelines. The projects include Kinross gold mine development, Ecuador; Prairie Creek zinc/lead/silver development, NWT; and Kabanga Nickel Project, Tanzania. Developed emission inventories from underground and surface mobile and stationary sources and fugitive dust; conducted air quality dispersion modelling for the construction and operation activities associated with the projects.

2008-2010

**Air Quality Studies for Environmental Assessment, Power Generation Sector, Canada**

Provided technical support on numerous air quality assessment studies for power generation facilities across Canada including: Nuclear power plant Bruce Power – Tiverton (ON); Coal-fired power plants Nanticoke (ON) and TransAlta - Keephills (AB); Natural-gas fired power plant (cogeneration facility) ENMAX- Bonnybrook (AB); and Energy-from-waste facility Covanta, Gold River, Vancouver (BC). Involved in various aspects of the assessment including development of emission inventories associated with project construction, expansion, and operation. Carried out dispersion modelling using AERMOD or CALPUFF modelling system. Performed dispersion modelling to evaluate impact of cooling tower and flue gas plumes on fogging and icing on roads and power lines using CALPUFF model.

2008-2010

**Regional Air Quality Modelling, City of Toronto, Ontario**

Technical lead in a study carried out for the City of Toronto to assess local air quality and cumulative impacts of the local (City of Toronto), regional (Ontario) and trans-boundary (North-east U.S.) pollutants. Ontario-wide emission inventories were developed for industrial, commercial, residential, agricultural, biogenic, on-road and off-road mobile sources using bottom up approach. Dispersion modelling using tiered approach was performed using CALPUFF modelling system. Ambient Criteria Air Contaminant (CAC) concentrations from National Air Pollution Surveillance (NAPS) network and meteorological data were analysed to validate modelling results and estimate contributions from the local sources and long-range transport on local air quality.

2010

**Litigation support: Cement Manufacturing Facility, Canada**

Technical support in evaluating the feasibility and potential impact of proposed co-firing with biomass. Carried out literature review on fuel utilization and burning practices in cement sectors in Canada, the U.S. and Europe and the impact of alternative fuels on the facility operation and air emissions. Estimated potential qualitative impact of biomass co-firing on process conditions and emissions. Proposed changes to the continuous monitoring system to meet the new needs in monitoring process parameters and criteria air contaminant emissions.

2010

**Study on Alternative Fuel Opportunities for City Fleet, City of Calgary, Alberta**

A key technical resource in a study to assess the impact of alternative fuels on greenhouse gas (GHG) and criteria air contaminant (CAC) emissions for the City of Calgary's heavy-duty fleet including transit based and refuse trucks. Took part in the development of a tool for emission comparison and cost benefit analysis of different alternative technologies based on direct and lifecycle emissions. Lifecycle emissions estimated using GHGenius model.

2008-2009

**Regional Air Quality Modelling****Halton Region, Ontario**

Technical support in an air quality modelling study carried out for Halton Region of Ontario. Involved in the development of municipality-wide emission inventories of industrial, commercial, residential, agricultural, biogenic, and on-road and off-road mobile sources. Carried out dispersion modelling using CALPUFF/CALMET modelling system.

2008

**A New Methodology for Modelling Emissions from Horizontal Vent Raises, Ontario Mining Association**

Technical lead in the development of a methodology to model fugitive emissions from vent raises - sources characteristic of underground mining sites. The methodology allows parameterization of vent raises for different source orientations (horizontal, angled and vertical), meteorological parameters, and site configurations. Developed a modelling procedure to implement the iterative approach into AERMOD dispersion model in a single step. The methodology was approved by Ontario Ministry of the Environment, Conservation and Parks for regulatory modelling of mining sites.

## PEER-REVIEWED PUBLICATIONS

1. B. Cosic, T. Roumeliotis and P. Labarge, "Estimating Emissions from Plastic-to-Fuel Pyrolysis: Data Needs, Challenges and Methods to Estimate Air Emissions", 27<sup>th</sup> International Conference on Thermal Treatment Technologies & Hazardous Waste Combustors, January 27-28, 2021.
2. K. Vijayaraghavan, B. Cosic, R. Beardsley, M. Traister, and K. Cooper, "Atmospheric Deposition of Perfluoroalkyl Substances", A&WMA 113th Annual Conference & Exhibition, June 30-July 2, 2020.
3. S. Cho, K. Vijayaraghavan, D. Spink, B. Cosic, M. Davies, and J. Jung, "Assessing the effects of oil sands related ozone precursor emissions on ambient ozone levels in the Alberta oil sands region, Canada", *Atm. Env.* Vol. 168, 62-74, 2017.
4. B. Cosic, M. Jammer and R. Singh, "Characterization of Background Concentrations for Dispersion Modeling Assessments", 107<sup>th</sup> Annual A&WMA Annual Proceedings, Long Beach, CA, June, 2014.
5. R. Singh, M. Jammer, B. Cosic, and Lit Chan "Development of a Transit Emission Model (TRANSEM)", 106<sup>th</sup> Annual A&WMA Annual Proceedings, Chicago, IL, June, 2013.
6. B. Cosic, M. Jammer, S. Capstick, C. Ransom, "Buoyant Line Plume Model Sensitivity Analysis", 103<sup>rd</sup> Annual A&WMA Annual Proceedings, Calgary, June, 2010.
7. A. Ciccone, C. Morgan, B. Cosic, R. Mahabir, S. Hartono, I. Yankova, B. Smith, S. Gower, C. Dejong, "An All Sources and Cumulative Air Quality Study - City of Toronto", 103<sup>rd</sup> Annual A&WMA Annual Proceedings, Calgary, June, 2010
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