École Champlain
Air Quality Study

Final Report

Department of Environment and
Local Government
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1.0 Background

In 2009 the New Brunswick Department of Environment and Local Government (DELG) conducted an air quality study at MacAleese Lane in Moncton, New Brunswick. The work was carried out in response to concerns raised by area residents, including staff and students of the nearby École Champlain. At issue were emissions from a nearby light industrial park.

On April 29, 2010, DELG issued its final report on the MacAleese Lane study and identified no exceedances of air quality objectives for any of the pollutants identified, with the exception of three events that resulted in high total suspended particulate levels. Overall, air quality in the MacAleese Lane area was found to be comparable to DELG's permanent air quality monitoring station in Moncton, which is located on Thanet Street, approximately 2.5 km southwest of the study site.

Since 2010 additional air quality complaints have been lodged with DELG's regional office for Moncton (DELG Region #3) with respect to air quality at École Champlain. A review of recent air quality complaints for the area identified dust/smoke and "propane odour" as the key concerns. The location of École Champlain in relation to nearby landmarks and the previous 2009 study site is illustrated in Figure 1. The illustrated landmarks have been included due to their potential for air contaminant emissions, which are described further in Appendix A.

Recognizing the extensive list of parameters that has been investigated previously in this area the current study focuses on two key areas of interest, rather than attempting to replicate past work. The two air quality parameters for the study are Total Reduced Sulphur (TRS) and Total Suspended Particulate (TSP).

The TRS parameter is useful when investigating odour issues. A TRS monitor can detect a variety of compounds that contribute to odour. However, the instrument cannot discern which specific odorant compound(s) it has detected. Thus, TRS monitors are best suited to establishing the presence of odourous compounds, or when a specific TRS compound is already known or is suspected to be impacting an area (e.g., based on emissions data from nearby sources).

For the current study, it is expected that a TRS monitor may detect certain compounds associated with nearby propane tank recycling activities wherein empty tanks are cut-up for scrap metal. Note that although "propane odour" was identified as a concern for the study area, propane itself is an odourless gas. "Propane odour" is the result of odorant TRS compounds (ethanethiol, also known as ethyl mercaptan, and methanethiol, also known as methyl mercaptan) that are added to propane for the purposes of facilitating leak detection. These substances can be released from propane tanks during recycling activities even after all propane has been removed and the tanks depressurized.

Total Suspended Particulate (TSP) is a measure of all wind-borne particles. This parameter was selected primarily due to the three TSP exceedances that were detected during the 2009 study. Also, particulate impacts (e.g., dust and smoke) continue to be reported at the school. It should also be noted that follow-up work at the school in 2010 investigated the smaller 10 micron particulate matter (PM_{10}) parameter, but identified no issues.

On March 19, 2014 DELG established TRS and TSP monitoring equipment at École Champlain. Monitoring continued for one year, ending on March 20, 2015. This report presents an analysis of the data collected over that period.

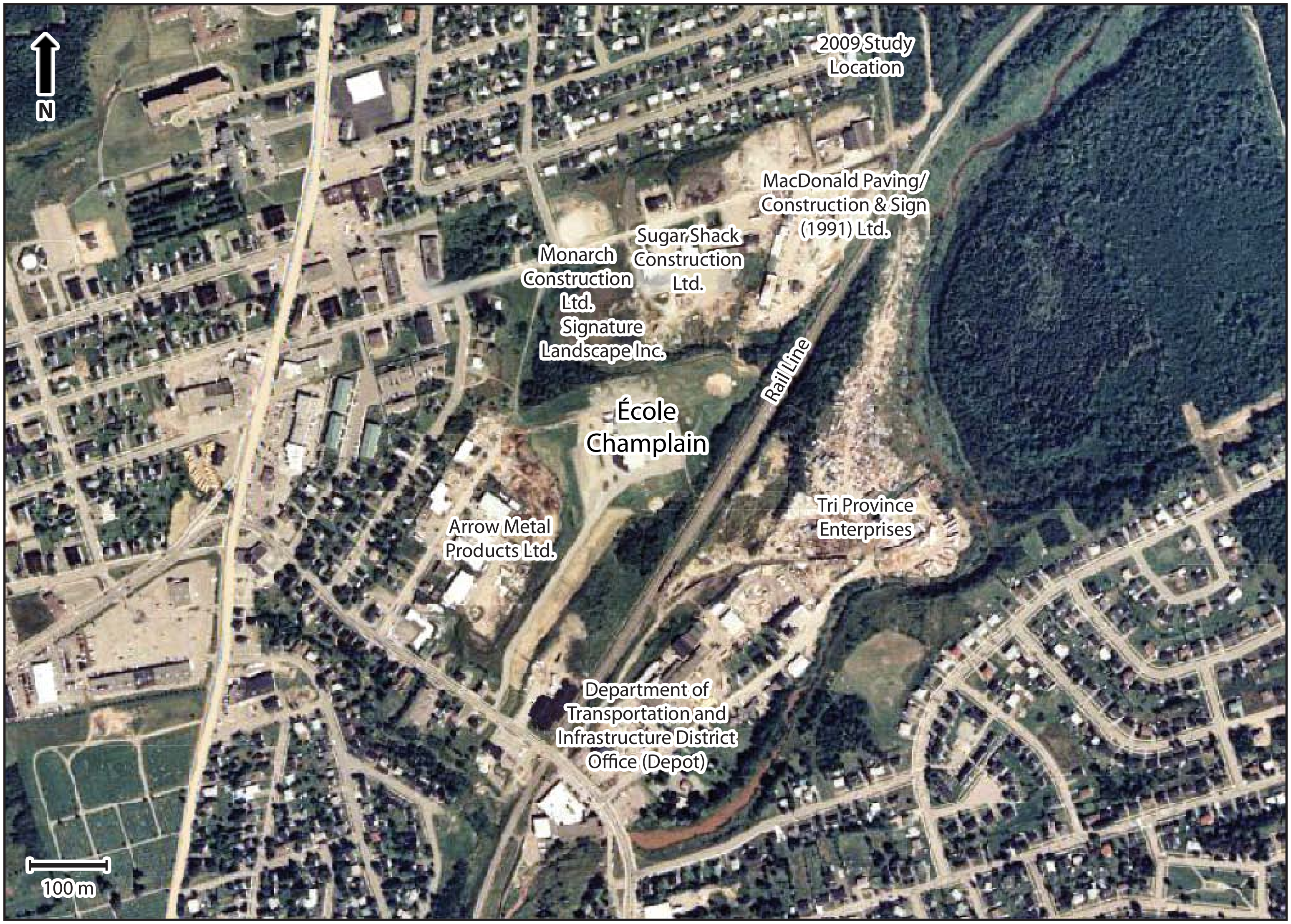

Figure 1. Location of École Champlain. (Base map image courtesy of GeoNB).

2.0 Methodology

2.1 Monitoring Equipment

DELG deployed monitoring equipment to measure ambient (outside air) concentrations of: Total Reduced Sulphur (TRS) and Total Suspended Particulate (TSP). Technical specifications for the instruments used are provided in Table 1.

Table 1: Technical Specifications for Air Quality Monitoring Equipment

Parameter	Instrument	Lower Detection Limit	Resolution
Total Reduced Sulphur (TRS)	Thermo Environmental Instruments Pulsed Fluorescence SO_2 Analyzer, Model 43*i*, modified for TRS measurement using a CD Nova-Tech Inc. Thermal Oxidizer, Model CDN-101 operated at 850°C.	1 ppb (60 second average of 300 millisecond samples)	± 0.5 ppb (noise) ± 1.0 ppb or 1% (precision)
Total Suspended Particulate (TSP)	Met-One Instruments Inc. Continuous Particle Monitor, model BAM-1020, outfitted with a TSP head.	4.8 $\mu g/m^3$ (hourly) 1.0 $\mu g/m^3$ (daily)	± 0.2 $\mu g/m^3$

Meteorological equipment (Vaisala model WXT520) was also deployed at the site to provide Wind Speed (WS) and Wind Direction (WD) data to inform data analysis. The meteorological unit also collects Relative Humidity (RH), Temperature (T), and Barometric Pressure (BP) parameters.

All equipment was housed at École Champlain.

2.3 Operation and Data Management

Continuous monitoring began on March 19, 2014 and concluded on March 20, 2015.

Total reduced sulphur data was logged as five minute averages. Total suspended particulate data was logged as hourly averages.

The data was retrieved automatically on an hourly basis for all parameters measured.

2.4 Other Data Sources

School district (district scolaire francophone Sud) personnel at École Champlain were invited to participate in the study by recording their observations of odours or other air quality issues during the study period.

2.5 Location

The work was carried out at École Champlain (211 Mill Street), Moncton, New Brunswick (46°6’32”N 64°46’1”W). The study area is pictured in Figure 1.

3.0 Results

3.1 Meteorology - Wind Speed and Direction

Hourly average wind speed and direction are illustrated via a wind rose diagram in Figure 2. As indicated in the wind rose diagram, winds at the study location originate most frequently from the southwest. Easterly and northwesterly winds were relatively rare.

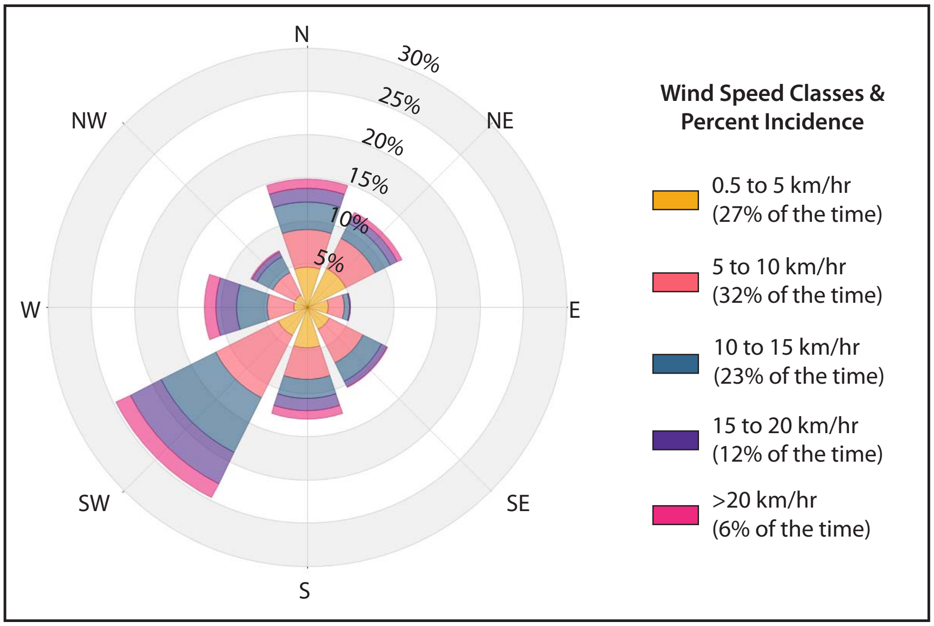

Figure 2. Wind Rose - École Champlain (March 19, 2014 to March 20, 2015)

Wind patterns are further illustrated in relation to nearby potential air contaminant emission sources in Figure 3.

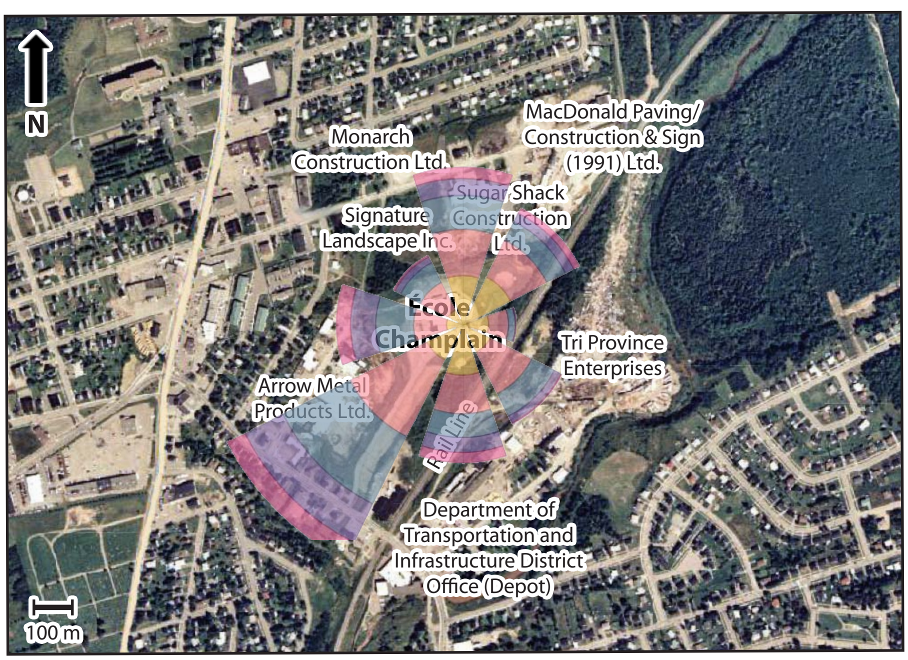

Figure 3. Wind Rose Diagram - Site Map Overlay. (Base map image courtesy of GeoNB).

3.2 Meteorology - Relative Humidity (RH)

Daily average relative humidity (RH) values are illustrated in Figure 4. Relative humidity was highly variable during the study period, with no clear seasonal trend. The minimum daily average relative humidity level measured was 36% and occurred on May 14, 2014. The maximum daily average value measured was 91% and occurred on several occasions throughout the year.

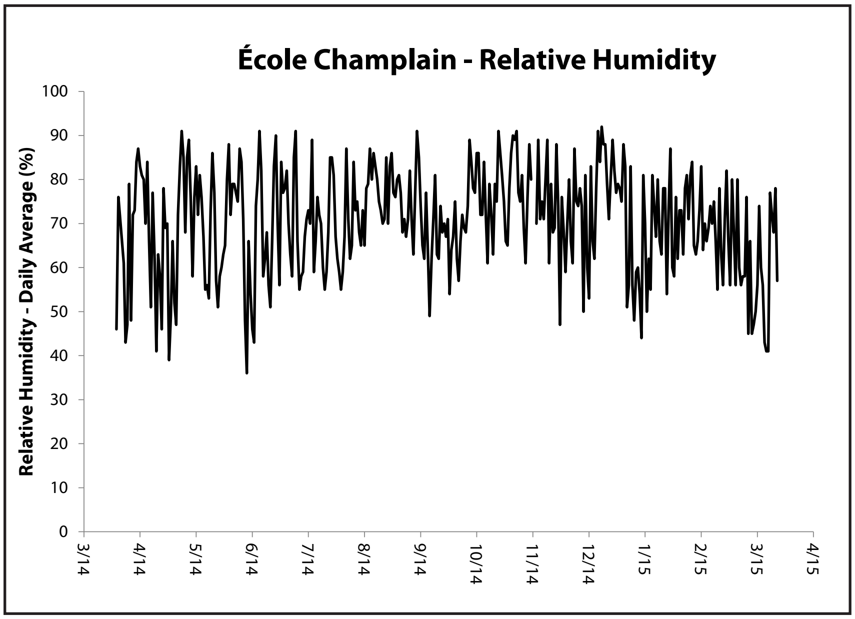

Figure 4. Relative Humidity - Daily Average

3.3 Meteorology - Temperature (T)

Daily average temperature (T) values are illustrated in Figure 5. The minimum daily average temperature measured was -20 degrees Celsius (°C) and occurred on January 15, 2015 and again on February 15, 2015. The maximum daily average value measured was 25 °C and occurred on July 2nd, 3rd, and 4th, 2014.

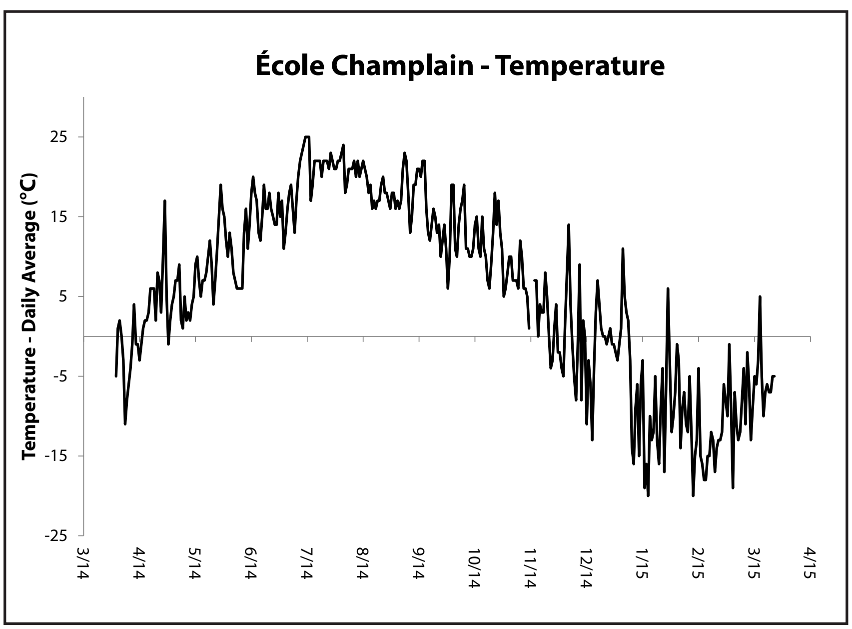

Figure 5. Temperature - Daily Average

3.4 Meteorology - Barometric Pressure (BP)

Daily average barometric pressure (BP) values are illustrated in Figure 6. The minimum daily average BP measured was 738 millimeters of mercury (mmHg) and occurred on January 25, 2015, and again on February 15, 2015. The maximum daily average measured was 779 mmHg and occurred on April 17, 2014, and again on December 8, 2015. The annual average BP was 758 mmHg.

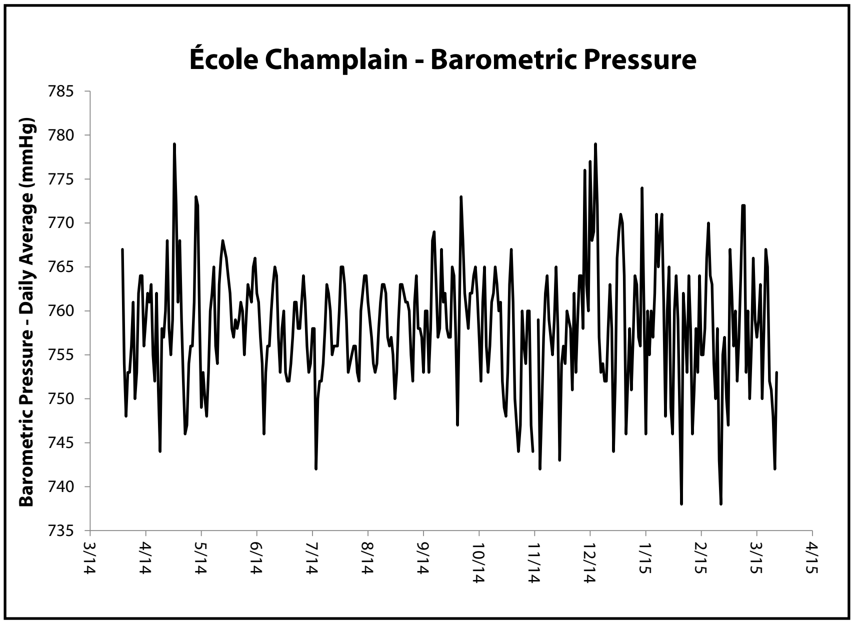

Figure 6. Barometric Pressure - Daily Average

3.5 Odour Observations

Odours of four varieties were detected and recorded by school personnel during the study period. The timing of these odour incidents over the course of the study period are illustrated in Figure 7. Each plotted point identifies a one-hour period during which the indicated odour was observed.

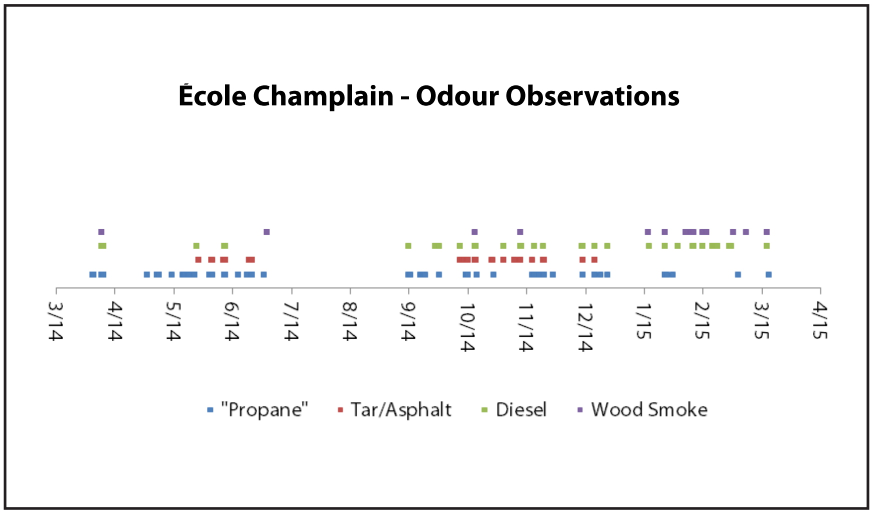

Figure 7. Odour Observation Timeline - Recorded by École Champlain Personnel

The cumulative duration of observed odours on each of the days of the week are illustrated in Figure 8. As indicated, the majority of odour observations occurred mid-week (Tuesday/Wednesday). Note that observations were only possible during regular staff working hours. Hence there were no observations on Saturdays or Sundays.

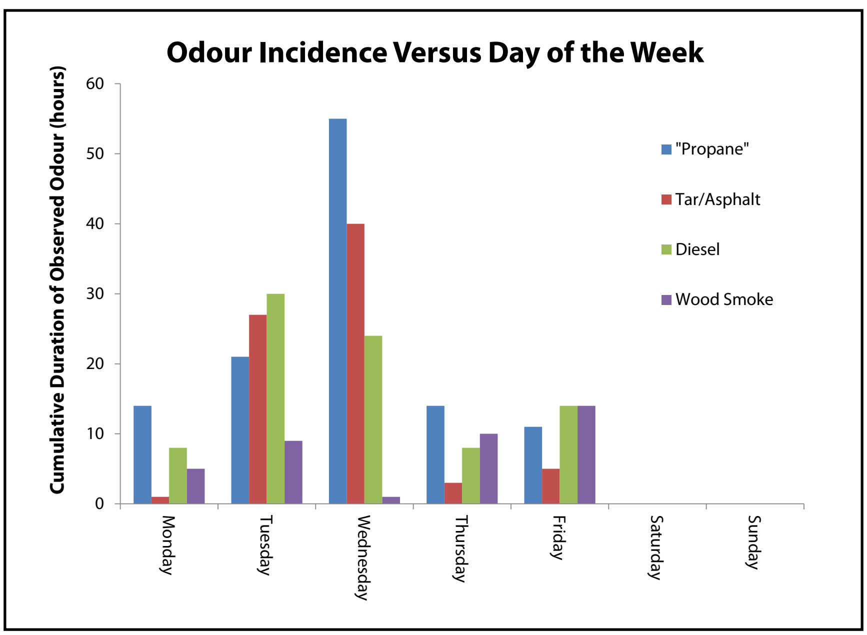

Figure 8. Daily Odour Incidence

The majority of odour observations involved “propane” odour (37% of observations), followed by diesel (27%), tar/asphalt odour (24%), and wood smoke (12%).

The influence of wind direction on odour observations is illustrated in Figure 9. Odour was reported under all wind conditions. However, higher rates of incidence were apparent when the wind originated from the North and Northeast. This tendency was most pronounced for tar/asphalt and diesel odour reports. Wood smoke odour was most frequently report when the wind originated from the Southwest and West.

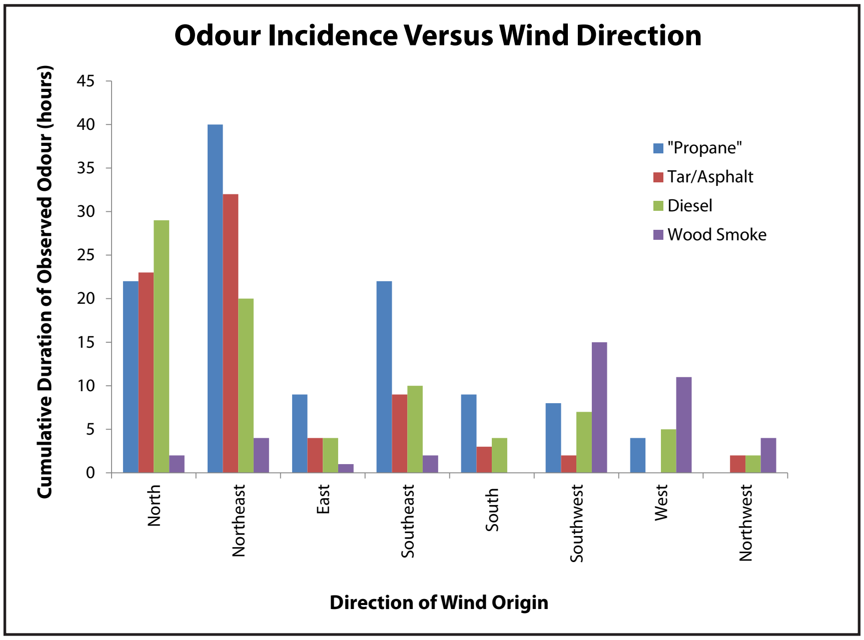

Figure 9. Effect of Wind Direction on Odour Incidence

The influence of wind speed on odour observations is illustrated in Figure 10. Highest rates of incidence were apparent when the hourly average wind speed was low to moderate (between 0 kilometers per hour and 15 kilometers per hour).

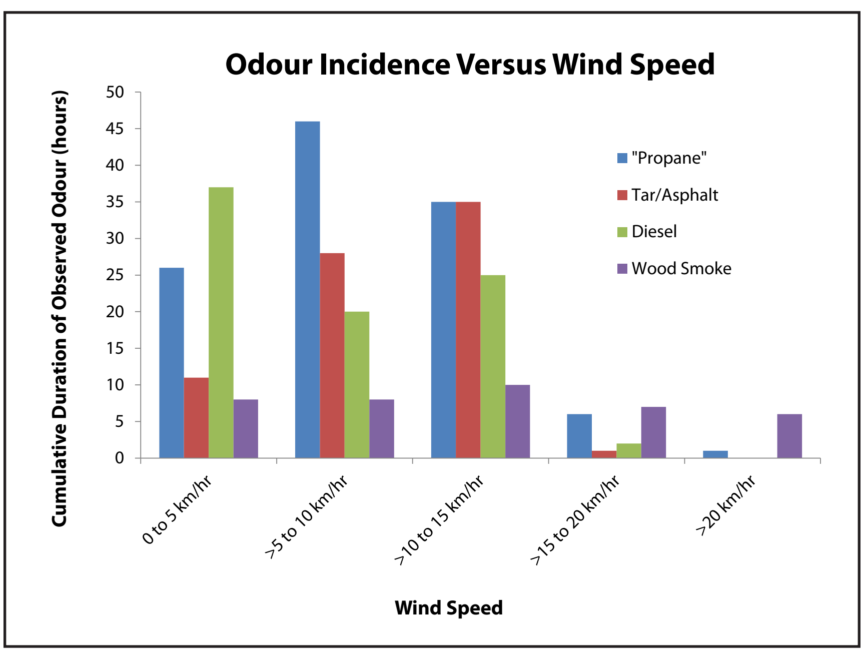

Figure 10. Impact of Wind Speed on Odour Incidence

3.6 Total Reduced Sulphur (TRS)

Total reduced sulphur levels remained below the 1 ppb detection limit for the TRS instrument throughout the majority of the study period. It was detected at very low levels (less than 2 ppb) on only nine occasions. These events are listed in Table 2. The peak five minute average value observed was 1.5 ppb. The peak hourly average value observed was 1.1 ppb, and occurred on May 11, 2014. All values are accurate to +/- 1 ppb, per the specifications of the instrument manufacturer.

Total reduced sulphur events are also compared against wind direction in Table 2. All detections were associated with generally northerly and southerly wind directions.

Table 2. Total reduced sulphur detection events, timing, and associated wind directions

Event Date	Timespan	Duration	Peak Five-Minute Average TRS Value (ppb)	Wind Origin (Predominant)
May 11, 2014	13:15 to 22:35	9 hours, 20 minutes	1.3	North & Northeast
May 20, 2014	06:15 to 8:55	2 hours, 40 minutes	1.1	North
August 21, 2014	23:50 to 23:55	5 minutes	1.1	South
October 14, 2014	06:15 to 07:15	1 hour	1.5	South
November 7, 2014	11:45 to 11:55	10 minutes	1.1	North
November 27, 2014	11:15 to 11:20	5 minutes	1.1	North
January 7, 2015	05:20 to 05:25	5 minutes	1.1	South
January 15, 2015	00:40 to 00:45	5 minutes	1.0	South
January 30, 2015	06:45 to 10:35	3 hours, 50 minutes	1.5	Northwest, North, and Northeast

3.7 Correlation of Odour and TRS

Total reduced sulphur detections are compared against odour incidence reports in Table 3. As indicated, there were two TRS detections that occurred during periods of reported odour. Note that for some of the dates indicated in Table 3, odour was observed, but was not reported to have coincided with the TRS detection (greater than 2 hour discrepancy).

Table 3. Total reduced sulphur detections and reported odour

Event Date	Timespan	Day of the Week	Peak Five-Minute Average TRS Value (ppb)	Reported Odour	Notes
May 11, 2014	13:15 to 22:35	Sunday	1.3	-	Weekend, no personnel on site.
May 20, 2014	06:15 to 8:55	Tuesday	1.1	-	-
August 21, 2014	23:50 to 23:55	Thursday	1.1	-	Summer break, no personnel on site.
October 14, 2014	06:15 to 07:15	Tuesday	1.5	-	-
November 7, 2014	11:45 to 11:55	Friday	1.1	-	-
November 27, 2014	11:15 to 11:20	Thursday	1.1	-	-
January 7, 2015	05:20 to 05:25	Wednesday	1.1	Diesel	Odour reported at 07:00. May be unrelated to TRS detection.
January 15, 2015	00:40 to 00:45	Thursday	1.0	-	After hours, no personnel on site.
January 30, 2015	06:45 to 10:35	Friday	1.5	Diesel and Wood Smoke	-

3.8 Total Suspended Particulate (TSP)

Total suspended particulate (TSP) values are illustrated in Figures 11 and 12. The peak hourly average exceeded 185 μg/m³, which is the maximum value that the monitor was calibrated to discern. These peak values occurred on September 10, and 19. The peak daily (24-hour) average was 72 μg/m³, which occurred on September 19.

The annual average (arithmetic mean) TSP level was 15.0 μg/m³, and the annual geometric mean TSP level was 12.6 μg/m³.

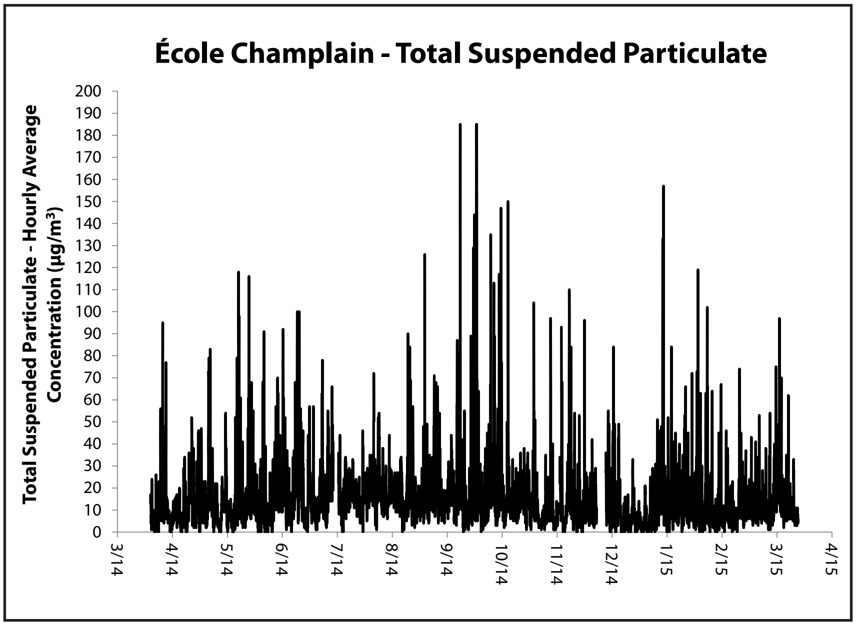

Figure 11. Total Suspended Particulate (One-Hour Average)

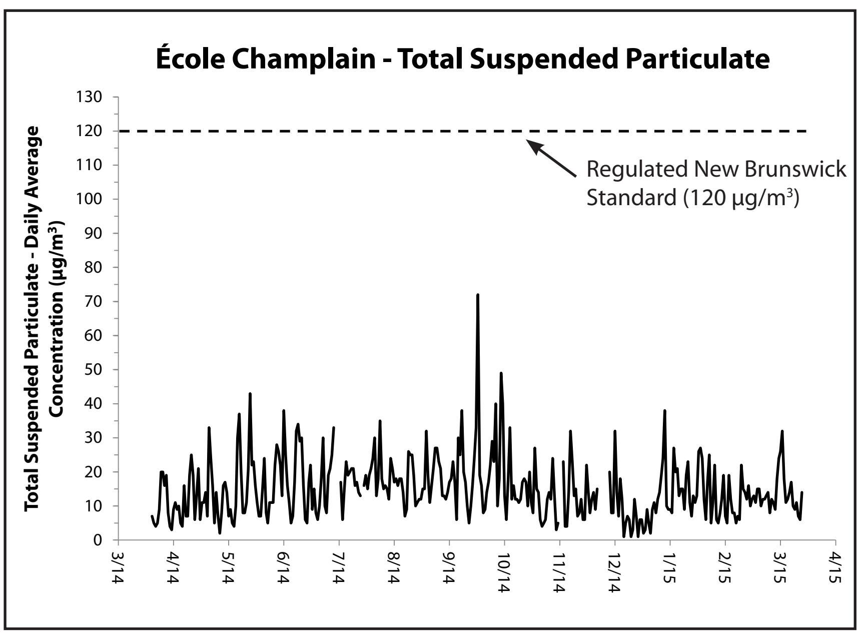

Figure 12. Total Suspended Particulate (24-Hour Average)

Average TSP levels are compared against wind direction in Figure 13. These values represent the overall average hourly TSP values for each each direction (this entails sorting all hourly values by wind direction and calculating an overall average for each). As illustrated in Figure 14, average values were highest when winds originated from generally northerly and southerly directions, and were lowest when originating from the west.

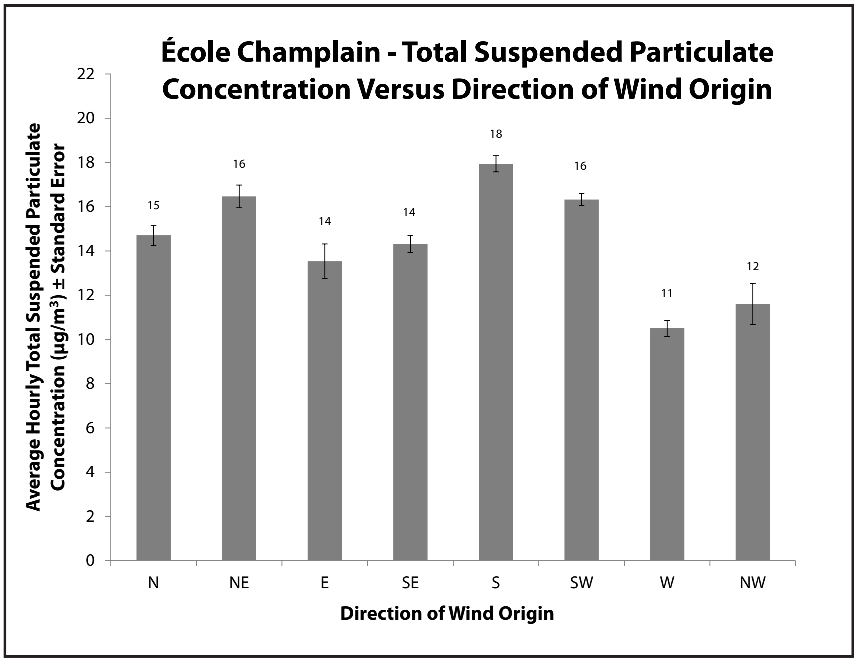

Figure 13. Average TSP Concentration Versus Wind Direction

Peak TSP values (the highest hourly average) for each wind direction is illustrated in Figure 14. These values represent the highest hourly TSP values achieved once all hourly values are sorted by wind direction. As illustrated in Figure 15, winds originating from the northeast and northwest achieved the highest peak values.

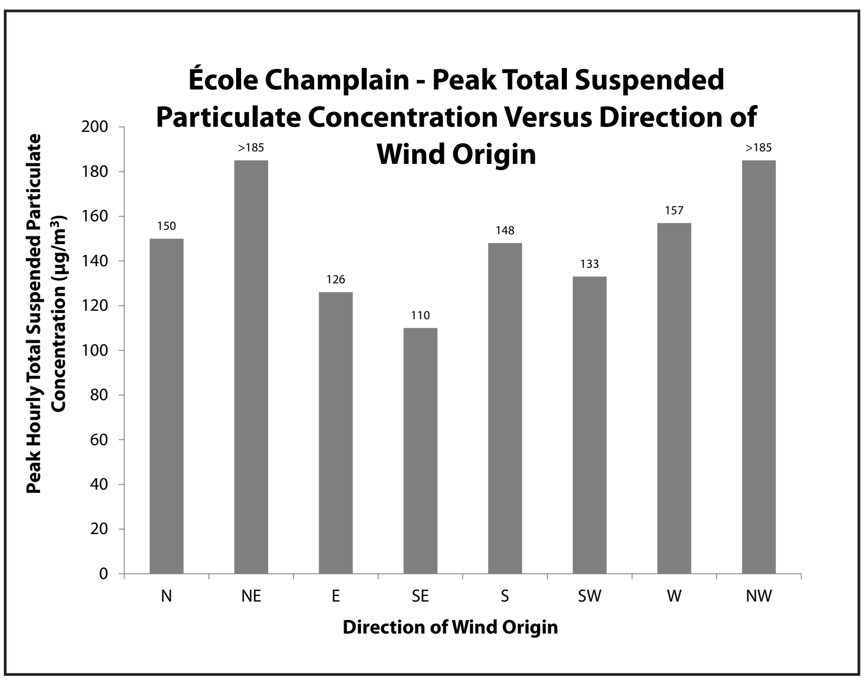

Figure 14. Peak TSP Concentration Versus Wind Direction

4.0 Discussion

4.1 Meteorology

The wind data collected indicate that equipment was suitably located to detect air quality impacts from potential air contaminant emission sources in the area. Predominant local wind patterns would carry emissions from nearby potential emissions sources toward the study location.

Temperature, relative humidity, and barometric pressure data may have proved useful in understanding the impact of weather on air quality events in the area. However, there was insufficient data for relevant parameters (TRS and odour reports) to allow a meaningful analysis with respect to these meteorological parameters.

It is beyond the scope of the current study to consider meteorological trends unrelated to air quality impacts.

4.2 Odour Observations

The study period encompassed a total of 8796 hours of monitoring activity. Of these "monitored hours", approximately 2000 occurred during regular business hours for École Champlain. Odours were reported during 229 of these 2000 "observable hours". This represents an odour incidence rate of approximately 11%. That is, odours were reported approximately 11% of the time that people were present at École Champlain.

Odour observations at École Champlain occurred most frequently on Tuesdays and Wednesdays. This suggests that there may be activities in the area that occur (or occur most frequently) during these days that may result in odour releases. However, the data collected do not provide insight with respect to what these activities might be.

"Propane", tar, and diesel odours were most frequently reported when the wind was originating from the north and northeast. As indicated in Appendix A, there are potential sources for all of these odours located to the north of the study site. However, it is not possible to identify a causative link between the odours and specific facilities based on the data collected. "Propane" odour reports were also somewhat more frequent when the winds were originating from the southeast. This may be associated with the propane tank recycling activities occurring in that area.

The relationship between wind direction and wood smoke odour is unclear. There appears to be an association between generally westerly winds and smoke odour reports. As noted in Appendix A, there is a wood smoke source southwest of the study site (Arrow Metal Products Ltd.) but there is no known point source directly west.

Wind speed data suggests a relationship between low to moderate wind speeds and increased incidence of odour. This may reflect the impact of increased mixing/dilution of air masses associated with higher wind speeds.

4.3 Total Reduced Sulphur (TRS)

Total reduced sulphur was detected at very low concentrations on nine occasions during the study period. Winds were originating from generally northerly or southerly directions during these events. As described in Appendix A, there are known potential TRS sources in these general areas that could account for these observations.

As TRS was detected very infrequently during the study there is insufficient data available to carry-out a meaningful correlation against odour observations. However, as outlined in Table 3, the available data is not suggestive of a strong relationship. Of the six TRS detection events that took place while personnel were on site to make observations, only two were recorded as odour events. Also, there were many odour reports during the study period that were not reflected in the TRS data.

The poor correlation between TRS and odour may be due to the odour recognition threshold (the concentration at which 50 percent of a human panel can identify the odour) for some TRS gases. This threshold is close to the lower detection limit for the TRS instrument. Table 4 lists the odour recognition thresholds for some common TRS gases. It should also be noted that the ability to detect odours varies widely between individuals, with more than a thousandfold difference between the least and the most sensitive[1]. It is therefore possible that personnel at the school might detect odours at concentrations much lower than those indicated in Table 2, and below the lower detection limit for the TRS instrument.

Table 4: Total Reduced Sulphur Compound Odour Information

Compound	Odour Recognition Threshold[1]	Odour Description
Ethyl mercaptan	1 ppb	Decayed cabbage ("propane")
Methyl mercaptan	2.1 ppb	
Hydrogen sulphide	4.7 ppb	Rotten eggs
Dimethylsulfide	1 ppb	Decayed vegetables

The target TRS gases for the current study were ethyl and methyl mercaptan. There are no regulated ambient air quality standards for these gases in New Brunswick. However, it is illustrative to compare the current data against standards that have been adopted in other jurisdictions.

The Province of Ontario has recently developed an Ambient Air Quality Criterion (AAQC) for mercaptan of 13 µg/m^3 (5.2 ppb) based on a 10 minute averaging period. The peak 10 minute average TRS value measured at École Champlain was 1.4 ppb, which provides an upper limit for all TRS gasses that may be present, including mercaptans. This is well below the Ontario AAQC. It should also be noted that the Ontario AAQC was developed specifically to address odour impacts.

[1] Powers, W. *The Science of Smell Part 1: Odour perception and physiological response*. PM 1963a. Iowa State University, University Extension. May 2004. (Available at http://www.extension.iastate.edu/Publications/PM1963A.pdf)

British Columbia has adopted an Ambient Air Quality Objective (AAQO) for TRS of 5 ppb (hourly average), which is also above the levels detected at École Champlain.

For additional context, the United States Occupational Safety and Health Administration (OSHA) has established recommended workplace exposure limits (REL) of 500 ppb for both ethyl and methyl mercaptan, based on a 15 minute exposure ceiling. Levels at École Champlain (peak level of 1.5 ppb - five minute average) were much lower than this reference value throughout the study period.

New Brunswick has a regulated standard of 11 ppb (hourly average) for hydrogen sulphide, which is another odorous reduced sulphur gas that is detected by TRS monitors. The maximum hourly TRS concentration observed at École Champlain was 1.1 ppb, which provides an upper limit for all TRS gasses that may be present, including hydrogen sulphide. This compares favourably to the New Brunswick standard.

The provincial air quality monitoring network includes three stations in The City of Saint John that monitor TRS on a continuous basis. Peak hourly values for these stations measured over the same period as the current study were all higher than the peak hourly value at École Champlain. Comparisons are provided in Table 5.

Table 5: Peak Hourly TRS Comparisons Between New Brunswick Stations

Location	Peak Hourly TRS Concentration During the Study Period
École Champlain (Moncton)	1.1 ppb
Forest Hills Subdivision (Saint John)	5.0 ppb
Westside Station (Saint John)	3.0 ppb
Champlain Heights Elementary School (Saint John)	4.0 ppb

4.4 Total Suspended Particulate

Total suspended particulate (TSP) values at the site remained below the regulated 24-hour limit of 120 μg/m^3 throughout the study period. New Brunswick also has a regulated annual (one year geometric mean) limit for TSP of 70 μg/m^3. The annual geometric mean TSP value at École Champlain was well below this standard (12.6 μg/m^3)

Peak hourly TSP values were highest when winds were originating from the northeast and northwest (see Figure 15). However, mean hourly TSP values were highest when the winds were generally northerly and southerly. As indicated in Appendix A and illustrated in Figure 1, there are several potential particulate emission sources located approximately north of the study site that could be contributing to the values observed. However, influences from more distant sources cannot be precluded. None of the facilities located south of the study site have been identified as significant potential particulate emission sources. However, all of the facilities listed in Appendix A have the potential to generate particulate emissions to some degree.

4.5 Implications for Human Health

The New Brunswick Department of Health has reviewed the data collected and has provided the following statement with respect to the potential for human health impacts:

> *"Little is known about long term exposures to ethyl or methyl mercaptan. However, given that local sources are located offsite of the school property, exposures are expected to be transient in nature and not ongoing for extended periods of time. In that light, guidelines addressing acute (*i.e., *lasting minutes or hours) exposures are more relevant to this setting. Based on a review of currently available guidelines on mercaptans and TRS, it is believed that the health risk to students, visitors and staff from transient exposure to the very low levels measured to date would be negligible. However, since the odor threshold for some of these products is very low, odors can and have been noticed on occasion and can be a nuisance to some."*[2]

[2] Dr. Yves A. Léger, Medical Officer of Health, East Region, New Brunswick Department of Health. Personal communication. May 29, 2015.

5.0 Glossary of Abbreviations

AAQC	Ambient Air Quality Criterion
BAM	Beta Attenuation Mass (mass measurement through beta ray attenuation)
BP	Barometric pressure
°C	Degrees Celsius
DELG	New Brunswick Department of Environment and Local Government
km/h	Kilometers per hour
mmHg	Millimeters of Mercury
OSHA	Occupational Safety and Health Administration
PM_{10}	Particulate matter less than 10 microns in diameter
ppb	Parts per billion
REL	Recommended exposure limit
RH	Relative humidity
T	Temperature
TRS	Total reduced sulphur
TSP	Total suspended particulate
$\mu g/m^3$	Micrograms per cubic meter
WD	Wind direction
WS	Wind speed

APPENDIX A

Potential Sources of Air Contaminant Emissions Near École Champlain

Facility/Business Name	Position Relative to Study Site*	Potential Air Contaminant Emissions**
Arrow Metal Products Ltd.	Southwest	Wood smoke (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide, and particulate matter)[1]
Monarch Construction Ltd.	North to Northwest	Diesel exhaust (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide, and particulate matter)[2] Fugitive dust/particulate
Signature Landscape Inc.	North to Northwest	Compost odour (This can be comprised of a variety of volatile sulphur compounds that contribute to total reduced sulphur (TRS) values. This potentially includes hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, and dimethyl disulfide)[3] Fugitive dust/particulate
Sugar Shack Construction Ltd.	Northeast	Diesel exhaust (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide and particulate matter)[2] Fugitive dust/particulate
MacDonald Paving/ Construction & Sign (1991) Ltd.	Northeast	Tar/asphalt odour (volatile organic compounds, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide, and particulate matter)[4] Fugitive dust/particulate
Tri Province Enterprises	Southeast to east	"Propane odour" (ethyl and/or methyl mercaptan)
Department of Transportation and Infrastructure District Office (Depot)	South	Diesel exhaust (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide and particulate matter)[2]
Rail Line	Southwest to northeast	Diesel exhaust (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide, and particulate matter)[2] Fugitive emissions from freight (uncharacterized)
École Champlain (bus traffic)	Not applicable	Diesel exhaust (volatile organic compounds, aldehydes, polycyclic aromatic hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide, and particulate matter)[2]

* Some facilities occupy sufficient land area such that portions of the property lie in more than one direction relative to the study location.

** Described emission potential for each facility is based on complaint reports to the Department of Environment and Local Government and emissions information from the literature for similar facilities.

[1] A Summary of the Emissions Characterization and Noncancer Respiratory Effects of Wood Smoke, EPA-453/R-93-036 (available at: http://nepis.epa.gov)

[2] Health Assessment Document for Diesel Engine Exhaust, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC (available at: http://www.epa.gov/ttnatw01/dieselfinal.pdf)

[3] Emission of Volatile Sulfur Compounds During Composting of Municipal Solid Waste. Hongyu Zhang, Frank Schuchardt, Guoxue Li, Jinbing Yang, and Qingyuan Yang. Waste Management. Vol. 33. Iss. 4. Pages 957-963. April 2014

[4] Hot Mix Asphalt Plants Emission Assessment Report. Office of Air Quality Planning and Standards Research, U.S. Environmental Protection Agency, Triangle Park, NC. EPA-454/R-00-019. December 2000. (available at: http://www.epa.gov/ttn/chief/ap42/ch11/related/ea-report.pdf)