New Nouveau Brunswick
CANADA

Air Quality Evaluation - Saint-François de Madawaska

Final Report

Department of Environment
and Local Government
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Report prepared by:

Air Sciences Section
Air and Water Sciences Branch
New Brunswick Department of Environment and Local Government

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1.0 Executive Summary

In 2016 the Department of Environment and Local Government (DELG) began receiving air quality complaints from homeowners in the Saint-François de Madawaska area of the Rural Community of Haut-Madawaska, New Brunswick. A fertilizer plant in the community was believed by the complainants to be the source of the air quality problem. The fertilizer plant implemented mitigative actions in 2017 in response to the complaints. However, this did not resolve the citizen's concerns.

Air quality monitoring equipment was deployed to the area on April 6, 2018 to undertake a general assessment of ambient air quality in the community. Continuous ambient air quality measurements were undertaken at a fixed location within the Saint-François de Madawaska area for a variety of common air contaminants.

An interim report covering the first five months (April 6, 2018 to September 6, 2018) of findings was issued in May of 2019 (see *Air Quality Evaluation - Saint-François de Madawaska, Interim Report*, May 2019, ISBN 978-1-4605-2008-6).

The interim report identified elevated particulate levels in the Saint-François de Madawaska area and a potential relationship between particulate emissions from the fertilizer plant and the odour/health issues reported by the community. The report suggested that further emissions characterization work at the fertilizer plant would be informative.

Shortly after the conclusion of the reporting period for the interim report (September 6, 2018) the fertilizer plant was ordered by the New Brunswick Department of Health to stop operations pending actions to reduce their emissions. New equipment (i.e. a new burner) was subsequently installed and the facility was permitted to resume operations, which occurred on November 30, 2018.

The fertilizer plant was also required to undertake comprehensive emissions testing of the facility as soon as practicable following the installation of the new burner, consistent with the suggestion in the interim report. This testing was carried out in April 2019. The testing and subsequent air quality modelling suggested that additional pollution control equipment was needed to reduce particulate emissions. The facility ceased operations again on September 1, 2019 to install a new pollution control system (baghouse) over a two month period.

Ambient air quality monitoring continued in the Saint-François de Madawaska area from September 7, 2018 until October 16, 2019. This provided opportunity to consider air quality over a longer time period, and to compare findings from before and after the installation of the new burner at the fertilizer plant.

Citizen complaints were reduced (78% reduction in complaints per week) in the second reporting period. However, particulate levels measured at the project site remained similar to the previous reporting period. Also, while the data from the interim report period suggested an association between particulate levels and citizen complaints, data from the current reporting period was inconclusive in this regard.

The project was unable to identify a causative agent (i.e. a specific pollutant) to explain the reported health effects in the area. This does not preclude the existence of a causative agent, but suggests that if one exists it is unlikely to be one of the common air pollutants that were included in the assessment.

It should be noted that monitoring ceased before work was complete on the fertilizer plant's baghouse. Any impact on air quality from the baghouse installation would not be reflected in this report.

2.0 Introduction

2.1 Background

In 2016 the Department of Environment and Local Government (DELG) began receiving air quality complaints from homeowners in the Saint-François de Madawaska area of the Rural Community of Haut-Madawaska, New Brunswick. The primary issue reported was odour. However, a variety of health impacts were also described.

Area residents indicated that they believed the source of the air quality issue to be the operation of a nearby fertilizer plant, which produces fertilizer by drying poultry bedding waste (a mixture of wood shavings and poultry manure). The facility burns wood waste to produce the necessary heat for the drying of the product.

Although the fertilizer plant has been in operation since 2003, citizen complaints did not begin until 2016. Available information about the plant suggests that their process did not change at that time. The plant changed its fuel source from poultry bedding waste to wood waste in 2017, but citizen complaints continued.

2.2 Area Emission Sources

Air pollution sources in the Saint-François de Madawaska area include a fertilizer plant, poultry farms, a poultry manure storage and handling facility, vehicle traffic, wood smoke, and wind-blown dust from dirt roads and soil tilling/disturbance. Some sources are in close proximity to one another. In particular, the fertilizer plant and the poultry manure storage facility are approximately 100 meters apart.

There is a chicken processing plant approximately 4 kilometers east of the area, and other industrial activities approximately 10 kilometers east. These facilities are considered unlikely to be significantly impacting air quality in the area from which complaints are being received.

As is the case for all of New Brunswick, the Saint-François de Madawaska area also receives long-range (transboundary) air pollution impacts (primarily fine particulates and ground level ozone) from pollution sources elsewhere in the World.

Although there are several air pollution emissions sources affecting the area, the fertilizer plant is the only facility that is required to obtain, and operate in accordance with, an Air Quality Approval issued under the *Clean Air Act*. Through the Approval to Operate, DELG has access to information about this facility that is not available for the other previously listed area emissions sources. This includes operational and design details, emissions testing data, and air quality monitoring data from equipment on the plant property. This provides opportunity for analyses involving this air pollution source that are not possible for other air pollution sources in the area.

Emissions from the fertilizer plant include combustion products from the furnace, exhaust gases from the drying process, vehicle (trucking) exhaust, and windblown dust from the property.

2.3 Project Design and Location

Based on a review of the facility design for the fertilizer plant, and in consideration of other nearby emission sources, a broad suite of common air contaminants was selected for inclusion in the evaluation. A list of the included pollutants is provided in Appendix A, along

with the rationale for the inclusion of each. Certain other air contaminants were considered for inclusion based on feedback from the community but were excluded from the project. The rationale for excluding these other parameters is also provided in Appendix A.

The monitoring work was carried out in the Saint-François de Madawaska area, which is part of the Rural Community of Haut-Madawaska, in Madawaska County, New Brunswick. This is a rural, lightly populated, agricultural area with significant forest cover.

The monitoring location was selected to be representative of the local community based on prevailing wind patterns, the pattern of complaints received from the area, and input from local residents and DELG regional personnel.

The DELG mobile air quality monitoring unit was positioned at the project site (approximately 47°14'48.65"N 68°46'12.94"W), which is approximately 1,700 meters South Southeast of the previously mentioned fertilizer plant. The site is within the river valley of Crocs River, which runs approximately northwest to southeast at this location. The project site and surrounding area are pictured in Figure 1.

2.4 Project Timing

DELG deployed its mobile air quality monitoring unit to the Saint-François de Madawaska area in March 2018, and data collection for most parameters began on April 6, 2018. Data collection concluded on October 16, 2019. Data for the April 6, 2018 to September 6, 2018 period was reported previously in an interim report. The remainder of the project period (September 7, 2018 to October 16, 2019) is reported herein, and comparisons made with data previously reported.

3.0 Methodology

3.1 Meteorology Equipment

Meteorological equipment (Vaisala model WXT520) was deployed at the project site to provide wind speed and wind direction data. The meteorological unit also collected relative humidity, temperature, and barometric pressure parameters.

All monitored meteorological parameters were logged as five-minute averages and retrieved automatically on an hourly basis.

3.2 Continuous Air Quality Monitoring Equipment

Continuous monitors provide objective measurements of air quality at all times, and do not rely on modelling or statistical approximations. With the exception of brief, intermittent, calibration cycles and occasional malfunctions, there are no gaps in data coverage. Air is constantly drawn through the monitors.

Continuous monitoring equipment was deployed to measure ambient (outside air) concentrations of nitrogen dioxide (NO_2), ground level ozone (O_3), sulphur dioxide (SO_2), total reduced sulphur (TRS), and carbon monoxide (CO). These parameters were logged as five-minute averages.

Equipment was also deployed to continuously measure ambient concentrations of

Figure 1. Project Site and Surrounding Area (Image courtesy of Google Earth)

particulate matter. Fine particulate matter ($PM_{2.5}$) and respirable particulate (PM_{10}) were logged as five minute averages. Total suspended particulate (TSP) was logged as hourly averages.

A monitor was also deployed to continuously measure ambient concentrations of ammonia (NH_3). This data was logged as five-minute averages.

Data was retrieved automatically on an hourly basis for all continuous parameters.

Technical specifications for all instruments are provided in Appendix B.

3.3 Other Data Sources

Particulate data was collected at the fertilizer plant by the facility operator during the reporting period (September 7, 2018 to October 16, 2019). This location is identified in Figure 1 as the "Facitly-Run Particulate Monitor Site" and is referred to as the "property line" monitoring location throughout this report.

Complaints to the DELG regional office, and to the regional Health Protection Branch of the Department of Public Safety were logged throughout the study period with as much specificity as possible (regarding date and timing of event). Complaint data was edited for duplicates (complaints reported to both Departments for the same event from the same complainant, or if several people from a single household complained).

The hours of operation for the fertilizer plant were logged by the facility operator.

3.4 Quality Assurance

Data collection and validation for DELG-operated equipment was conducted in accordance with the *National Air Pollution Surveillance (NAPS) network quality assurance and quality control guidelines* (*Environment Canada Report No.* AAQD 2004-1). DELG is periodically audited by Environment and Climate Change Canada to ensure that operations throughout its network remain consistent with these guidelines.

4.0 Results

4.1 Meteorology - Wind at Project Site

Winds at the project site originated generally from the North and North Northwest during the study period. North and North Northwesterly winds (i.e. blowing from the direction of the fertilizer plant toward the study site) were frequent, occurring 50% of the time.

A distinct “time of day” effect was also noted wherein winds originated from the North more often during nighttime hours. During the overnight period (8:00 PM to 8:00 AM) winds were northerly 65% of the time.

Wind data is further illustrated in Appendix C.

4.2 Continuous Monitors at Project Site

Summary statistics for each of the continuously monitored parameters at the project site are provided in Table 1.

Additional data for each parameter is illustrated graphically in Appendix D.

Table 1: Summary Statistics - Continuously Monitored Parameters at Project Site

Parameter	Average Concentration (13 Month)	Peak Concentration (24-hour average)	Peak Concentration (1-hour average)	Peak Concentration (5-minute average)
Sulphur Dioxide (SO_2)	<0.1 ppb	0.4 ppb	2.3 ppb	3.3 ppb
Total Reduced Sulphur (TRS)	0.1 ppb	0.4 ppb	1.0 ppb	4.0 ppb
Nitrogen Dioxide (NO_2)	1.1 ppb	9.8 ppb	28.9 ppb	66.4 ppb
Ground Level Ozone (O_3)	21.8 ppb	43.4 ppb	54.3 ppb	95.6 ppb
Carbon Monoxide (CO)	0.4 ppm	0.4 ppm	0.5 ppm	9.9 ppm
Ammonia (NH_3)	<1 ppm	~2 ppm (See note 1)	~2 ppm (See note 1)	~2 ppm (See note 1)
Fine Particulate ($PM_{2.5}$)	5.2 µg/m^3	22 µg/m^3	70 µg/m^3	234 µg/m^3
Respirable Particulate (PM_{10})	22 µg/m^3	117 µg/m^3	889 µg/m^3	2654 µg/m^3
Total Suspended Particulate (TSP)	15 µg/m^3	158 µg/m^3	>985 µg/m^3 (See note 2)	NA (See note 3)

Note 1: 2 ppm is 1 ppm above the detection threshold for the instrument, but a 1 ppm difference is within the inherent error of the instrument under varying ambient temperature and humidity conditions.

Note 2: On April 12, 2019 at 16:00 concentrations exceeded the upper detection limit for the instrument (985 µg/m^3).

Note 3: This instrument cannot produce 5-minute averages.

4.3 Other Data

4.3.1 Particulate Concentrations at Fertilizer Plant Property Line

Summary statistics for each of the continuously monitored parameters at the property line site are provided in Table 2. Additional data for each parameter is illustrated graphically in Appendix E.

Table 2: Summary Statistics - Continuously Monitored Parameters at Fertilizer Plant Property Line

Parameter	Average Concentration (13 Month)	Peak Concentration (24-hour average)	Peak Concentration (1-hour average)	Peak Concentration (5-minute average)
Fine Particulate ($PM_{2.5}$) (Industry Monitor)	9 µg/m^3	74 µg/m^3	578 µg/m^3	923 µg/m^3
Total Suspended Particulate (TSP) (Industry Monitor)	9 µg/m^3	70 µg/m^3	500 µg/m^3	775 µg/m^3

4.3.2 Observational Data (Citizen Complaints)

A total of 105 complaints were lodged by seven households during the September 7, 2018 to October 16, 2019 reporting period. This corresponds to an average of approximately 1.8 complaints per week. The daily complaint log is provided along with a graphical illustration in Appendix F.

4.3.3 Fertilizer Plant Operating Hours

From September 7, 2018 through October 12, 2018 the fertilizer plant typically operated Monday to Friday, running 6 to 9 hour shifts each day. Shifts typically began in the 10:30 AM to 11:30 AM period and ended in the 6:00 PM to 7:00 PM period. The plant stopped operations between October 13, 2018 and November 29, 2018. Upon restarting, the plant typically operated 10 to 12 hour shifts each day. These shifts typically began in the 7:00 AM to 8:00 AM period and ended in the 5:00 PM to 7:00 PM period. In late July of 2019 shift lengths became less consistent up until the plant again stopped operations. This final stoppage began on September 1, 2019 and the plant remained offline through the end of the study period (October 16, 2019).

Excluding the shut down periods, on average the facility operated 36 hours per week during the current study period.

Daily and weekly hours of operation data for the fertilizer plant are illustrated graphically in Appendix G.

5.0 Analysis and Discussion

5.1 Comparisons to Standards and Guidelines

The following analysis compares the monitored values against objective ambient air quality standards. New Brunswick has adopted “Maximum Permissible Ground Level Concentrations” under the *Air Quality Regulation* (New Brunswick Regulation #97-133) - *Clean Air Act* for several contaminants. However, the Regulation does not address all contaminants. In these cases, concentrations are evaluated against standard or guideline values that have been adopted by policy (*e.g.*, national standards, standards adopted by other jurisdictions, or guidelines adopted by various national or international agencies).

Note that air quality standards take a variety of statistical forms (*e.g.*, hourly averages, daily averages, annual averages, daily maximum, etc.). These various forms have been crafted to support specific environmental or public health goals. However, it is beyond the scope of this report to explore the underlying rationale for each. Rather, this analysis will focus on a simple comparison against the standards and guidelines that are relevant to the evaluation.

In order to compare results against regulated standards and guidelines the data must be converted into the correct form. For instance, by averaging 12 five-minute averages together to create a 1-hour average. In some cases the data collected cannot be converted into the appropriate form. However, approximations can sometimes be applied (*e.g.*, comparing data collected over several months against a standard that is based on annual average conditions).

Monitoring results at the project site are compared against regulated standards and guideline values in Table 3. Results for the property-line monitoring location are compared against regulated standards and guideline values in Table 4. These results are based on the entire September 7, 2018 to October 16, 2019 reporting period.

Table 3: Comparisons to Standards and Guidelines - Project Site

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Sulphur Dioxide (SO_2)	339 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	2.3 ppb (Highest 1-hour value recorded)	
	113 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.4 ppb (Highest 24-hour value recorded)	
	23 ppb (Annual average)	N.B. Reg. 97-133, *Clean Air Act*	<0.1 ppb (Highest 12-month average recorded)	
Total Reduced Sulphur (TRS)	11 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	1.0 ppb (Highest 1-hour value recorded)	These standards are for one specific reduced sulphur compound - Hydrogen Sulphide.
	3.5 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.4 ppb (Highest 24-hour value recorded)	
Nitrogen Dioxide (NO_2)	210 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	28.9 ppb (Highest 1-hour value Recorded)	
	105 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	10.0 ppb (Highest 24-hour value Recorded)	
	52 ppb (Annual average)	N.B. Reg. 97-133, *Clean Air Act*	1.2 ppb (Highest 12-month average recorded)	
Ground Level Ozone (O_3)	63 ppb (Fourth worst daily 8-hour average, averaged over three years)	Canadian Ambient Air Quality Standard	50 ppb (Fourth worst daily 8-hour average)	The standard is based on a statistic that requires three years of data collection, whereas the current study period included only 13 months of data.

Table 3 Continued: Comparisons to Standards and Guidelines - Project Site

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Carbon Monoxide (CO)	30 ppm (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.5 ppm (Highest 1-hour value recorded)	
	13 ppm (8-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.5 ppm (Highest 8-hour value recorded)	
Ammonia - Continuous Monitoring (NH_3)	25 ppm (Time-Weighted Average - short term exposure)	National (US) Institute for Occupational Health and Safety-Recommended Exposure Limit	2 ppm (Highest 1-hour value recorded)	
Total Suspended Particulate (TSP)	120 µg/m^3 (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	158 µg/m^3 (Highest 24-hour value recorded)	
	70 µg/m^3 (Annual geometric mean)	N.B. Reg. 97-133, *Clean Air Act*	11.4 µg/m^3 (final 12-month geometric mean)	
Respirable Particulate (PM_{10})	50 µg/m^3 (24-hour average)	Ontario Ambient Air Quality Criteria	117 µg/m^3 (Highest 24-hour value recorded)	
Fine Particulate ($PM_{2.5}$)	28 µg/m^3 98th percentile daily average	Canadian Ambient Air Quality Standard	14 µg/m^3 98th percentile daily average	The standard is based on a statistic that requires three years of data collection, whereas the current study period included only 13 months of data.
	10 µg/m^3 (3-year average)	Canadian Ambient Air Quality Standard	5.2 µg/m^3 (13-month average)	

Table 4: Comparisons to Standards and Guidelines - Property-Line Location

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Fine Particulate ($PM_{2.5}$)	120 µg/m^3 (24-hour average)	Property Line Limit Stipulated in the DELG Certificate of Approval to Operate (issued under the *Clean Air Act*)	70 µg/m^3 (Highest 24-hour value recorded)	The Certificate of Approval includes a standard for "particulates", which has been applied here to both particulate parameters (TSP and $PM_{2.5}$)
Total Suspended Particulate (TSP)	120 µg/m^3 (24-hour average)	Property Line Limit Stipulated in the DELG Certificate of Approval to Operate (issued under the *Clean Air Act*)	70 µg/m^3 (Highest 24-hour value recorded)	

5.2 Non-Impacting Parameters

As indicated in Table 3, monitoring results for SO_2, TRS, NO_2, O_3, CO, and NH_3 remained well below the relevant standards and guidelines for those parameters throughout the evaluation period. The measured values for these contaminants fall within the normal expected range of values for rural locations in New Brunswick (for comparison values please see "New Brunswick Department of Environment and Local Government Air Quality Monitoring Results - 2017" ISBN 978-1-4605-2359-9). As such, these parameters are excluded from further consideration. No further analysis of these parameters will be undertaken.

5.3 Parameters of Interest

5.3.1 Total Suspended Particulate (TSP)

The running 24-hour average TSP concentration measured at the project site is illustrated in Figure 2. As shown, the relevant standard (120 µg/m^3) was exceeded on only one occasion, on April 12, 2019. The cause of this event could not be determined. However, the fertilizer plant was not operating, and wind was light (less than five kilometers per hour throughout the day) and from the south. Road dust is suspected.

5.3.2 Respirable Particulate (PM_{10})

The running 24-hour average PM_{10} concentration measured at the project site is illustrated in Figure 3. As illustrated, the relevant standard (50 µg/m^3) was exceeded on five occasions. Additional information about each of these events is provided in Table 5.

As reflected in Table 5, the five PM_{10} events had a number of similarities. They typically occurred during periods of low humidity (i.e. when the air was dry), and when winds were out of the south. Although the fertilizer plant was operating during portions of three of the events, there was no clear relationship between its operational status and the measured PM_{10} levels. Also, winds were not generally favourable to carry pollutants from the plant toward the project site during these events. Similarly, there was no clear relationship

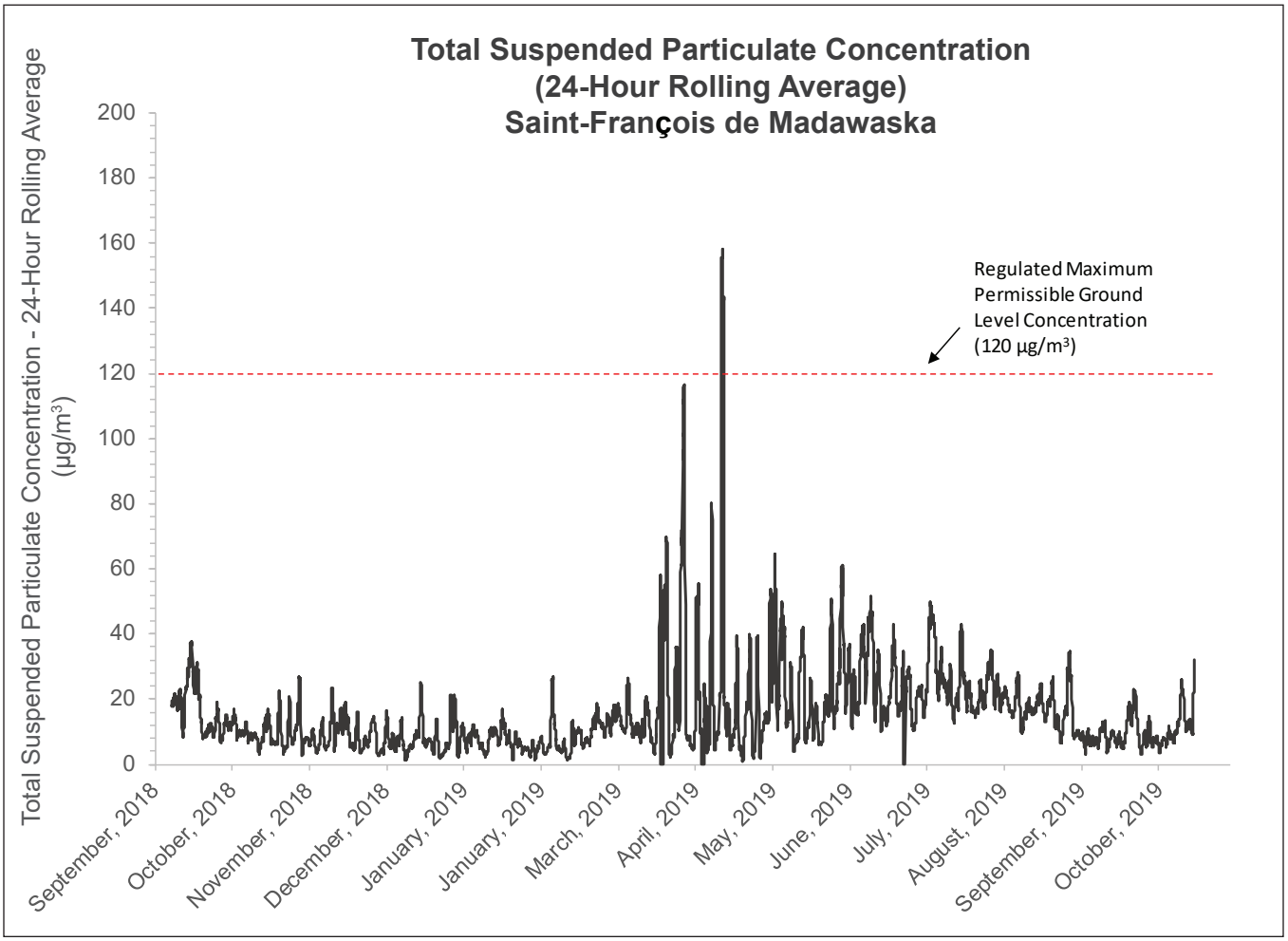

Figure 2: 24-Hour Rolling Average Total Suspended Particulate Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

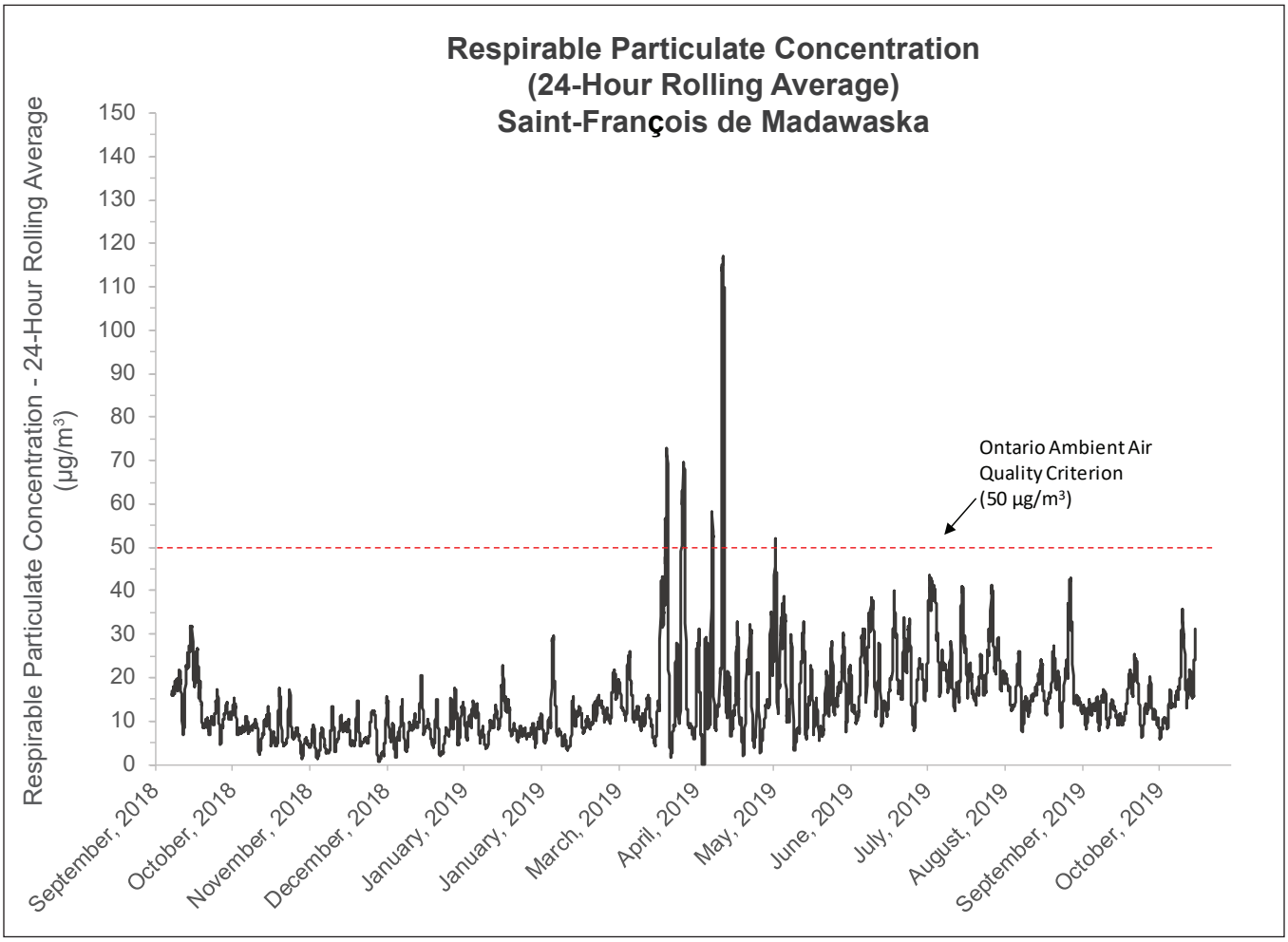

Figure 3: 24-Hour Rolling Average Respirable Particulate (PM_{10}) Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

Table 5: Respirable Particulate (PM_{10}) Event Details

Event Start	Event Stop	Duration	Predominant Wind Direction (Origin)	Relative Humidity	Fertilizer Plant Operating (during all or a portion of the event duration)?	Complaints Received?
Thursday March 21, 2019 11:00 AM	Friday March 22, 2019 8:00 AM	21 hours	Southeast changing to Northwest	Began high (70%) then fell to 33% before rising to 85% at the end of the event	Yes	No
Wednesday March 27, 2019 6:00 PM	Friday March 29, 2019 6:00 AM	36 hours	South	Began low (20%), gradually rose to 87% at the end of the event	Yes	No
Monday April 8, 2019 1:00 PM	Tuesday April 9, 2019 5:00 AM	16 hours	South changing to North (see note 1)	Began low (31%), gradually rose to 82% at the end of the event	Yes	Yes
Friday April 12, 2019 3:00 PM	Saturday April 13, 2019 5:00 PM	26 hours	South and West	Began low (26%) then rose to 74% and then fell to 27% at the end of the event	No	No
Friday May 3, 2019 3:00 PM	Friday May 3, 2019 8:00 PM	5 hours	South	Began low (41%), gradually rose to 78% at the end of the event	No	No

Note 1: Wind changed to northwesterly at approximately 9:30 PM. However, the wind monitor malfunctioned at approximately 9:55 PM and did not resume collecting wind data until 10:40 AM the following morning.

between citizen complaints and the PM_{10} events. Complaints were received during only one of the five events.

Technicians visiting the project site over the April 2019 to May 2019 period reported significant wind blown road dust in the area. In the absence of additional information, and in consideration of the details described in Table 5, wind blown road dust is the most likely source for these PM_{10} events.

5.3.3 Fertilizer Plant Property Line Particulates

Particulate data from the property line location is illustrated in relation to the property line concentration limit in Figures 4 and 5. As shown, and as reflected in Table 4, there were no exceedances of the property line concentration limit based on the data available. However, it should be noted that there were numerous data gaps due to malfunctions of the two monitors at this location.

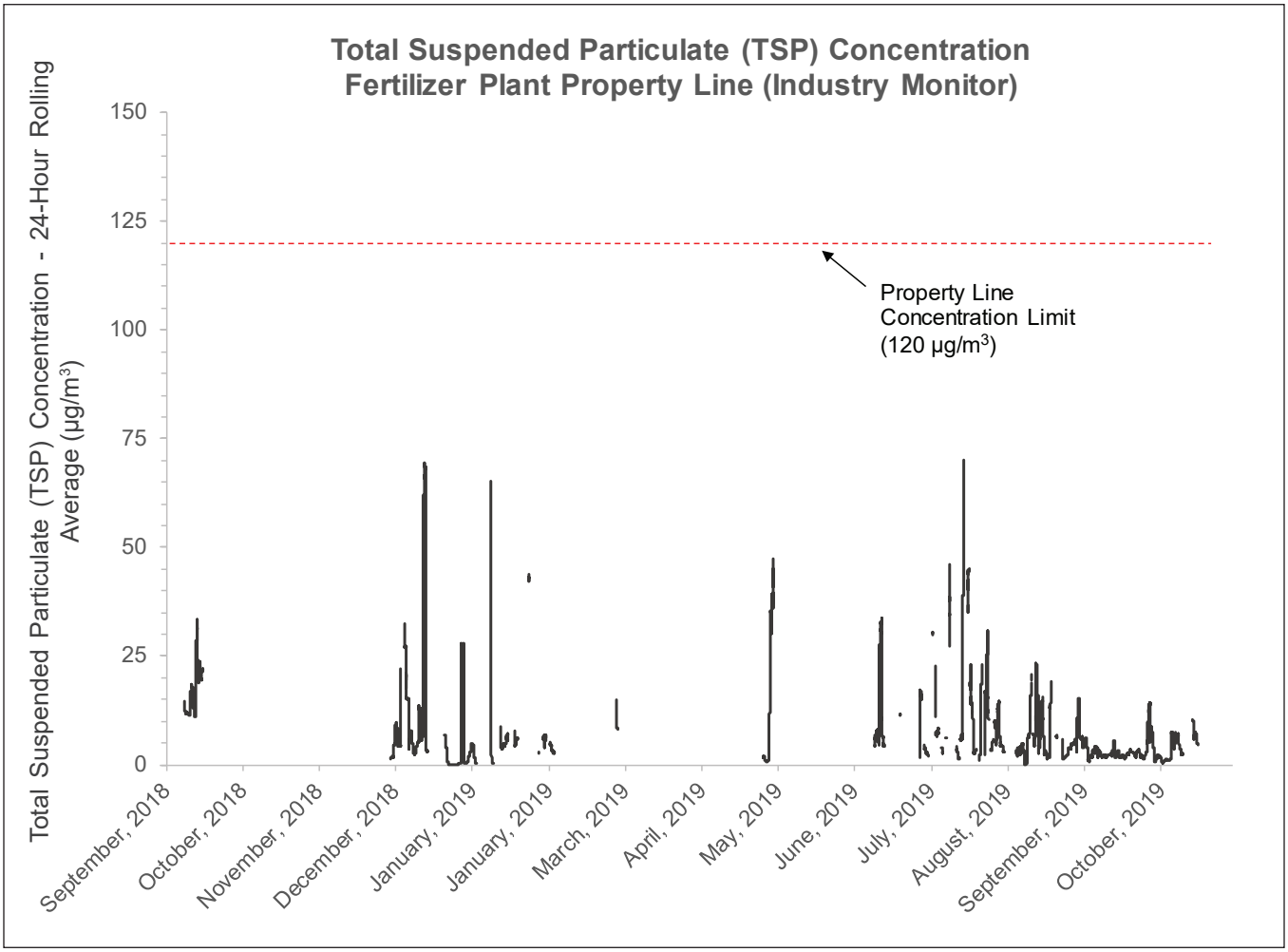

Figure 4: 24-Hour Rolling Average Total Suspended Particulate Concentration - Fertilizer Plant Property Line, Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

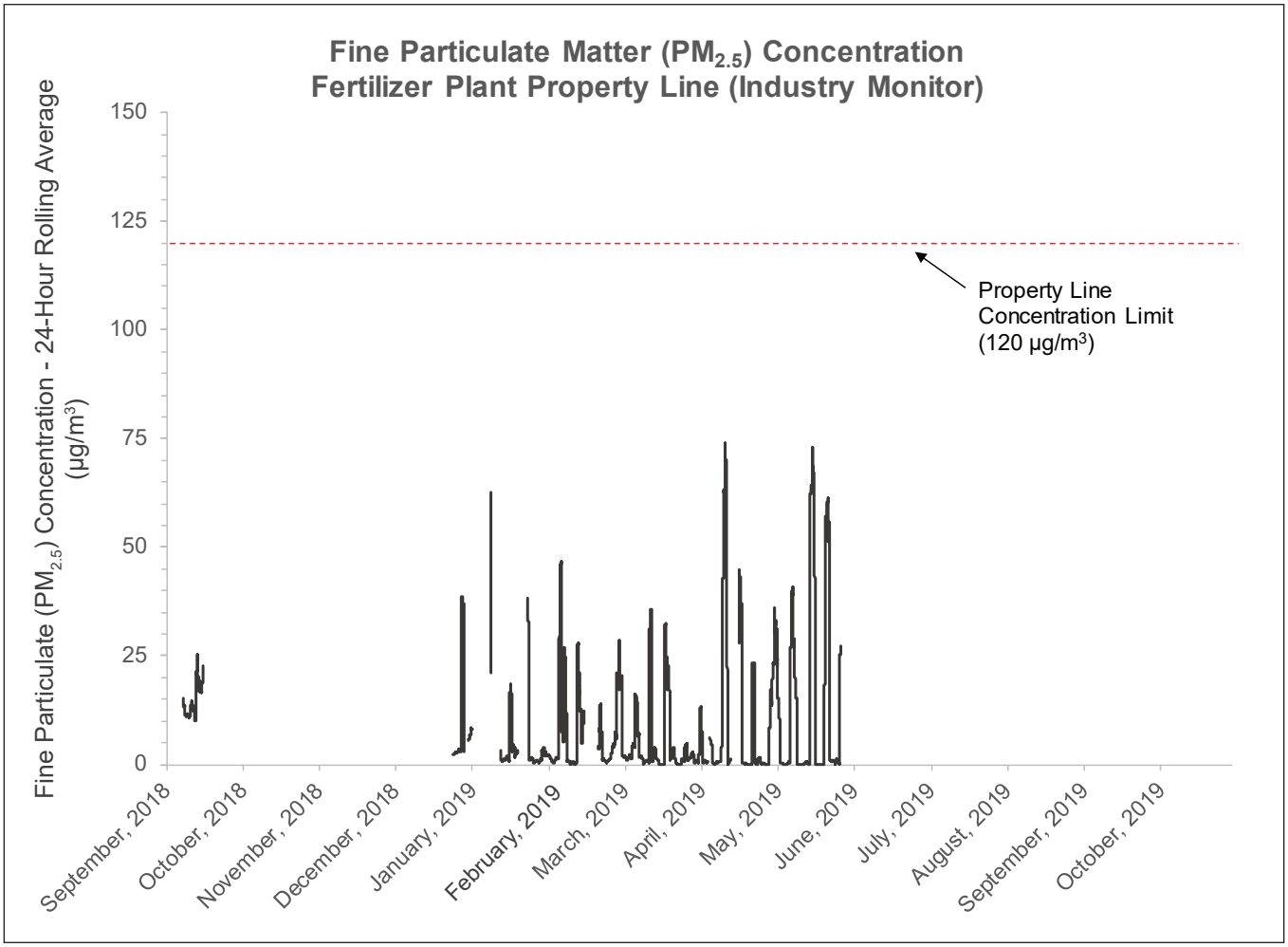

Figure 5: 24-Hour Rolling Average Fine Particulate Concentration - Fertilizer Plant Property Line, Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

6.0 Comparisons to Interim Report Findings

6.1 Meteorology

The prevailing wind direction remained relatively constant throughout the two reporting periods. Winds at the project site originated from the North and North Northwest 50% of the time during the current reporting period versus 48% reported previously.

A "time of day effect" was described in the previous reporting wherein winds were observed to originate from the north more frequently during the night. This effect continued throughout the current reporting period but with slight variation. During the overnight period (8:00 PM to 8:00 AM) winds were northerly 65% of the time whereas overnight northerly winds were reported 62% of the time previously. Daytime (8:00 AM to 8:00 PM) winds were northerly 49% of time during the current reporting period as compared to 37% reported previously. It is unclear if these minor differences are due to inter annual variability, seasonal variations, or both.

6.2 Comparisons to Standards and Guidelines

For most monitored parameters the statistical values (related to the various relevant standards and guidelines) remained similar between the two study periods with only minor variation. All parameters except the various particulate fractions remained well below the relevant standard or guideline values through both periods.

Both periods experienced exceedances (of the relevant standards or guidelines) for some particulate fractions. However, the first reporting period included exceedances of the TSP standard at the facility property line location, whereas none were detected at this location during the second reporting period. Conclusions cannot be drawn regarding whether this represents an improvement in TSP levels at this location due large data gaps resulting from malfunctions of the TSP monitor at this location.

6.3 Non-Impacting Parameters

Monitoring results for SO_2, TRS, NO_2, O_3, CO, and NH_3 remained well below the relevant standards and guidelines for those parameters throughout both reporting periods. Values for these parameters were similar during both periods.

6.4 Parameters of Interest

6.4.1 Total Suspended Particulate (TSP)

TSP data from the project site for the current reporting period is comparable to the previous findings. There was one exceedance of the relevant 24-hour standard (120 µg/m^3) during the current period as compared to only one exceedance during the interim reporting period. Considering the differing sampling periods (5 months for the interim report versus 13 months for the current reporting) the rate of occurrence is approximately half of the previous reporting (an average occurrence rate of 1 event per 5 months during the interim report period, versus 1 per 13 months in the current period.)

6.4.2 Respirable Particulate (PM_{10})

The relevant 24-hour standard for PM_{10} (50 µg/m^3) was exceeded five times during the current reporting period (average rate of one event per 2.6 months) which is similar to the previous reporting period, which experienced two exceedance events (average rate of one event per 2.5 months).

6.4.3 Number and Rate of Citizen Complaints

Complaints were received from 7 households during the current 13-month reporting period (September 7, 2018 to October 16, 2019), this is reduced from the 11 households that reported complaints during the previous 5-month reporting period (April 6, 2018 to September 6, 2018).

The total number of complaints logged in the second reporting period was also reduced relative to the first reporting period (173 complaints in the interim reporting period versus 105 complaints in the current reporting period). This is a reduction in the average rate of complaints from 8 per week to 1.8 per week. This represents a 78% reduction in the average rate of complaints.

Excluding the periods when the fertilizer plant was in extended shut-down, the rate of complaints increases to 2.4 per week. This represents a 70% reduction in complaints compared to the previous reporting.

6.4.4 Respirable Particulate (PM_{10}) and Citizen Complaints

The interim reporting explored a possible relationship between citizen complaints and respirable particulate (PM_{10}) levels. However, the analysis was hindered by the small number of significant PM_{10} events (exceedances of PM_{10} standards or guidelines) that were observed. The current study period included five PM_{10} events (see subsection 5.3.2), which allows further exploration of this line of enquiry. However, these PM_{10} events were not strongly associated with citizen complaints. Although this does not disprove the previously identified relationship, it does weaken the case and prevents further statistical exploration.

6.4.5 Fertilizer Plant Operational Status and Citizen Complaints

The fertilizer plant operated (during any period from midnight to midnight) on 195 days of the current 404-day evaluation period, and complaints were received on 66 (34%) of those (operating) days. This is substantially reduced from the previous reporting period, which saw complaints reported on 67% of the days that the fertilizer plant operated.

There was one “complaint day” that did not coincide with “operating days” (over the current 13 month period). This is much reduced from the previous reporting period during which 10 “complaint days” did not coincide with “operating days” (over a 5 month period).

Considering only the days that complaints were received (67), 66 of them coincided with days that the plant operated (98% agreement). This is closer agreement between plant operational status and complaints than was reported in the previous period (85% agreement reported previously).

This is in agreement with the previously suggested relationship between the operation of the fertilizer plant and citizen complaints. This is illustrated graphically in Figure 6. However, the occurrence of complaints (of which there were two) on a day when the plant was not operating (and had not operated for 3 days prior) continues to support the previously reported suggestion that there may be other sources in the area that cause or contribute to the reported concerns.

The operational status of other potential sources was not monitored.

6.4.6 Wind Direction and Respirable Particulate (PM_{10}) Levels

The previous reporting investigated the relationship between wind direction and respirable particulate (PM_{10}) levels. However, this analysis was undertaken subsequent to the identification of an apparent relationship between PM_{10} and citizen complaints. As this relationship cannot be inferred from the current data (see subsection 5.3.2), the relationship between PM_{10} and wind direction is not meaningful and will not be explored further.

6.4.7 Wind Direction and Citizen Complaints

As described in the previous reporting, the inherent imprecision of the complaint data, the changeable nature of wind direction, and the disparate positioning of complainants relative to the project site prevents meaningful analysis of wind direction versus complaints. No further analysis of this potential relationship was attempted.

6.4.8 Fertilizer Plant Property Line Particulates

The previous reporting included analyses of particulate levels monitored at the fertilizer plant property line versus levels monitored at the project site and attempted to correlate the measured values against citizen complaints. A similar analysis could not be undertaken for the current reporting period due to significant gaps in monitoring coverage for the two particulate parameters (TSP and $PM_{2.5}$) monitored at the fertilizer plant property line.

There were no exceedances of the property line particulate concentration limit based on the data available. While this represents a potential improvement versus the previous reporting period, during which seven exceedance events were detected at this location, the incompleteness of the property line data for the current period prevents drawing such a conclusion.

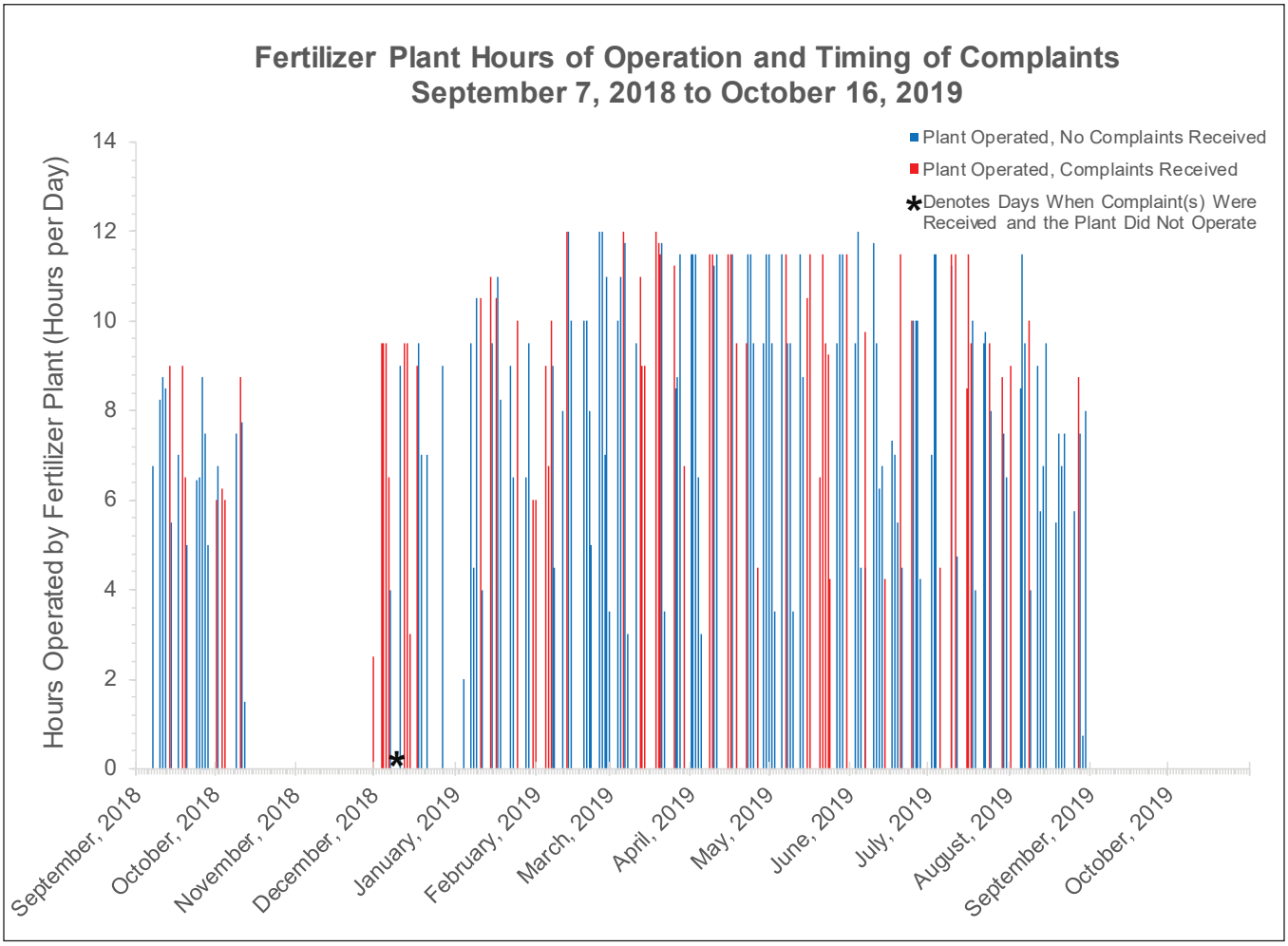

Figure 6: Daily Odour Complaints Reported in Saint-François de Madawaska Compared Against the Hours of Operation for the Nearby Fertilizer Plant, September 7, 2018 to October 16, 2019.

7.0 Conclusions

With the exception of particulates (Total Suspended Particulate and respirable fractions), concentrations of monitored pollutants in the Saint-François de Madawaska community were found to be typical of rural New Brunswick. This is in agreement with the findings of the previous reporting period.

Respirable particulate levels were found to exceed standard/guideline values at the project site on five occasions during the current reporting period. The causes of all five were unclear, but based on available wind data the source(s) were likely to the South of the project site for at least four of the five events. Meteorological and observational data are suggestive of wind-blown dust as a significant contributor to these five events. A complaint was lodged during one of these five particulate events.

There were only two significant respirable particulate events in the previous reporting period, and one was clearly related to nearby roadwork. The single remaining event coincided with a citizen complaint. A relationship was therefore inferred between non-roadwork-related particulate levels and complaints. The current reporting period has now identified four additional respirable particulate events that did not result in complaints. As such, the data from the current reporting period does not support the previously inferred association. However, such an association is not precluded by the current data. Whether and to what extent particulates (and/or which sources of particulates) are implicated in the issues reported in this area is unclear.

The occurrence of significant respirable particulate events during winds of varying directions further suggests that there are many particulate sources in the area.

The previous reporting identified significant particulate (all fractions) concentrations at the fertilizer plant property line monitoring location, including exceedances of the facility's regulated limit. However, due to data quality issues, insufficient valid data was available for the current study period to make meaningful comparisons to the previous reporting.

The number and frequency of citizen complaints was reduced in the second reporting period. This may be indicative of improved air quality from the replacement of the fertilizer plant's burner, which was installed following regulatory action by the Department of Health. However, the reduction in citizen complaints could also be influenced by other factors (e.g. complaint fatigue).

The previous reporting also identified a complex relationship/association between reported complaints, northerly winds, the operating hours of the fertilizer plant, $PM_{2.5}$ levels measured at the fertilizer plant, and PM_{10} levels measured at the project site. Such a relationship was not evident in the current reporting period, as significant particulate levels were not strongly associated with complaints.

The complete reporting period for this project (including the current and previous reporting) does not suggest a strong relationship between any monitored contaminant and the environmental/ health effects reported by the community. This suggests that if a causative agent (or agents) exists, it was not included in the suite of parameters for the current project.

The project targeted key health-related air quality contaminants that were expected to be emitted by pollution sources in the Saint-François de Madawaska area. The only strong association identified in the data was between citizen complaints and the operational status of the fertilizer plant. This suggests that although a causative agent is not evident, if such an agent (or agents) exists, the fertilizer plant's emissions may be a potential source. However, there were a small

number of instances (11 across both reporting periods) where complaints were received during periods when the fertilizer plant was not operating, including some instances when it had not operated for some time. This implies the existence of other potential sources.

Any further work on this issue would first require emissions characterization work (e.g. review of chemical processes and theoretical end products, source testing, etc.) to identify potential causative agents (i.e. pollutants that are being emitted, and which could result in the reported effects and odour, but which were not monitored during this project) from the various area emissions sources.

8.0 Data Limitations

The data collected represents conditions during the evaluation period and does not reflect all possible variations in ambient air quality conditions that may be possible at this location.

This project involved the collection of ambient air quality data under field conditions. Consequently, unforeseen and unavoidable disruptions (e.g., weather, electrical power failures, equipment malfunctions, etc.) resulted in brief data interruptions at various points throughout the collection period.

The project analyzed air quality at two fixed locations. As such, the results provide a quantitative assessment of air quality at these locations only. Inferences can be made about air quality at other nearby locations, but certainty decreases with distance from the monitoring sites.

The project location may have been impacted by air pollutants from multiple sources during the evaluation period. Meteorology data can suggest likely sources for the contaminants detected during a given period. However, the data is insufficient for comprehensive “source apportionment” (i.e. discerning and quantifying the impacts from individual pollution sources).

Data was collected for a period of 13 months for the current reporting period, and 5 months for the interim reporting period (total of 18 months). However, some comparisons are made to standard or guideline values that require a longer observation period (e.g. 3 years).

9.0 Glossary of Abbreviations

CO	Carbon Monoxide
DELG	Department of Environment and Local Government
km/hr	Kilometers per hour
NAPS	National Air Pollution Surveillance (program)
NH_3	Ammonia
NO_2	Nitrogen dioxide
O_3	Ozone (ground level ozone)
$PM_{2.5}$	Fine particulate (particulates with a diameter ≤ 2.5 microns)
PM_{10}	Respirable Particulate (particulates with a diameter ≤ 10 microns)
PPB	Parts per billion
PPM	Parts per million
SO_2	Sulphur dioxide
TRS	Total Reduced Sulphur
TSP	Total Suspended Particulates
$\mu g/m^3$	Micrograms per cubic meter
µm	Microns (also micrometers)

Appendix A: Pollutant Parameters

Table A1: Rationale for Inclusion of Monitored Parameters

Air Contaminant	Rationale for Inclusion
Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2)	Emissions monitoring (stack testing) for the fertilizer plant indicates that SO_2 and NO_2 are being emitted from the facility. Inclusion of these parameters in the study provides quantification of off-site impacts from these emissions. Complaints received from the local community make reference to irritation of the eyes, throat, and lungs. These are some of the known health impacts of exposure to sulphur dioxide and nitrogen dioxide. However, it should be noted that there are other pollutants that can cause similar effects.
Carbon Monoxide (CO)	The reported health effects in the complaints received from the area are not consistent with CO exposure. However, emissions monitoring (stack testing) for the fertilizer plant indicates that carbon monoxide is being emitted from the facility. Inclusion of this parameter in the study provides quantification of off-site impacts from these emissions.
Total Reduced Sulphur (TRS) and Ammonia (NH_3)	Emissions monitoring (stack testing) for the fertilizer plant indicates that SO_2 is being emitted from the facility. The existence of SO_2 within the exhaust gases suggests that other sulphur compounds (including reduced sulphur compounds) could also be emitted. Although emissions monitoring (stack testing) for ammonia has not been carried out, based on the chemical constituents of poultry manure, it is likely that the fertilizer facility emits some quantity of ammonia. Also, there are other significant ammonia sources (poultry farms) in the area. Complaints received from the local community routinely include references to noxious odours. Reduced sulphur compounds and ammonia are potential sources of odours in air pollutant emissions. Also, ammonia is an upper respiratory tract irritant, consistent with health effects reported from area residents.
Ground Level Ozone (O_3)	Ozone is not directly emitted by pollution sources. Rather, it is formed in the air by reactions between certain pollutants (principally volatile organic compounds and nitrogen dioxide). Ground level ozone concentrations change in predictable ways in response to the presence of these other contaminants. Monitoring this parameter along with NO_2 allows inferences to be made about local volatile organic compound emissions.
Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)	Complaints received from the local community make reference to irritation of the throat and lungs. These are some of the known health impacts of airborne particulate matter. Combustion of organic materials (such as wood) generates significant amounts of particulate matter. It is therefore expected that the fertilizer plant would emit this contaminant. Also, emissions monitoring (stack testing) for the fertilizer plant indicates that particulate matter is being emitted from the facility. Inclusion of these parameters in the study provides quantification of off-site impacts from these emissions. Monitoring for particulates also provides a surrogate for a variety of other contaminants that can be generated by combustion and drying operations. These other pollutants react with other chemicals and water in the air to form “secondary aerosols” which contribute to the amount of particulates detected.

Table A2: Rationale for Exclusion of Certain Parameters

Air Contaminant		Rationale for Exclusion
Arsenic		Local residents identified arsenic emissions as a potential issue, as it has been identified as a contaminant of concern from similar fertilizer facilities in other parts of the World. However, the potential for arsenic emissions from this particular facility is extremely low. This is because arsenic is banned from poultry feed in Canada. Also, DELG has confirmed that the wood fuel used by the facility is not treated with arsenic.
Volatile Organic Compounds	Total VOCs	Consideration was also given to the monitoring of Volatile Organic Compounds (VOCs) in aggregate. However, the primary impact of VOC emissions, in aggregate, is their contribution to the formation of ground level ozone (O_3), which is a key component of smog. As this end product (O_3) is already included in the parameter list, this concern is already suitably addressed.
	Dioxins and Furans	Dioxins and furans were considered for inclusion but rejected due to low potential for emissions (equivalent to other wood fired boilers). Also, it was noted that the potential health impact from these contaminants is via oxidative stress. Fine particulate matter ($PM_{2.5}$) is included as a surrogate for all particulate-bound chemical species causing oxidative stress. Also, the health impacts reported in the community are "acute" (reported as occurring immediately upon exposure), whereas plausible levels of dioxin and furan exposure would not result in sudden acute health impacts.
	Other Specific (Toxic) VOCs	There are many specific VOC species that can cause severe health effects (those identified as "air toxic" by the United States Environmental Protection Agency). However, the emissions potential for these VOCs is low (similar to other wood fired boilers).
	Odorous VOCs	The fertilizer plant is assumed to emit various odorous VOCs and Volatile Fatty Acids (VFAs), which are generated biologically in chicken manure, and would be further volatilized by the drying process. However, the known effects of these contaminants at expected concentrations are aesthetic in nature (odour) whereas the primary focus of the project is health impacts. In addition, as there is a wide variety of VOCs and VFAs that could be emitted by the fertilizer plant and other sources in the area, it would first be necessary to identify which odorous chemical species are likely present and of interest. This information is not available.

Appendix B: Technical Specifications - Continuous Monitors

Table B1: Technical Specifications of Continuous Air Quality Monitors

Parameter	Instrument	Lower Detection Limit	Resolution
Sulphur Dioxide (SO_2)	Thermo Environmental Instruments Pulsed Fluorescence SO_2 Analyzer, Model 43*i*.	1 ppb (60 second average of 300 millisecond samples)	± 0.5 ppb (noise) ± 1.0 ppb (precision)
Nitrogen Dioxide (NO_2)	Thermo Environmental Instruments Chemiluminescence NO-NO_2-NO_X Analyzer, Model 42*i*.	0.4 ppb	± 0.2 ppb (noise) ± 0.4 ppb (precision)
Carbon Monoxide (CO)	Thermo Environmental Instruments Gas Filter Correlation CO Analyzer, Model 48C.	0.04 ppm	± 0.1 ppm (noise)
Total Reduced Sulphur (TRS)	Thermo Environmental Instruments Pulsed Fluorescence SO_2 Analyzer, Model 43i, 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 (precision)
Ground Level Ozone (O_3)	Thermo Environmental Instruments Ultraviolet Photometric Ozone Gas Analyzer, Model 49*i*.	0.5 ppb	± 0.25 ppb (noise) ± 1.0 ppb (precision)
Total Suspended Particulate (TSP)	Met-One Instruments Inc. Continuous Particle Monitor, model BAM-1020, outfitted with a total suspended particulate head.	4.8 µg/m^3 (hourly) 1.0 µg/m^3 (daily)	± 0.2 µg/m^3
Fine and Respirable Particulate Matter ($PM_{2.5}$ and PM_{10})	Teledyne API Model T640 Mass Monitor	0.1 µg/m^3 (hourly)	± 0.5 µg/m^3
Ammonia (NH_3)	Dräger Polytron 5100 Oxygen / Toxic Gas Detector, outfitted with a Dräger NH_3 (type TL) sensor.	~1 ppm (varies with ambient meteorological conditions)	± 5% of measured value (sensitivity)

Appendix C: Wind Data

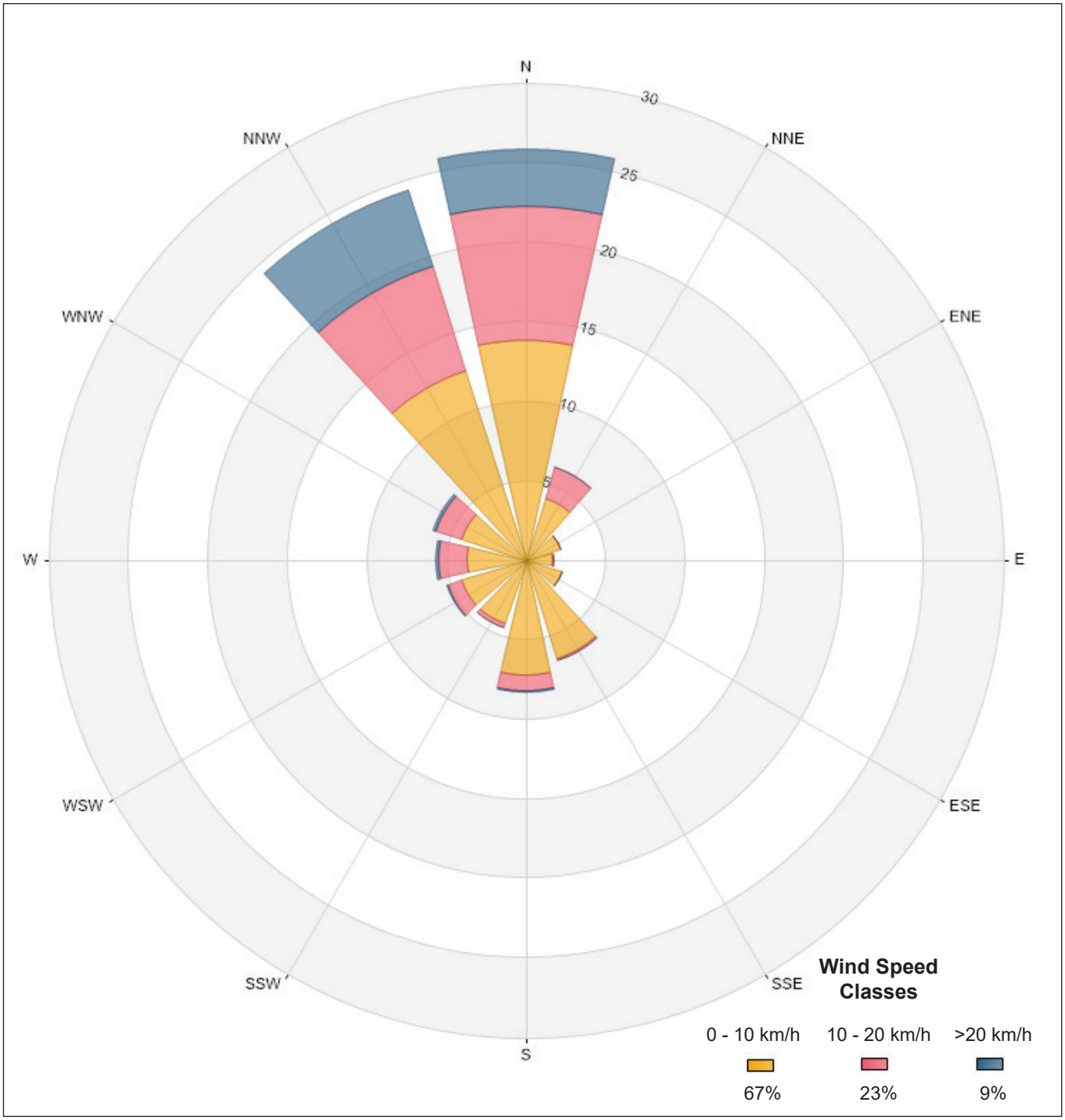

Figure C1: Wind Rose Diagram (Direction of Wind Origin) - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

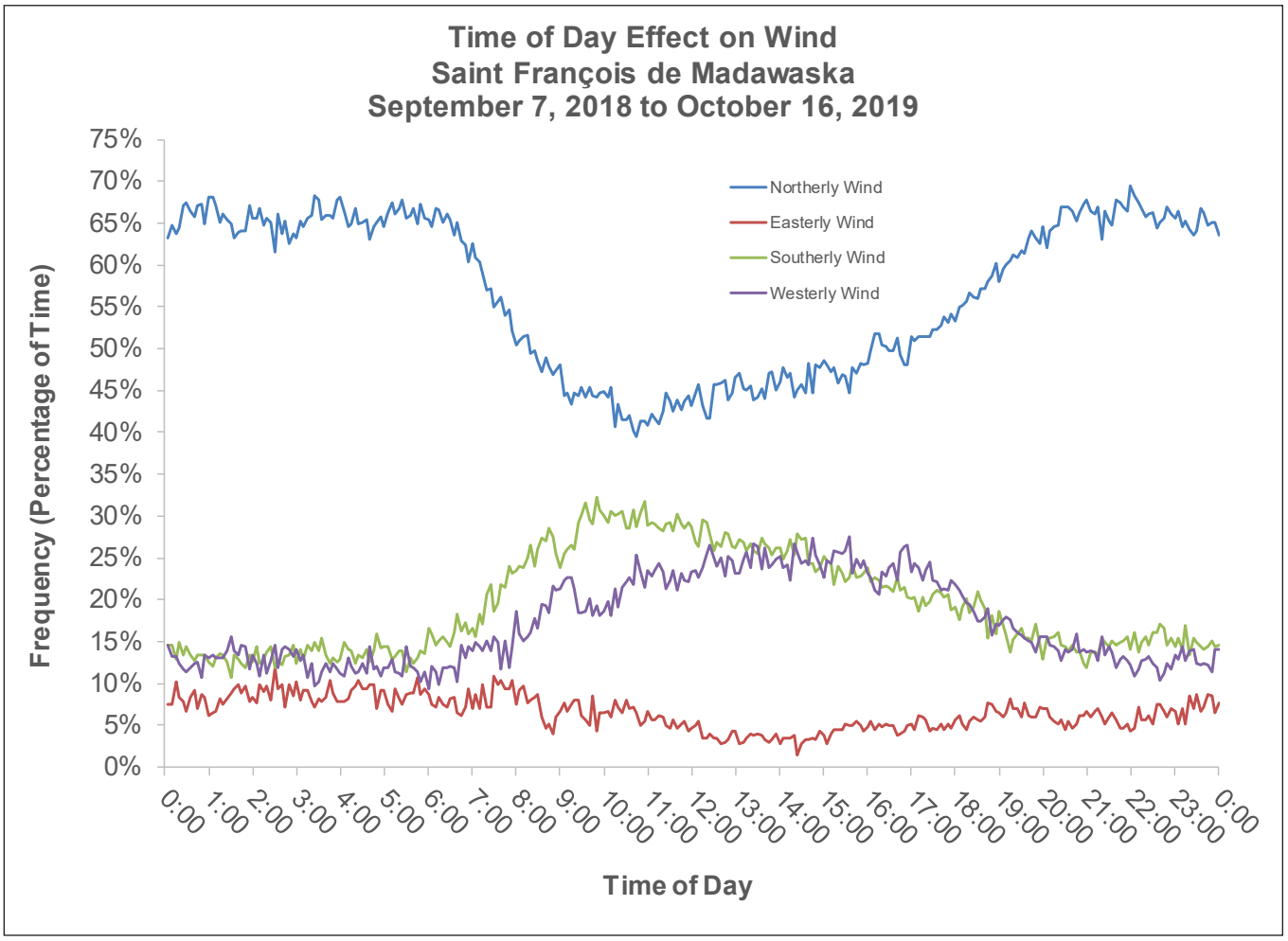

Figure C2: Relative Frequency of Direction of Wind Origin Versus Time of Day - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

Appendix D: Project Site Continuous Monitors - Additional Data

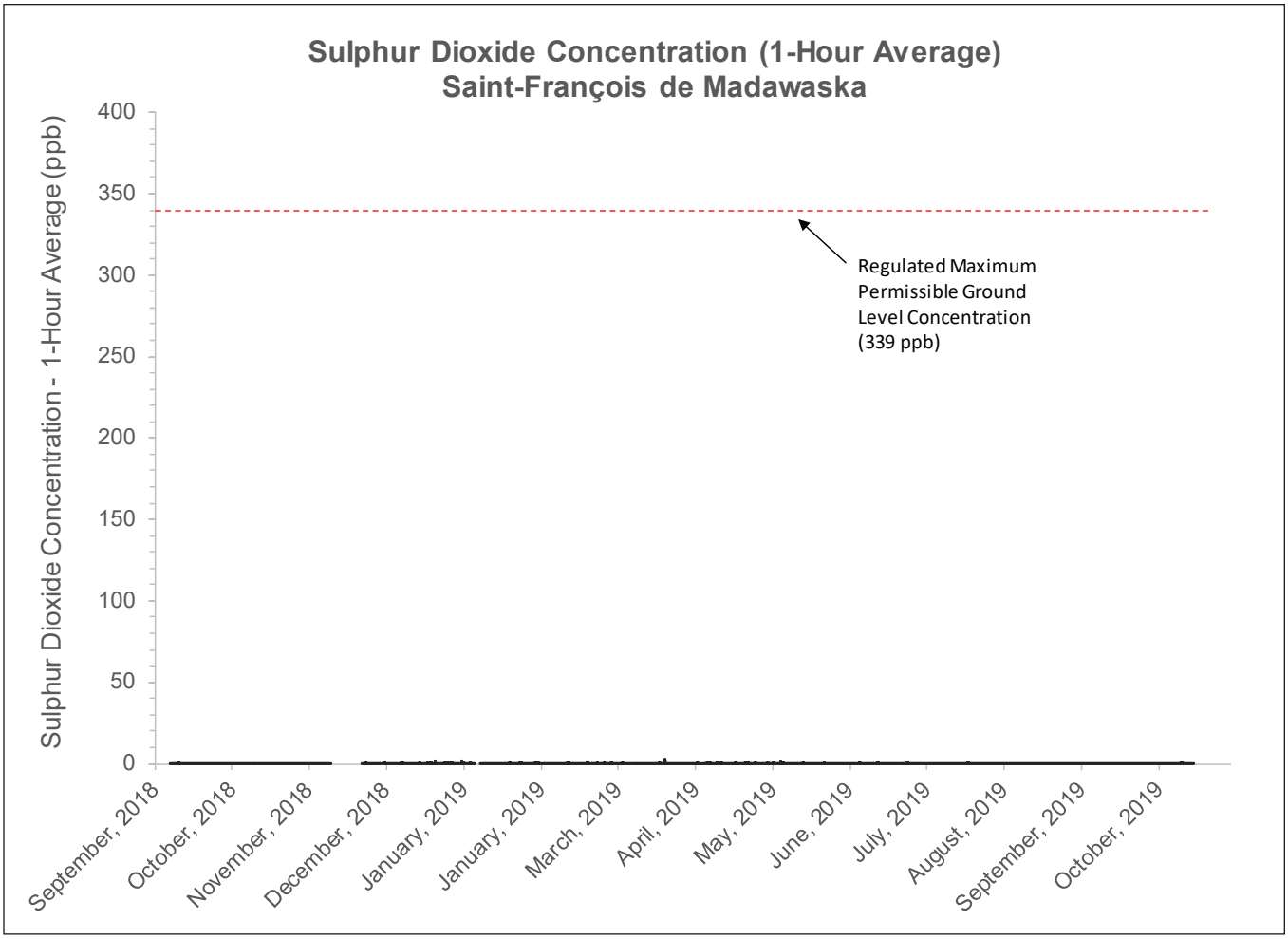

Figure D1: Hourly Average Sulphur Dioxide Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

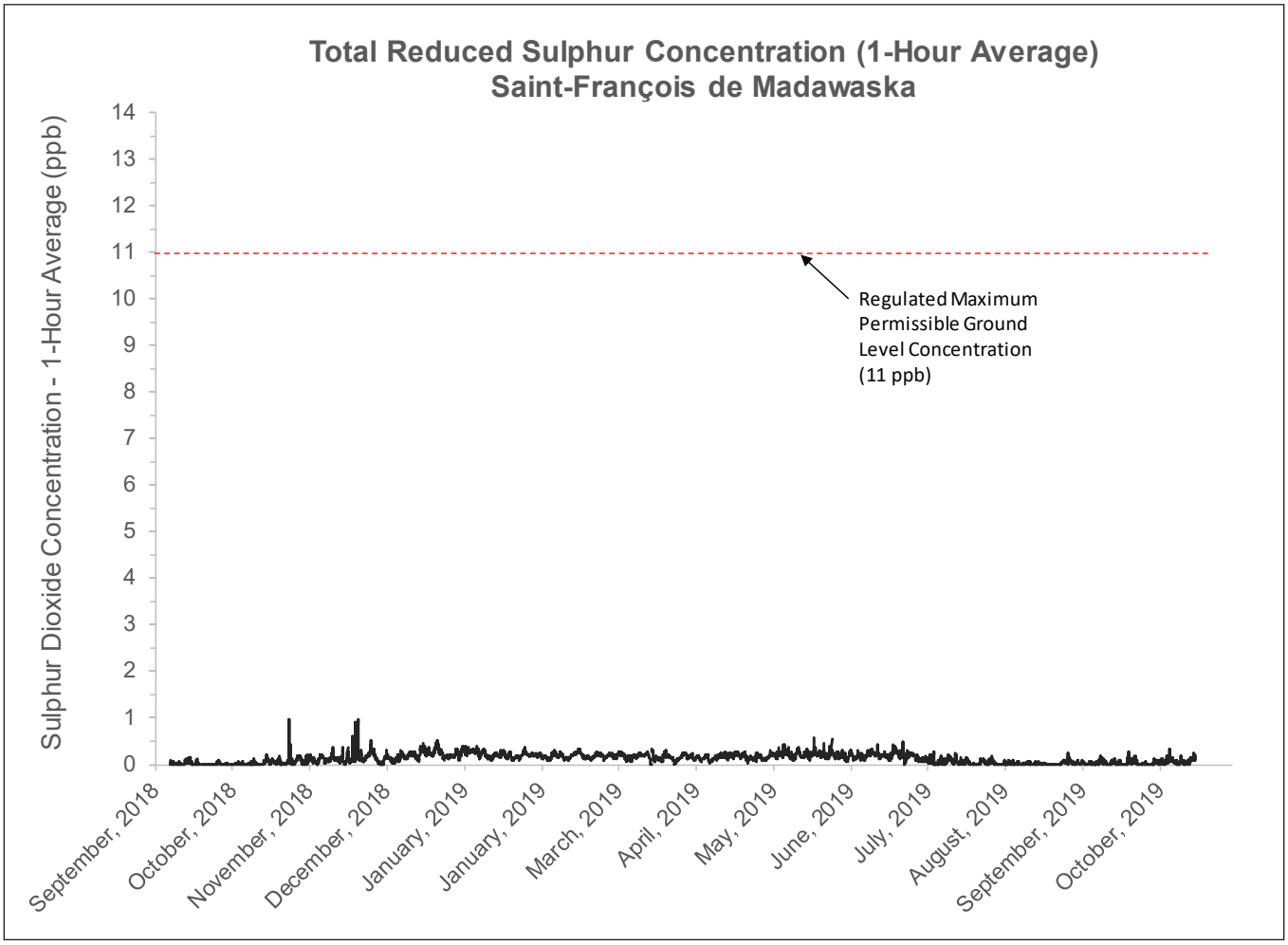

Figure D2: Hourly Average Total Reduced Sulphur Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

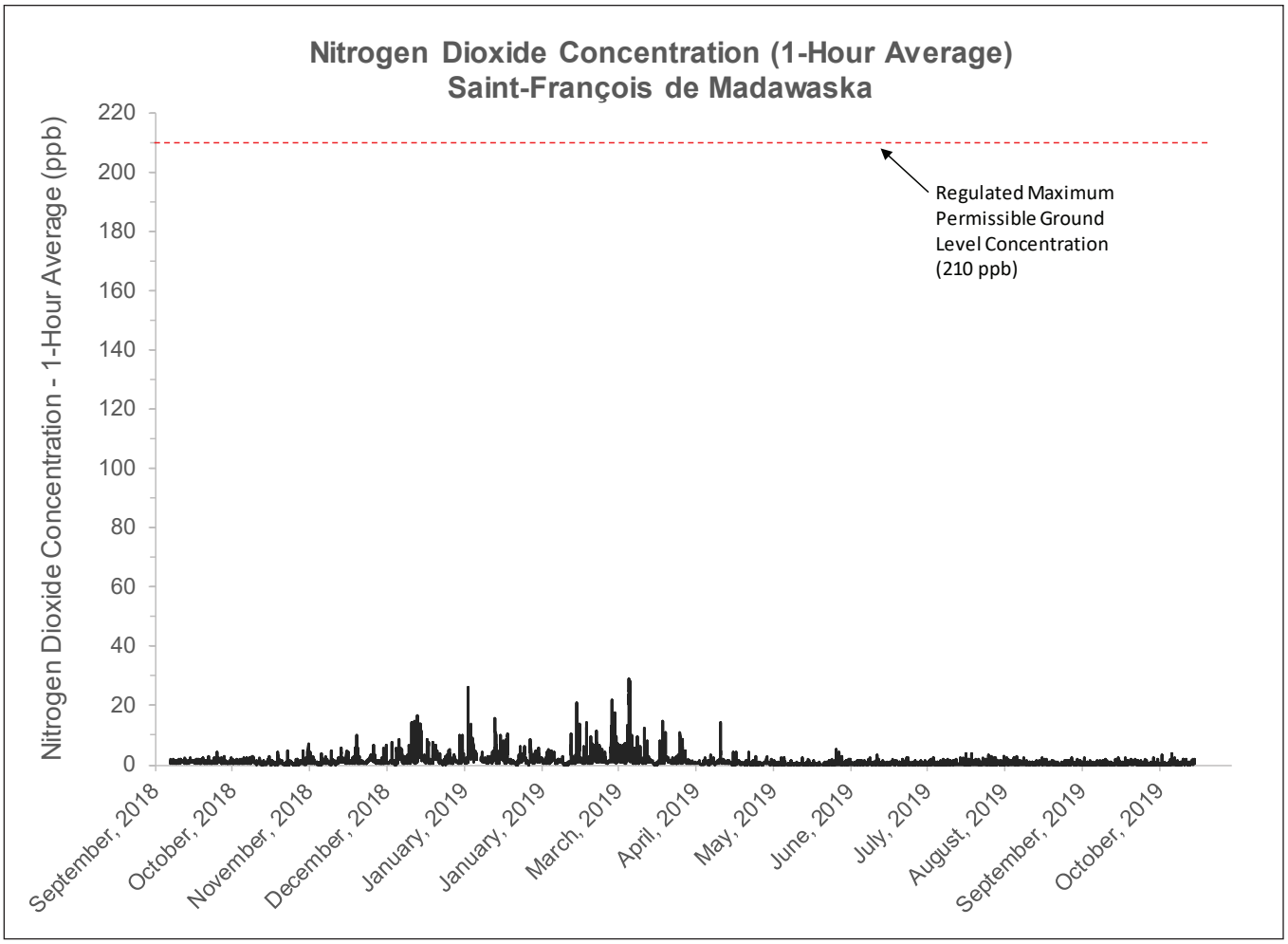

Figure D3: Hourly Average Nitrogen Dioxide Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

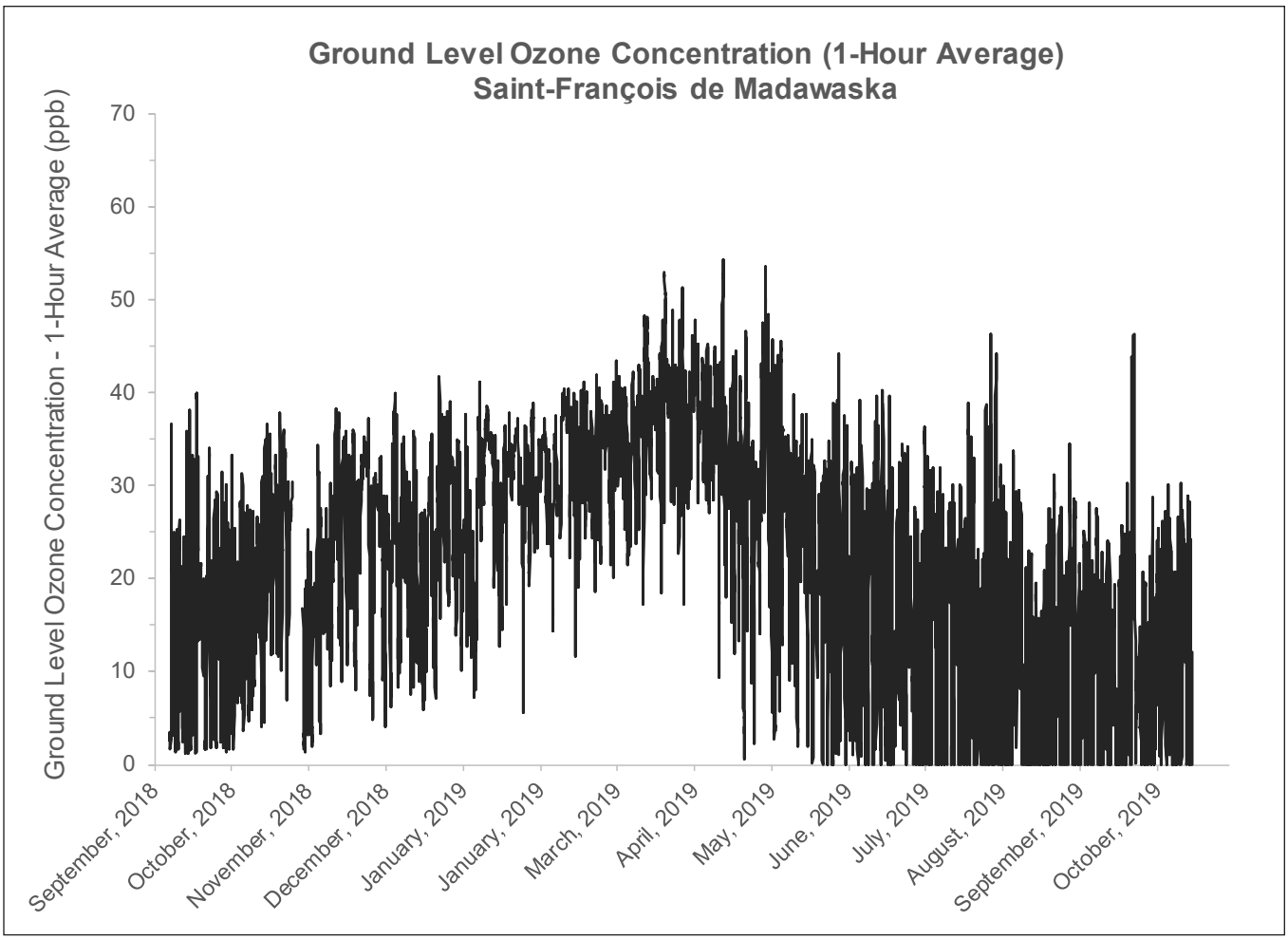

Figure D4: Hourly Average Ground Level Ozone Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

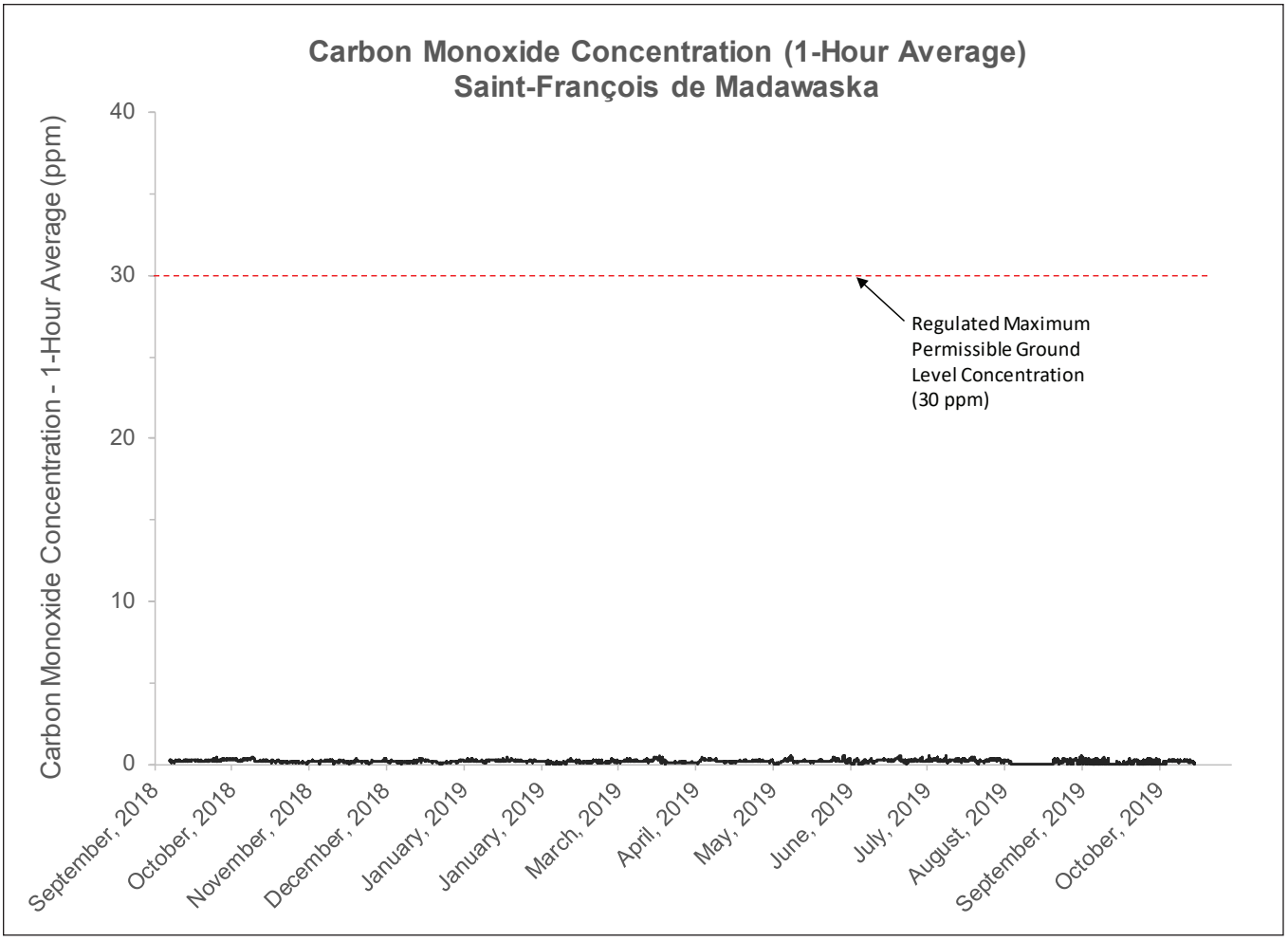

Figure D5: Hourly Average Carbon Monoxide Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

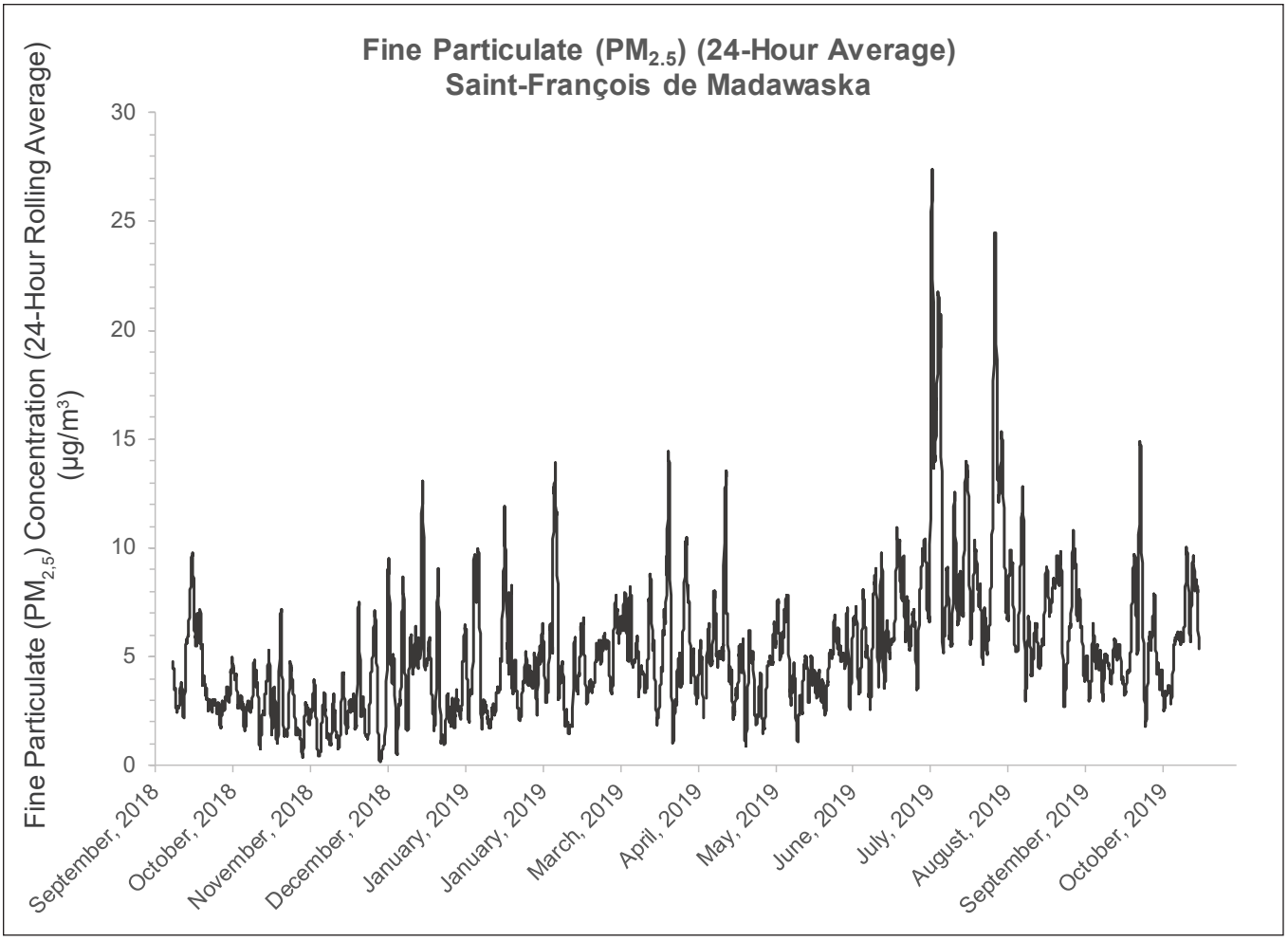

Figure D6: 24-Hour Rolling Average Fine Particulate ($PM_{2.5}$) Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

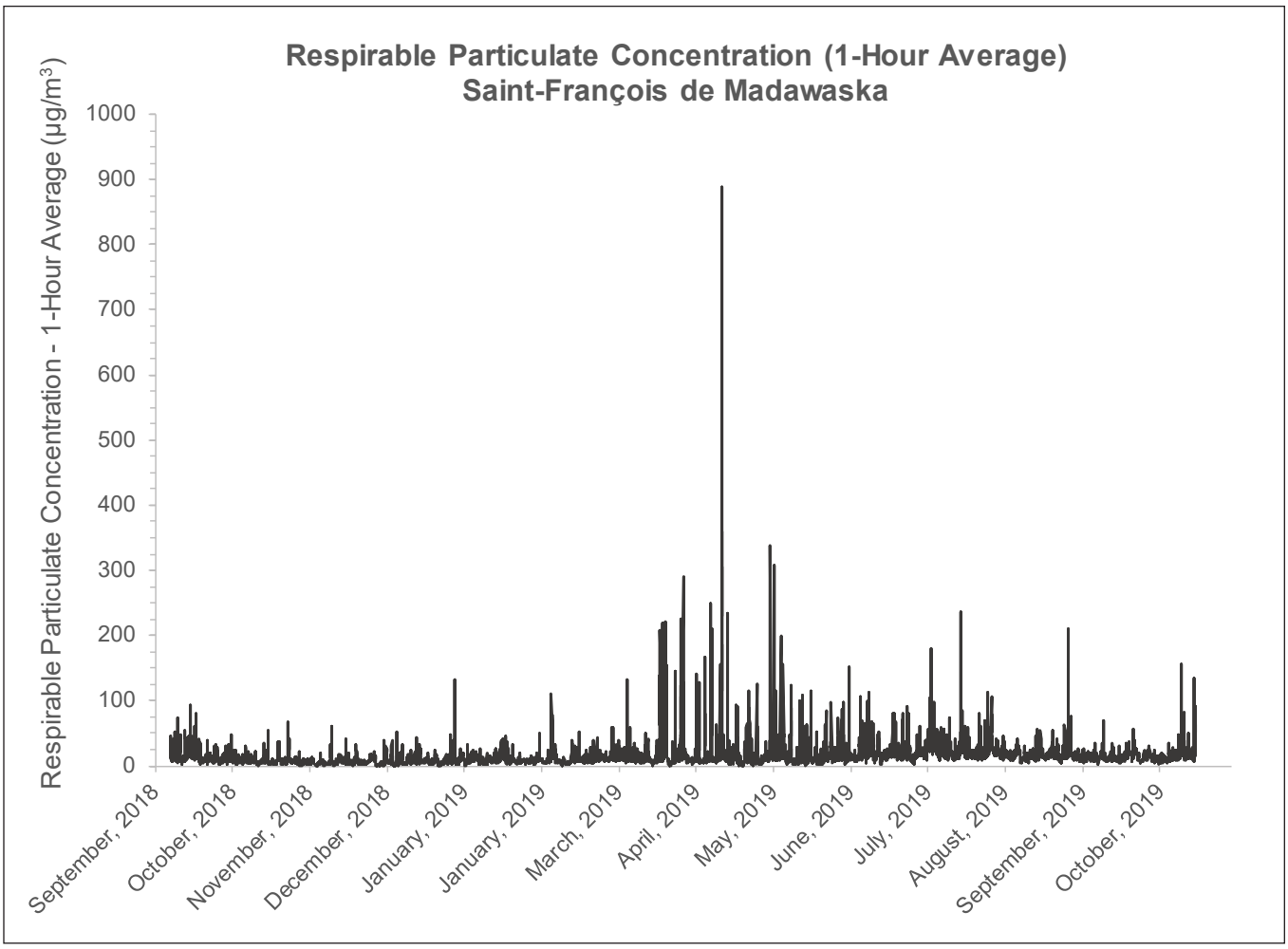

Figure D7: Hourly Average Respirable Particulate (PM_{10}) Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

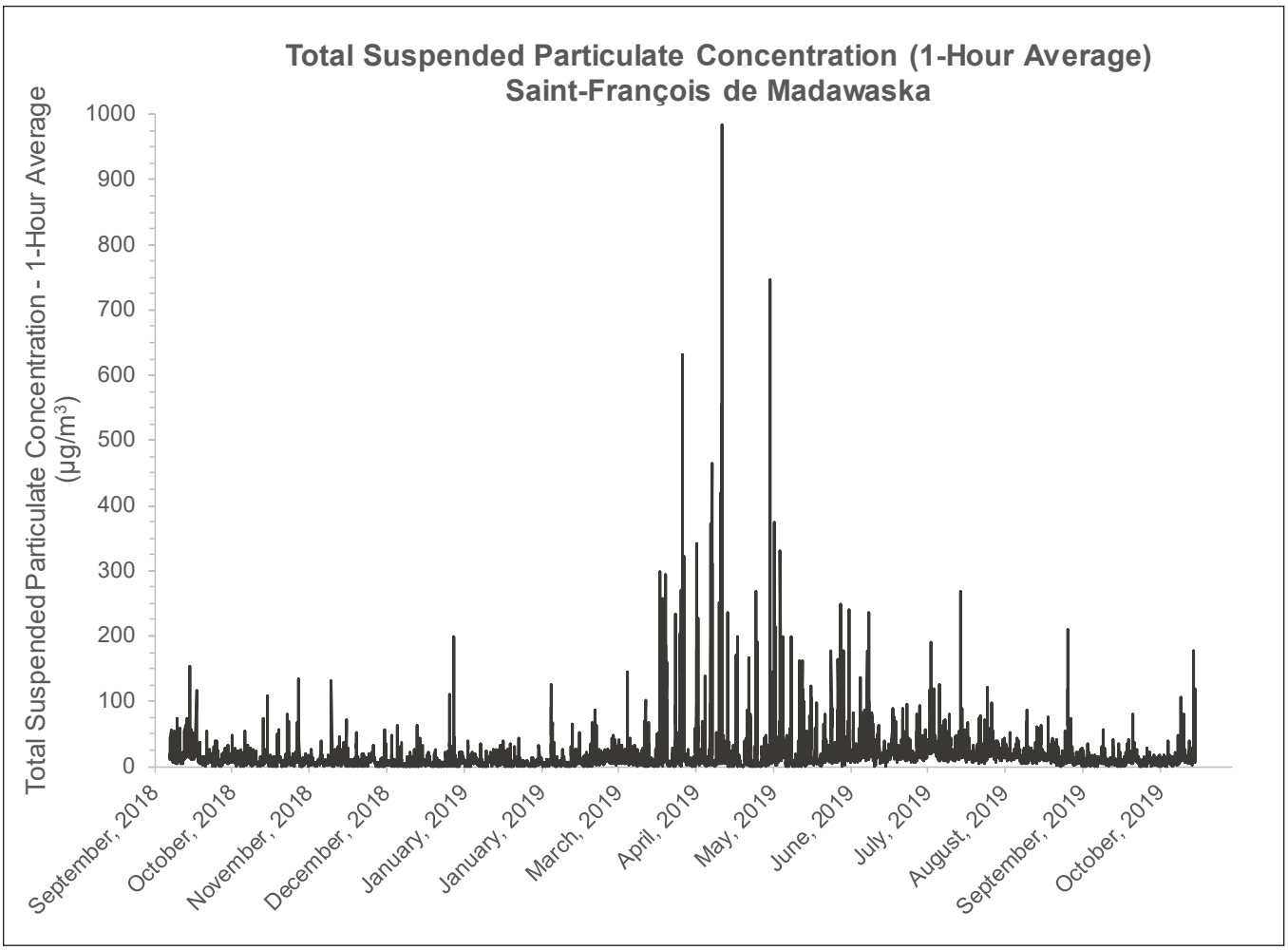

Figure D8: Hourly Average Total Suspended Particulate (TSP) Concentration - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

Appendix E: Fertilizer Plant Property Line Site Continuous Monitors - Additional Data

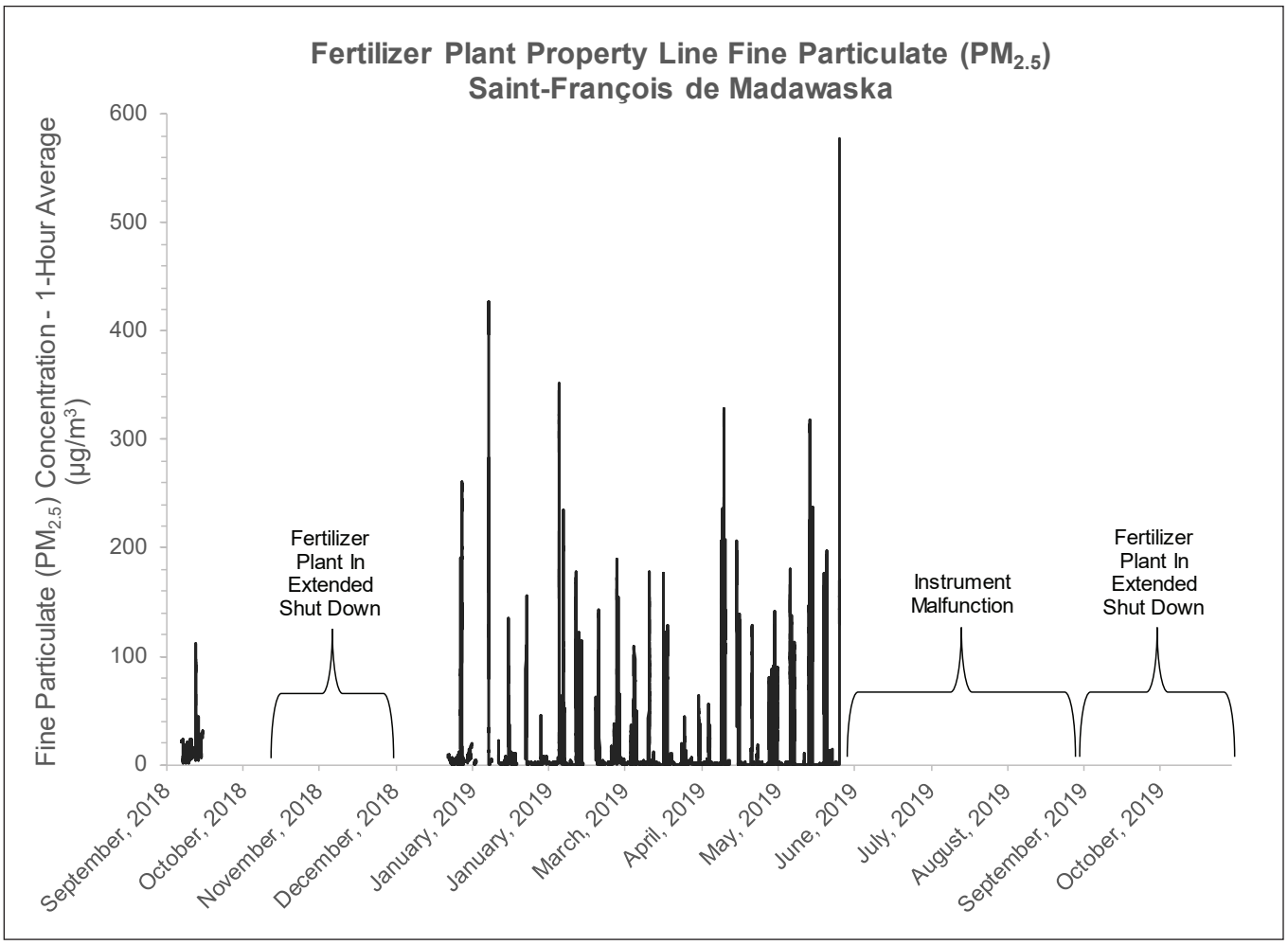

Figure E1: Industry-run Monitor. 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

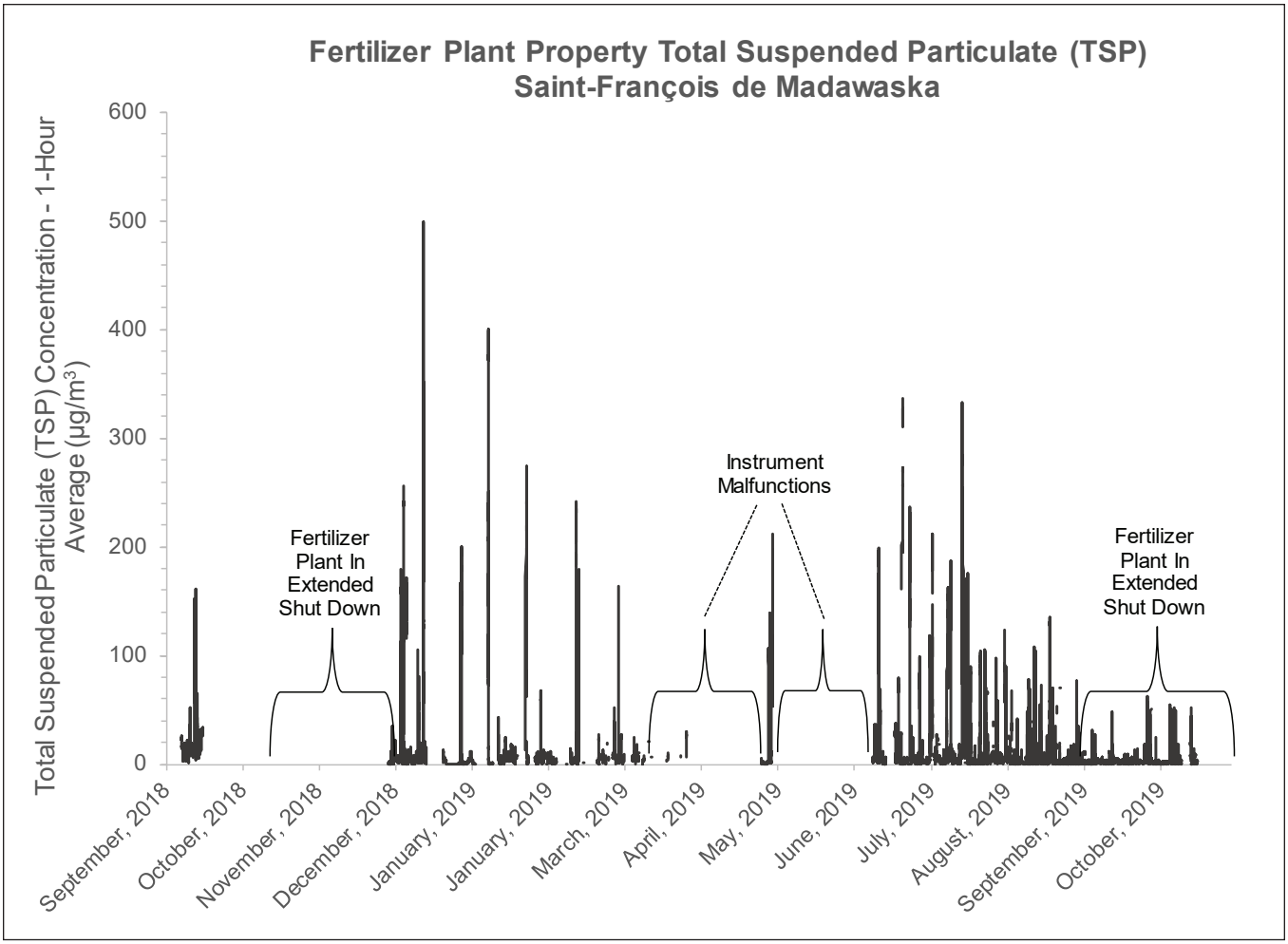

Figure E2: Industry-run Monitor. 1-Hour Average Respirable Particulate (PM_{10}) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix F: Odour/Health Complaint Data

Citizen Complaint Log

Year	Month	Day	Number of Complaints (Time of Day)
2018	September	13	1 (6:05 PM)
		18	1 (unspecified)
		19	1 (unspecified)
	October	1	1 (unspecified)
		3	1 (unspecified)
		4	1 (unspecified)
		10	1 (unspecified)
	November	30	1 (morning), 1 (9:30 AM), 1 (unspecified)
	December	3	1 (11:50 AM), 1 (10:53 AM), 1 (morning)
		4	1 (9:30 AM), 1 (unspecified)
		5	1 (9:30 AM), 1 (10:15 AM), 1 (10:27 AM), 1 (10:40 AM), 1 (8:00 - 10:30 PM)
		6	1 (all day)
		10	1 (2:40 PM) 1, (unspecified)
		12	1 (morning)
		13	1 (morning)
		14	1 (8:20 AM), 1 (8:37 AM), 1 (unspecified)
		17	1 (unspecified)
2019	January	10	1 (afternoon)
		14	1 (10:25 AM)
		16	1 (unspecified)
		24	1 (9:15 AM)
		30	1 (10:50 AM)
		31	1 (unspecified)
	February	4	1 (11:00 AM),1 (11:10 AM), 2 (morning), 1 (afternoon)
		5	1 (10:40 AM)
		6	1 (11:50 AM)
		12	1 (4:10 PM)
	March	6	1 (8:30 AM),1 (10:10 AM), 2 (morning)
		12	1 (8:50 AM) , 1 (afternoon)
		13	1 (afternoon)
		14	1 (8:55 AM)
		18	1 (11:11 AM)
		19	1 (10:15 AM), 1 (11:19 AM)
		20	1(9:15 AM)
		25	1 (9:03 AM), 1 (9:30 AM)
		29	1 (10:30 AM)
	April	8	1 (3:55 PM)
		9	1 (8:45 AM)
		15	1 (8:45 AM), 1 9:05 AM)
		16	1 (9:15 AM), 1 (9:40 AM)
		18	1 (morning)
		22	1 (8:04 AM)
		26	1 (8:45 AM)
	May	7	1 (2:50 PM)
		15	1 (morning), 1 (2:00 PM)
		16	1 (4:00 - 7:00 PM)
		20	1 (unspecified)
		21	1 (unspecified)
		22	1 (10:00 AM), 1 (all day)
		23	1 (morning)
		24	1 (8:45 AM)
		30	1 (1:30 PM), 1 (3:30 PM)

Appendix F: Odour/Health Complaint Data

Citizen Complaint Log (Continued)

Year	Month	Day	Number of Complaints (Time of Day)
2019	June	6	1 (morning), 1 (8:20 AM)
		14	1 (8:45 AM)
		20	1 (9:25 AM), 1 (11:15 AM)
		24	1 (morning)
	July	5	1 (morning)
		9	1 (6:23 PM), 1 (5:00 PM)
		11	1 (9:00 AM), 1 (9:55 AM)
		15	1 (11:44 AM), 1 (1:20 PM), 1 (unspecified)
		16	1 (8:27 AM)
		17	1 (2:20 PM)
		24	1 (10:25 AM), 1 (11:45 AM), 1 (unspecified)
		29	1 (11:40 AM)
	August	1	2 (morning)
		8	1 (8:40 AM)
		15	1 (8:35 AM)
		27	1 (8:55 AM), 1 (10:15 AM)

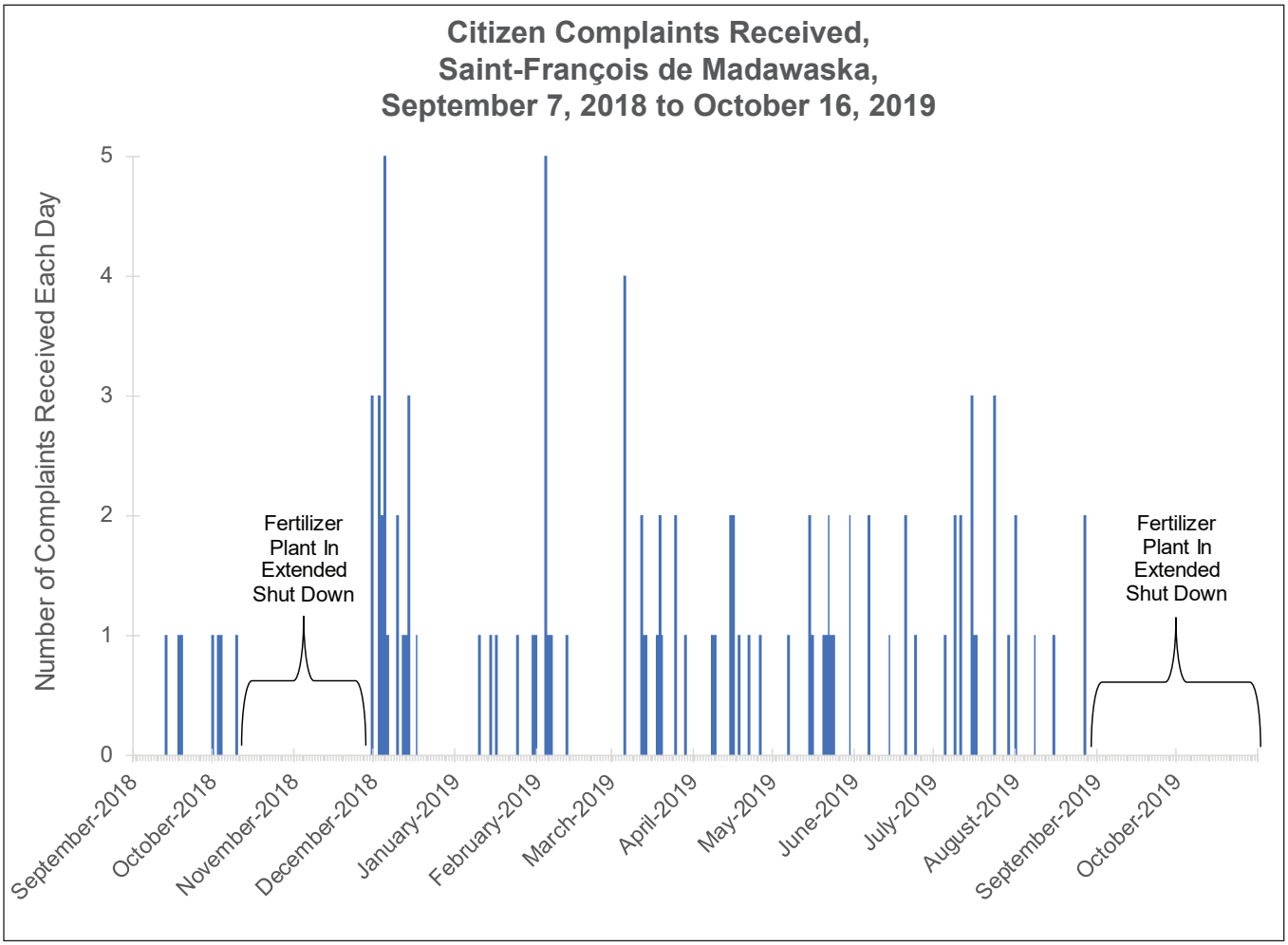

Figure F1: Citizen Complaints - Saint-François de Madawaska, September 7, 2018 to October 16, 2019.

Appendix G: Fertilizer Plant Operating Hours

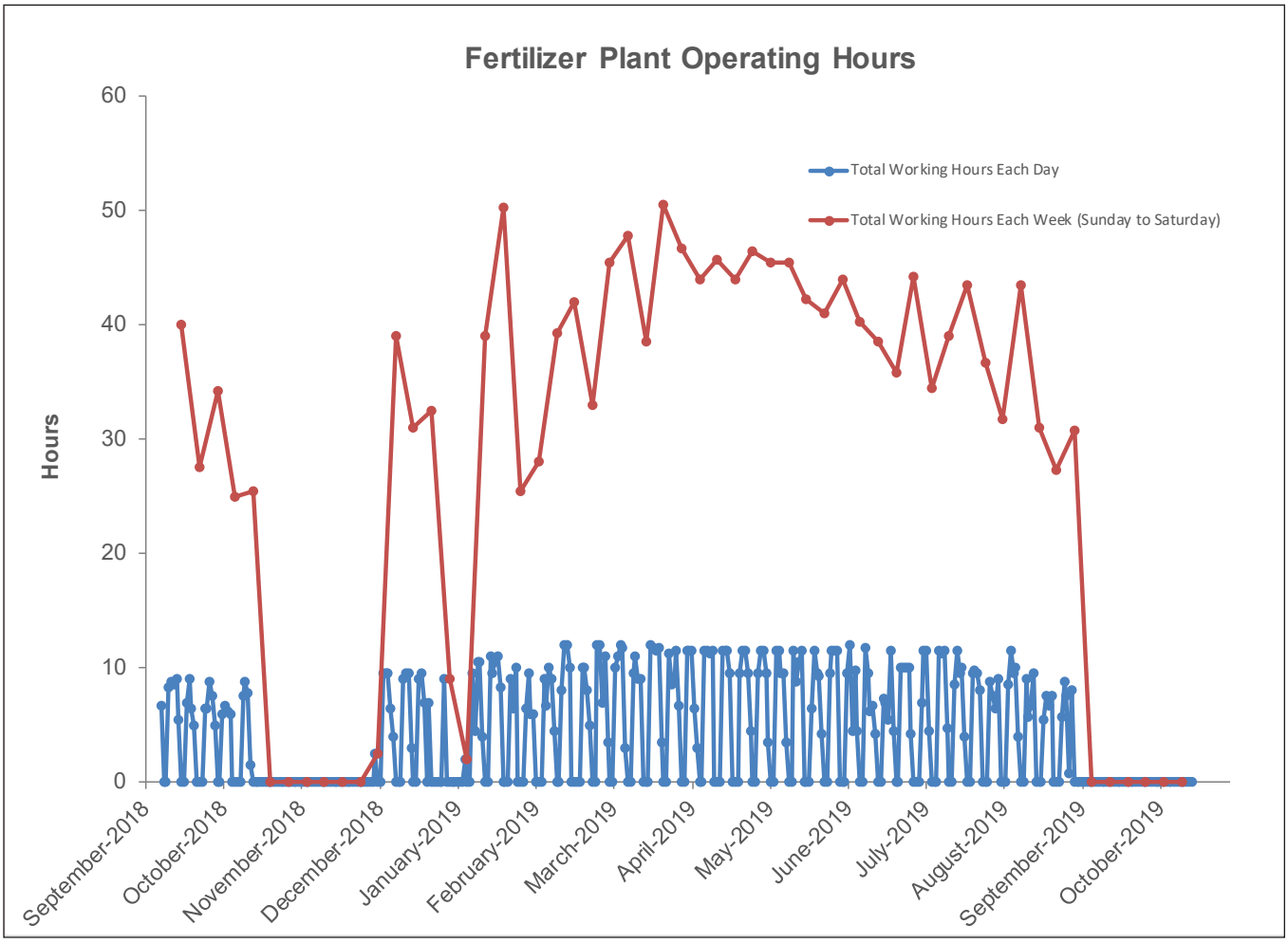

Figure G1: Daily and Weekly Total Operating Hours of the Fertilizer Plant - Saint-François de Madawaska, September 7, 2018 to October 16, 2019