2015 Annual Ambient Air Quality Monitoring Report for the Durham York Energy Centre (Crago Road Station)

Durham York Energy Centre

Prepared for:
The Regional Municipality of Durham
605 Rossland Rd
Whitby, ON L1N 6A3

Prepared by:
Stantec Consulting Ltd.
300W-675 Cochrane Dr.
Markham, ON L3R 0B8

Project No.: 160950528

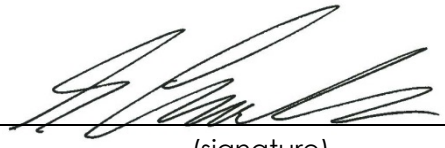
June 13, 2016

Sign-off Sheet

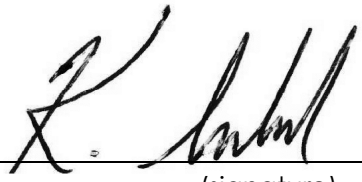
This document entitled 2015 Annual Ambient Air Quality Monitoring Report for the Durham York Energy Centre (Crago Road Station) was prepared by Stantec Consulting Ltd. for the account of The Regional Municipality of Durham. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Prepared by 
(signature)

Connie Lim, B.A.Sc.

Reviewed by 
(signature)

Gregory Crooks M.Eng., P.Eng.

Reviewed by 
(signature)

Kimberly Ireland, P.Eng.

V:\01609\Active\160950528\planning\report\final\2015\2015 Annual Crago Report\160950528_crago_rpt_ Ann2015_final_2016_06_13.docx

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

The Regional Municipalities of Durham and York operate the Durham York Energy Centre (DYEC) which is an Energy-from-Waste (EFW) Facility intended to provide a long-term, sustainable solution to manage municipal solid waste remaining after diversion from the Regions.

An Ambient Air Quality Monitoring Plan – Durham York Residual Waste Study (Ambient Monitoring Plan) was developed and included two monitoring stations referred to as the Courtice Water Pollution Control Plant (WPCP) Station and the Rundle Road Station (as well as a temporary fence line monitor). The Ambient Monitoring Plan was developed to satisfy the conditions of the Environmental Compliance Approval and the environmental mitigation commitments set out in the Environmental Assessment completed during the planning phase of the project. The Ambient Monitoring Plan aligns with the Regional Municipality of Durham (the Region) Council's mandate to provide ambient air quality monitoring in the area of the DYEC for a three year period.

Subsequently, the Region decided to add a third ambient air monitoring station located near the corner of Crago and Osborne Roads (referred to as the Crago Road Station), which was installed in October/November 2014. The Crago Road Station is not part of the Ambient Monitoring Plan; however, it is operated following the same protocols as the other two stations. Results of the Crago Road Station are reported separately from the Courtice WPCP and Rundle Road Stations.

The Crago Road Station is equipped to measure concentrations of the several air contaminants either continuously or at scheduled intervals (non-continuously) as outlined below:

- Contaminants monitored continuously:
  - Sulphur Dioxide (SO_2)
  - Nitrogen Oxides (NO_X), and
  - Particulate Matter smaller than 2.5 microns ($PM_{2.5}$).
- Contaminants monitored non-continuously:
  - Metals in Total Suspended Particulate (TSP) matter
  - Polycyclic Aromatic Hydrocarbons (PAHs), and
  - Dioxins and Furans.

The DYEC commenced commissioning on February 13, 2015 and was being commissioned throughout the rest of 2015. As per the Ambient Monitoring Plan (Stantec, 2012), collection of continuous parameters only during commissioning (and in the 6-weeks in 2015 prior to commissioning) was required. When the DYEC facility is fully operational, monitoring of non-continuous parameters will resume (as specified in the Ambient Monitoring Plan).

Meteorological data is also measured at the station. The predominantly downwind Crago Road Station measures horizontal wind speed, wind direction, atmospheric temperature, relative humidity and rainfall.

This annual report provides a summary of the ambient air quality data collected at the Crago Road Station for the period January to December 2015 and follows the same annual reporting requirements as for the Courtice WPCP and Rundle Road monitoring stations.

The 2015 monitoring primarily collected air quality levels while the DYEC was being commissioned. The following observations and conclusions were made from a review of the measured ambient air quality monitoring data:

1. Measured concentrations of NO_2, SO_2 and $PM_{2.5}$ were below the applicable O.Reg. 419/05 criteria and/or human health risk assessment (HHRA) health-based standards presented in **Table 2-1** of this report for hourly, 24-hour and annual averaging periods.

2. The 98th percentile of the measured daily average $PM_{2.5}$ levels during the 2015 monitoring period was 22.7 µg/m^3 at the Crago Road Station. As detailed below, this value of the 98th percentile should not be used for comparison against the Canadian Ambient Air Quality Standard.

3. The 24-hour and annual $PM_{2.5}$ Canadian Ambient Air Quality Standards (CAAQS) criteria both require a 3-calendar year average for comparison, with the data considered valid if an annual 98th percentile value is available for at least two of the three calendar years. Since only 2015 data is available, the measurements were not explicitly compared to the CAAQS criteria as any comparison would not be valid.

4. Metals in TSP and PAHs were not measured in 2015 as per Section 1.2 of the Ambient Monitoring Plan (Stantec, 2012).

5. Dioxins and furans sampling was resumed on October 21, 2015 (during commissioning of the facility) as requested by the Region. This additional sampling was not part of the Ambient Monitoring Plan and was conducted at 12-day intervals for the rest of 2015 (and into 2016). The maximum toxic equivalent dioxin and furan concentration measured over this period was well below the applicable criteria presented in **Table 2-2**.

In summary, the measured concentrations of the air contaminants monitored were below their applicable Ministry of the Environment and Climate Change (MOECC) criteria during the 2015 monitoring period. Furthermore, the measured levels of the monitored contaminants were below their applicable HHRA health-based standards. Air quality trends will be assessed in the next annual report after the collection of more data.

Abbreviations

AAQC	Ambient Air Quality Criteria
CAAQS	Canadian Ambient Air Quality Standard
CAC	Criteria Air Contaminants
DAS	Digital data acquisition system
D/Fs	Dioxins and Furans
DYEC	Durham York Energy Centre
EFW	Energy from Waste
HHRA	Human Health Risk Assessment
MOECC	Ontario Ministry of the Environment and Climate Change
SO_2	Sulphur Dioxide
NO_X	Nitrogen Oxides
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbons
Particulate	A particle of a solid or liquid that is suspended in air.
PCB	Polychlorinated biphenyl
PCDD/PCDF	Polychlorinated dibenzo-p-dioxins and dibenzofurans
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter smaller than 2.5 microns
TEQ	Toxic equivalent quotient
TEQs	Toxic Equivalents
TSP	Total Suspended Particulate
WPCP	Water Pollution Control Plant
Elements	
Cd	Cadmium
Hg	Mercury
Pb	Lead
Al	Aluminum
As	Arsenic
Be	Beryllium
Cr	Chromium
Cu	Copper
Mn	Manganese
Ni	Nickel
Ag	Silver

Tl	Thallium
Sn	Tin
V	Vanadium
Zn	Zinc
Miscellaneous	
°C	temperature in degrees Celsius
N/A	not available
%	percent
ppm	part per million
ppb	part per billion
ppt	part per trillion
min	minimum
max	maximum
µg/m^3	microgram per cubic metre

1.0 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

The Regional Municipalities of Durham and York operate the Durham York Energy Centre (DYEC) which is an Energy-from-Waste (EFW) Facility intended to provide a long-term, sustainable solution to manage municipal solid waste remaining after diversion from the Regions. The facility commenced commissioning on February 13, 2015 and was being commissioned throughout the rest of 2015. The site location of the DYEC is shown in **Figure 1-1** below.

An Ambient Air Quality Monitoring Plan – Durham York Residual Waste Study (Ambient Monitoring Plan) was developed and included two monitoring stations referred to as the Courtice Water Pollution Control Plant (WPCP) Station and the Rundle Road Station (as well as a temporary fence line monitor). The plan developed for these stations was based on the Regional Council's mandate to provide ambient air quality monitoring in the area of the DYEC for a three year period.

The purposes of the Ambient Monitoring Plan are to:

1. Quantify any measureable ground level concentrations resulting from emissions from the DYEC cumulative to local air quality, including validating the predicted concentrations from the dispersion modelling conducted in the Environmental Assessment (Jacques Whitford, 2009).
2. Monitor concentration levels of EFW-related air contaminants in nearby residential areas.
3. Quantify background ambient levels of air contaminants in the area.

At the request of the Regional Municipality of Durham (the Region), a third ambient air monitoring station located near the corner of Crago and Osborne Roads was installed. This station, which is not part of the Ambient Monitoring Plan, is operated following the same protocols as the other two stations (Courtice WPCP and Rundle Road Stations) already in operation.

Since November 2014, the predominantly downwind Crago Road Station has measured the following air contaminants continuously:

- Sulphur Dioxide (SO_2)
- Nitrogen Oxides (NO_X), and
- Particulate Matter smaller than 2.5 microns ($PM_{2.5}$).

The facility commenced commissioning on February 13, 2015 and was being commissioned throughout the rest of 2015. As per the Ambient Monitoring Plan, collection of continuous parameters only during commissioning (and in the 6-weeks in 2015 prior to commissioning) was conducted. Operation of the non-continuous monitors at the Crago Road Station was therefore

not started as per Section 1.2 of the Ambient Monitoring Plan (Stantec, 2012). When the EFW facility is fully operational, monitoring of non-continuous monitors will start (as specified in the Ambient Monitoring Plan). The following air contaminants will be measured non-continuously:

- Metals in total suspended particulate matter (TSP)
- Polycyclic Aromatic Hydrocarbons (PAHs), and
- Dioxins and Furans.

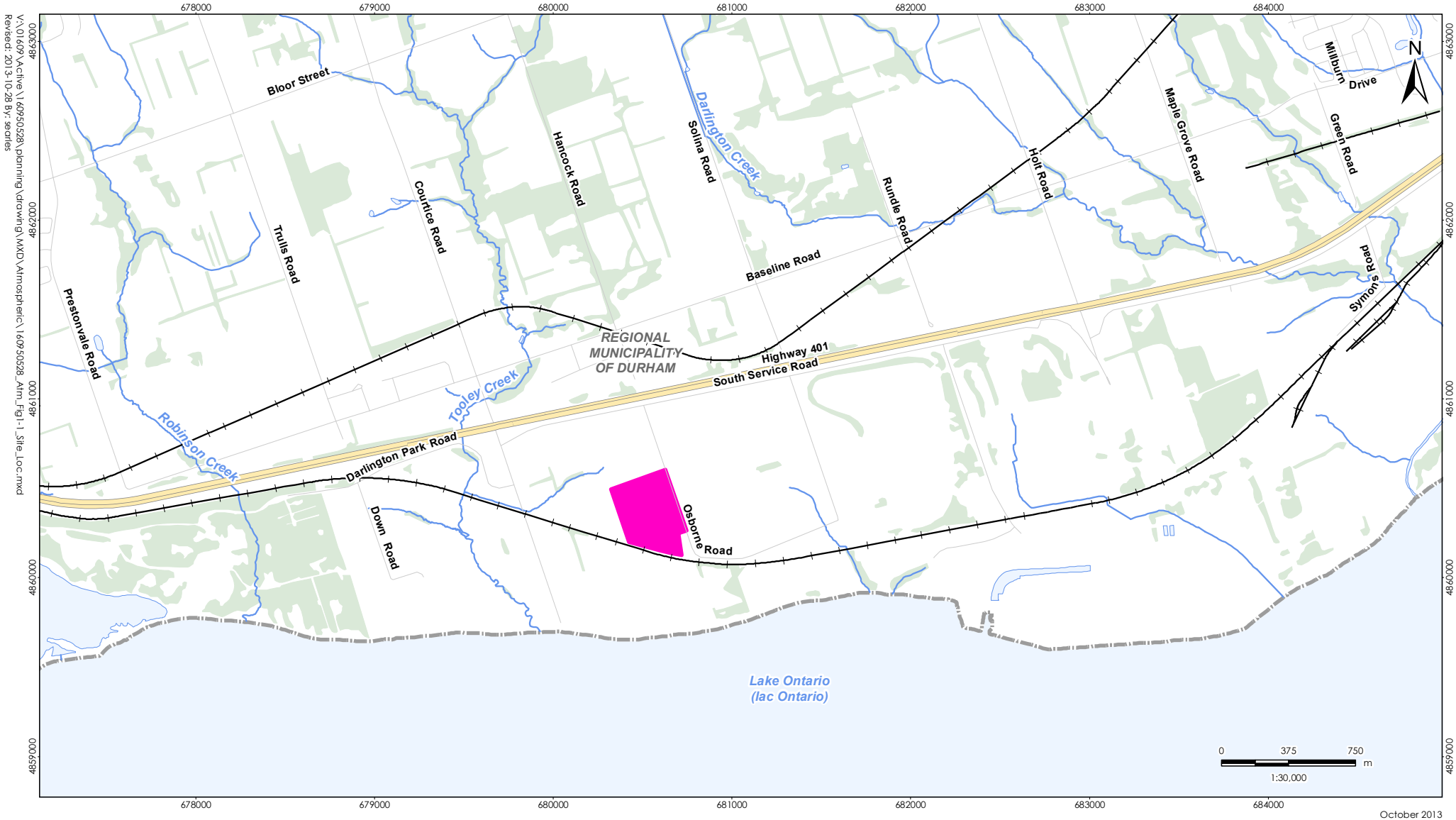
Quarterly reports presenting the ambient air quality data collected at this station for 2015 were prepared by Stantec and submitted to the Regional Municipality of Durham. This Annual Report summarizes the results of the ambient air monitoring from January to December 2015.

At the request of the Region, dioxins and furans sampling was resumed on October 21, 2015 during commissioning of the facility. This additional sampling was outside the scope of the Ambient Monitoring Plan (Stantec, 2012). The sampling was conducted at 12-day intervals corresponding with the Ontario Ministry of the Environment and Climate Chante (MOECC) province-wide ambient sampling schedule between October 21, 2015 and the end of the year (and into 2016). Results of the additional 2015 dioxins and furans sampling are presented in this report.

1.2 LOCATION OF THE AMBIENT AIR QUALITY MONITORING STATION

The selection of the site for the monitoring station was accomplished in consultation with Regional Municipality of Durham representatives, with consideration of the location of the existing monitoring stations and general MOECC siting criteria. The final location of the monitoring station was influenced by the availability of electrical power, accessibility of each location, and security.

The Crago Road Station location is sited east of the DYEC in the vicinity of the Darlington Hydro Upper and Lower Soccer Fields on the east side of Crago Road, north of Osborne Road. Its location is shown in **Figure 1-2** and **Figure 1-3**. The monitoring station is equipped to measure all the air contaminants listed in Section 1.1 and collects meteorological data.



V:\01609\Active\160950528\planning\drawing\MXD\Atmospheric\160950528_Atm_Fig1-1_Site_Loc.mxd
Revised: 2013-10-28 By: seorles

October 2013
160950528

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Legend

- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse
- Waterbody
- Wooded Area

Client/Project

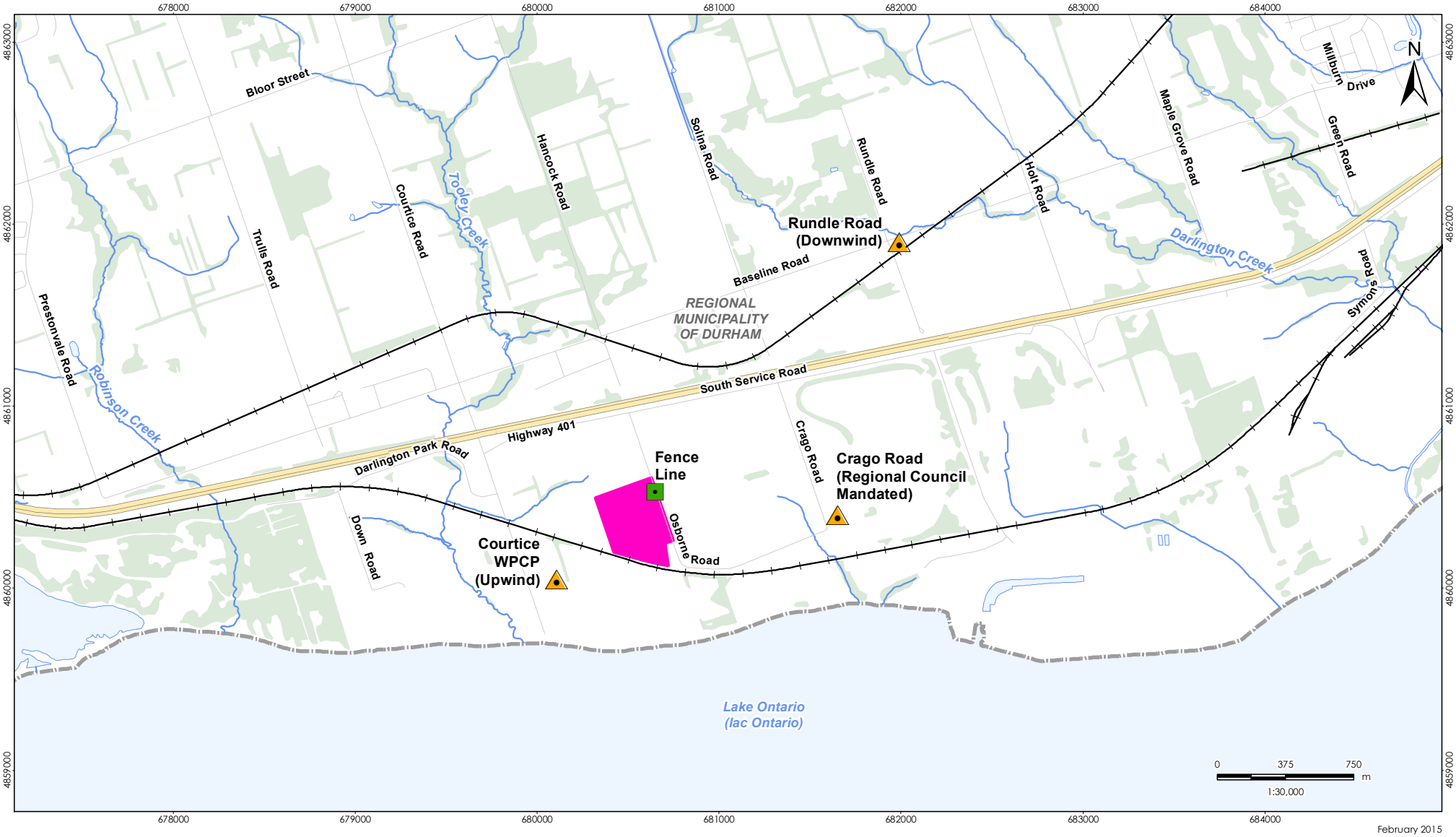
The Region of Durham
Durham York Energy Centre

Figure No.

1-1

Title

Site Location Plan



Revised: 2015-02-27 By: seorles
\\cd1215-001\work_group\01609\Active\160950528\planning\drawing\MXD\Atmospheric\OctDecQR\160950528_ODQR_Fig1-2_Ambient_Monitor_Loc.mxd

February 2015
160950528

Stantec

Legend

- Station Location
- Fence Line Station Location (Monitoring to begin after DYEC commissioning period)
- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse
- Waterbody
- Wooded Area

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Client/Project

The Region of Durham
Durham York Energy Centre

Figure No.

1-2

Title

Locations of Ambient Monitoring Stations

Figure 1-3 View of the Crago Road Ambient Air Quality Monitoring Station

2.0 KEY COMPONENTS ASSESSED

2.1 METEOROLOGY

The following meteorological parameters are measured at the Crago Road Station:

- Wind Speed and Direction at a height of10-m
- Ambient Temperature at a height of 2-m
- Relative Humidity, and
- Rainfall

2.2 AIR QUALITY CONTAMINANTS OF CONCERN

The ambient air quality monitoring program for the Crago Road Station includes the following contaminants specified in the Ambient Monitoring Plan (Stantec 2012):

- Continuously monitored criteria air contaminants (CACs)
  - Sulphur Dioxide (SO_2)
  - Nitrogen Oxides (NO_X), and
  - Particulate Matter smaller than 2.5 microns ($PM_{2.5}$).
- Non-continuously monitored
  - Metals in Total Suspended Particulate (TSP) matter
  - Polycyclic Aromatic Hydrocarbons (PAHs), and
  - Dioxins and Furans.

The Facility commenced commissioning on February 13, 2015 and was being commissioned throughout the rest of 2015. Operation of the non-continuous monitors at the Crago Road Station was not required during the commissioning period (nor in the 6-weeks in 2015 prior to commissioning), as per Section 1.2 of the Ambient Monitoring Plan (Stantec, 2012). When the EFW facility is fully operational, monitoring of non-continuous parameters will start (as specified in the Ambient Monitoring Plan).

At the request of the Regional Municipality of Durham, dioxins and furans sampling was started on October 21, 2015 and continued to January 25, 2016, however this additional sampling was outside the scope of the Ambient Monitoring Plan (Stantec, 2012). As such, the following air contaminants were not measured during 2015:

- Total Suspended Particulate (TSP) matter and metals, and
- Polycyclic Aromatic Hydrocarbons (PAHs).

2.2.1 Nitrogen Oxides (NO_X)

Nitrogen oxides (NO_X) are produced in most combustion processes, and are almost entirely made up of nitric oxide (NO) and nitrogen dioxide (NO_2). Together, they are often referred to as NO_X. NO_2 is an orange to reddish gas that is corrosive with an irritating odour. Most NO_2 in the atmosphere is formed by the oxidation of NO, which is emitted directly by combustion processes, particularly those at high temperature and pressure. NO is a colourless gas. The levels of NO and NO_2, and the ratio of the two gases, together with the presence of hydrocarbons and sunlight, are the most important factors in the formation of ground-level ozone (O_3). Further oxidation and combination with water in the atmosphere forms what is known as "acid rain".

Nitrogen oxides are emitted from a variety of combustion sources including vehicles, industrial heaters and boilers, and residential gas-fired furnaces and hot water boilers. Generally for combustion, 5 to 10% of the initial total emissions of NO_X are NO_2 with the remaining 90-95% being NO. The conversion of the majority of NO occurs after release to the atmosphere. The rate of conversion depends on the oxidizing potential of the atmosphere at the time of release. For example, if the ambient concentration of O_3 is high at the time of release, the conversion might be expected to be higher than if the ambient concentration of O_3 was low at that time.

2.2.2 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is a colourless gas with a distinctive pungent sulphur odour. It is produced in combustion processes by the oxidation of sulphur in the fuel. The presence of SO_2 can, at high enough concentrations, cause damage to vegetation and health effects to animals through their respiratory system. The SO_2 can also be further oxidized and combines with water to form the sulphuric acid component of "acid rain."

Sulphur dioxide is emitted mainly from industrial sources utilizing coal, coke or oil fired heaters and boilers.

2.2.3 Particulate Matter Smaller than 2.5 Microns ($PM_{2.5}$)

Total suspended particulate matter (TSP) is a measure of the particles in the atmosphere that are too small to settle out quickly, but remain suspended for significant periods of time. Generally, this means particles with an aerodynamic diameter of less than 44 µm. TSP is produced by a variety of emissions sources including wind erosion of agricultural fields and other open areas, abrasion of vehicle tires on paved and unpaved roads, agricultural activities, and combustion processes (e.g., industrial boilers and heaters, power generation, vehicle emissions).

Although total suspended particulate matter is an excellent measure of the loading of particulate matter in the air, it does not necessarily reflect the health risks of the particulate matter. The larger aerodynamic particles (PM_{10}) are trapped by the upper airways, and do not enter the lungs. Smaller diameter particles ($PM_{2.5}$) can make their way deep into the lungs, and

may become lodged there. Over the past few years, greater concern with regard to these fine particles has led to research resulting in new sampling methods and criteria.

2.2.4 Dioxins and Furans

Dioxins and furans refer to a family of toxic substances that all share a similar chemical structure. Dioxins and furans all contain chlorine and can occur in different configurations, called congeners. Most dioxins and furans are not produced intentionally, but are created when other chemicals or products are manufactured. Of all of the dioxins and furans, one cogener 2,3,7,8-tetrachloro-p-dibenzo-dioxin (2,3,7,8 Tetra CDD) is considered the most toxic. Toxicity equivalency factors (TEFs) from the World Health Organization (WHO) are applied to 17 dioxin and furan isomers to convert them into an equivalent 2,3,7,8 Tetra CDD concentration (TEQ) for comparison to ambient air quality criteria.

Concentrations of the following dioxins and furans were measured:

Dioxins and furans:

- 2,3,7,8-Tetra CDD
- 1,2,3,7,8-Penta CDD
- 1,2,3,4,7,8-Hexa CDD
- 1,2,3,6,7,8-Hexa CDD
- 1,2,3,7,8,9-Hexa CDD
- 1,2,3,4,6,7,8-Hepta CDD
- Octa CDD
- Total Tetra CDD
- Total Penta CDD
- Total Hexa CDD
- Total Hepta CDD
- 2,3,7,8-Tetra CDF
- 1,2,3,7,8-Penta CDF
- 2,3,4,7,8-Penta CDF
- 1,2,3,4,7,8-Hexa CDF
- 1,2,3,6,7,8-Hexa CDF
- 2,3,4,6,7,8-Hexa CDF
- 1,2,3,7,8,9-Hexa CDF
- 1,2,3,4,6,7,8-Hepta CDF
- 1,2,3,4,7,8,9-Hepta CDF
- Octa CDF
- Total Tetra CDF
- Total Penta CDF
- Total Hexa CDF
- Total Hepta CDF
- Total toxic equivalency (I-TEQ)

2.3 AIR QUALITY CRITERIA

Two sets of ambient air quality standards were used for comparison to the air quality data as specified in the Ambient Monitoring Plan (Stantec, 2012). The first set of standards is the limits as reported in O.Reg. 419/05 (Schedules 3 and 6). These are compliance based standards used throughout the province of Ontario. However, not all chemicals have O.Reg. 419/05 criteria, and in some instances updated health-based standards were used in the human health risk assessment (HHRA) that was conducted in support of the Environmental Assessment (July 31, 2009 - December 10, 2009). These health-based values, which were reported in Table 7-2 (Summary of Inhalation TRVs and Inhalation Benchmarks Selected for CACs) and Table 7-3 (Inhalation TRVs and Inhalation Benchmarks for Selected COPCs) of the HHRA (Stantec, 2009) were used as the second set of standards.

The previously applicable 24-hour Canada-Wide Standard (CWS) for $PM_{2.5}$ of 30 µg/m³ (98th percentile averaged over 3 consecutive years) has been superseded by the new Canadian Ambient Air Quality Standard (CAAQS) of 28 µg/m³ (98th percentile averaged over 3 consecutive years) and an annual objective of 10 µg/m³, as noted in **Table 2-1**. The proposed CAAQS 24-hour objective for 2020 is 27 µg/m³.

A summary of the ambient air quality criteria for dioxins and furans is presented in **Table 2-2**.

Table 2-1 Summary of Air Quality Criteria for CACs

Contaminant	CAS	O. Reg. 419/05 – Schedule 3/AAQC			HHRA Health-Based Standards		
		1-Hour (µg/m³)	24-Hour (µg/m³)	Annual (µg/m³)	1-Hour (µg/m³)	24-Hour (µg/m³)	Annual (µg/m³)
Sulphur dioxide	7446095	690	275	-	690	275	29
Nitrogen oxides [A]	10102-44-0	400	200	-	400	200	60
Contaminant	**CAS**	**Canadian Ambient Air Quality Standards (CAAQS)**			**HHRA Health-Based Standards**		
		1-Hour (µg/m³)	**24-Hour (µg/m³)**	**Annual (µg/m³)**	**1-Hour (µg/m³)**	**24-Hour (µg/m³)**	**Annual (µg/m³)**
$PM_{2.5}$	N/A	-	28 [B]	10 [C]	-	30 [D]	-

Notes:

A. The Schedule 3 standards for NO_X are based on health effects of NO_2, as NO_2 has adverse health effects at much lower concentrations than NO. Therefore the standard was compared to NO_2 in this report. However, as per the current April 2012 version of O. Reg. 419 Summary of Standards and Guidelines, the standard was also compared to the monitored NO_X.

B. Canadian Ambient Air Quality Standard for Respirable Particulate Matter, effective by 2015. The Respirable Particulate Matter Objective is referenced to the 98th percentile over 3 consecutive years.

C. Annual Canadian Ambient Air Quality Standard for Respirable Particulate Matter, effective by 2015. The Respirable Particulate Matter Objective is referenced to the 3-year average of the annual average concentrations.

D. HHRA Health-Based Standard for $PM_{2.5}$ was selected referencing CCME (2006).

Table 2-2 Summary of Air Quality Criteria for Dioxins and Furans

Contaminant	CAS	O. Reg. 419/05 – Schedule 3/AAQC			HHRA Health-Based Standards			
		1-Hour (ng/m^3)	24-Hour (ng/m^3)	Other time Period (ng/m^3)	1-Hour (ng/m^3)	24-Hour (ng/m^3)	Annual (ng/m^3)	Toxic Equivalency Factor Annual [D] $(ng/m^3)^{-1}$
Dioxins and Furans Total Toxic Equivalency [A]	NA	-	0.1 (pg TEQ/m^3) [B] 1 (pg TEQ/m^3) [C]	-	-	-	-	-

Notes:

A. Application of the air standard for dioxins, furans, and dioxin-like PCBs requires the calculation of the total toxicity equivalent (TEQ) concentration contributed by all dioxin-like compounds in the mixture. TEQ is calculated using the methodology as per the O. Reg. 419 Summary of Standards and Guidelines, and the corresponding WHO_{2005} toxic equivalency factors (TEFs).
B. Ontario Ambient Air Quality Criteria
C. O. Reg. 419 Schedule 6 Upper Risk Thresholds
D. Carcinogenic Annual Average. Units in $(ng/m^3)^{-1}$.

3.0 INSTRUMENTATION AND OPERATIONS SUMMARY

3.1 INSTRUMENTATION

The measurement program at the monitoring site includes both continuous and non-continuous monitors to sample air contaminant concentrations.

Monitoring for respirable particulate matter ($PM_{2.5}$), nitrogen oxides (NO_X) and sulphur dioxide (SO_2) are conducted on a continuous basis. A summary of the continuous monitors and a brief description of their principle of operation are provided in **Table 3-1** below.

Table 3-1 Summary of Continuous Ambient Air Quality Monitors

Contaminant	Monitor	Principle of Operation	Range	Time Interval
$PM_{2.5}$	Thermo Sharp 5030 Synchronized Hybrid Ambient Real-time Particulate Monitor	Light Scattering Photometry / Beta Attenuation - Consists of a carbon14 source, detector and light scattering Nephelometer in a rack-mountable enclosure. The Thermo Sharp utilizes a continuous (non-step wise) hybrid mass measurement and a combination of beta attenuation and light scattering technology. The unit's filter tape is automatically advanced based upon a user defined frequency or particulate loading.	0-10 mg/m^3	1 minute
NO, NO_2, NO_X	API Model 200E Chemiluminescence Analyzer	Chemiluminescence - Uses a chemiluminescence detection principle and microprocessor technology for ambient continuous emissions monitoring (CEM). Measurements are automatically adjusted for temperature and pressure changes.	0 – 1000 ppb	1 second

Table 3-1 Summary of Continuous Ambient Air Quality Monitors

Contaminant	Monitor	Principle of Operation	Range	Time Interval
SO_2	Teledyne Monitor Labs Sulphur Dioxide Analyzer Model T100	Pulsed Florescence - SO_2 levels are measured based on the principle that SO_2 has a strong ultraviolet (UV) absorption at a wavelength between 200 and 240 nanometres (nm). The absorption of photons at these wavelengths results in the emission of fluorescence photons at a higher wavelength. The amount of fluorescence measured is directly proportional to the concentration of SO_2.	0 – 1000 ppb	1 second

Two manually operated, hi-volume air samplers are installed at the Crago Road Station to collect metals in total suspended particulate (TSP), polycyclic aromatic hydrocarbons (PAHs), and dioxins and furans. As per Section 1.2 of the Ambient Monitoring Plan (Stantec, 2012), monitoring for metals/TSP, PAHs and dioxins and furans was not required in 2015.

However, as mentioned above, Stantec was requested to conduct additional dioxins and furans sampling on a 12-day schedule between October 21, 2015 and January 25, 2016. The methodology and analyses for the dioxins and furans sampling followed those described in the Ambient Monitoring Plan (Stantec 2012) as presented in **Table 3-2**, with the exception of the sampling schedule (dioxins and furans sampling is on a 24-day schedule in the Ambient Monitoring Plan). The samples were submitted to Maxxam Analytics Inc., which is a lab accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) / Standards Council of Canada (SCC) for these analyses.

Table 3-2 Summary of Non-Continuous Ambient Air Quality Monitors

Contaminant	Sampler	Filter Media	Lab Analysis	Sampling Schedule
Dioxins and Furans	Tisch Environmental TE-1000 mass-flow high volume air sampler	Dual chambered sampling module with a Teflon-coated glass fibre filter and a Poly-Urethane Foam (PUF) cartridge	Gas Chromatography / Mass Spectrometry (GC/MS)	24 hour sample taken every 12 days

Horizontal wind speed, wind direction, atmospheric temperature, relative humidity, and rainfall are measured at the predominantly downwind Crago Road Station. The meteorological sensors at the Crago Road Station are mounted on an external 10-m aluminum tower and are logged using a digital data acquisition system (DAS).

The meteorological equipment at the Crago Road Station is summarized in **Table 3-3**.

Table 3-3 Summary of Meteorological Equipment

Parameter	Equipment
Wind Speed/Wind Direction	Met One Instruments Inc. Model 034B
Temperature / Relative Humidity	Campbell Scientific Model HMP 60
Rainfall	Texas Electronic TE525M

A Campbell Scientific CRX1000 station data acquisition system is used to collect continuous instrument monitoring data and status codes from the ambient air quality monitors. Continuous station data are maintained in the data logger, and data is viewed locally using a laptop and the relevant DAS software applications. Remote data transmission is accomplished by the periodic transmission of collected station air quality data via cellular phone.

3.2 MONITORING STATION VISITS AND REGULAR MAINTENANCE ACTIVITIES

Monitoring station visits are conducted on a regular basis to:

- Confirm the integrity and proper operation of the sampling and monitoring equipment as well as the data acquisition systems
- Ensure the collection of valid and complete data
- Conduct routine maintenance and housekeeping; and
- Confirm continued safe and secure environment at the station.

Station visits in 2015 were documented in the site logbook, and visual checks of the equipment were documented during each site visit in an Ambient Pod Checklist. A list of the regular and major preventative maintenance activities performed by Stantec and/or Valley Environmental during the station visits in 2015 is presented in **Table A-1** in **Appendix A**.

Daily diagnostic tests were performed remotely on the continuous monitoring equipment and station parameters to check for anomalous data and assess whether the equipment was functioning normally. Any issues identified were immediately assessed and rectified as soon as possible. If required, Valley Environmental was notified to dispatch a trained technician to address the issue.

3.3 DATA ACQUISITION/ARCHIVING

Data from the continuous monitors at the station are maintained in the data logger. These data were viewed and collected via the automated data acquisition system and cell phone modem. Data review and storage schedule was as follows:

- On a daily basis during weekdays, the data logger was remotely accessed and the current data were reviewed to check the operational status of each monitor and for anomalous data
- Data was downloaded and backed-up once a week (to a separate file location) to avoid any file overwriting or data loss; and
- The full set of collected data was reviewed including manual verification of values, invalidating false / suspicious / calibration data, etc. The protocols used to invalidate continuous data followed those provided in Table 5 of the MOECC Operations Manual (MOECC, 2008).

Details of the data editing are presented in the quarterly reports.

3.4 INSTRUMENTATION CALIBRATION

Continuous Monitors

The samplers were calibrated when they were installed in the field before their first use. On-going performance checks and external calibrations of the continuous monitors were performed monthly. This meets the recommended calibration schedule listed in the MOECC Operations Manual (MOECC, 2008). The external calibrations for the NO_X and SO_2 monitors involved challenging each monitor with certified calibration gases (each referenced to a primary standard) for zero and span measurements.

Non-Continuous Monitors

The high volume air samplers were calibrated at a minimum monthly (or after any motor maintenance) during their sampling period in 2015. The calibration frequency exceeded the MOECC Operations Manual (MOECC, 2008) requirement of quarterly calibrations.

A summary of the calibration tasks that are required and have been performed for each sampler are provided in **Table A-2** in **Appendix A**.

3.5 MINISTRY OF THE ENVIRONMENT AND CLIMATE CHANGE MONITOR PERFORMANCE AND SITE AUDIT

The Crago Road Station is not part of the ambient monitoring network required by the Ambient Monitoring Plan (Stantec, 2012) therefore the MOECC does not conduct performance or site audits of the equipment.

3.6 INSTRUMENTATION ISSUES

A few instrumentation issues were encountered during 2015. The most significant of these were the motherboards for the Sharp $PM_{2.5}$ and the SO_2 monitors failing during operation, requiring the monitors to be removed and sent to the manufacturer, who replaced these components under warranty. These issues were determined to be manufacturing defects – failures of this type are not usual for newly installed equipment. There were also some minor equipment issues that commonly occur when operating instrumentation continuously for extended periods of time.

A summary of operational issues and the resolution for each measurement parameter during the 2015 monitoring period is presented in **Table A-3** in **Appendix A**.

3.7 DATA RECOVERY RATES

Data recovery rates for each continuous monitor at the station during the 2015 sampling period (January to December 2015) are presented in **Table 3-4**. The data recovery rates for the measured air contaminants met or exceeded MOECC requirements for data validity.

Table 3-4 Summary of Data Recovery Rates for the Crago Road Station (Downwind) – 2015 Monitoring Period

Parameter	Valid Measurement Hours	Data Recovery Rate (%)
SO_2	7544	86%
NO_X	8545	98%
$PM_{2.5}$	7327	84%
Temperature	8760	100%
Rainfall	8760	100%
Relative Humidity	8760	100%
Wind Speed/Direction	8760	100%
TSP/Metals	N/A [A]	N/A [A]
PAHs	N/A [A]	N/A [A]
Dioxins and Furans	6 [B]	100%

Note:

A - Not sampled in 2015.

B - Number of filters/24-hour average samples.

4.0 SUMMARY OF AMBIENT MEASUREMENTS

The following sections provide summaries of the validated data for each measured parameter.

4.1 METEOROLOGICAL DATA

A summary of the maximum, minimum, arithmetic mean, and standard deviation of the hourly average meteorological parameters measured at the monitoring station for January - December 2015 is presented in **Table 4-1**.

Table 4-1 Summary of Hourly Meteorological Measurements – 2015 Monitoring Period

Parameter		Crago Road Station (Downwind)	Units
Temperature	Max	29.2	C
	Min	-25.8	C
	Mean	7.5	C
	Standard Deviation	10.8	C
Rainfall	Max	15.9	mm
	Min	0.0	mm
	Mean	0.08	mm
	Standard Deviation	0.60	mm
Relative Humidity	Max	99.5	%
	Min	18.4	%
	Mean	73.3	%
	Standard Deviation	15.8	%
Wind Speed [B]	Max	44.6	km/hr
	Min	0.0	km/hr
	Mean	12.4	km/hr
	Standard Deviation	7.6	km/hr

Notes:

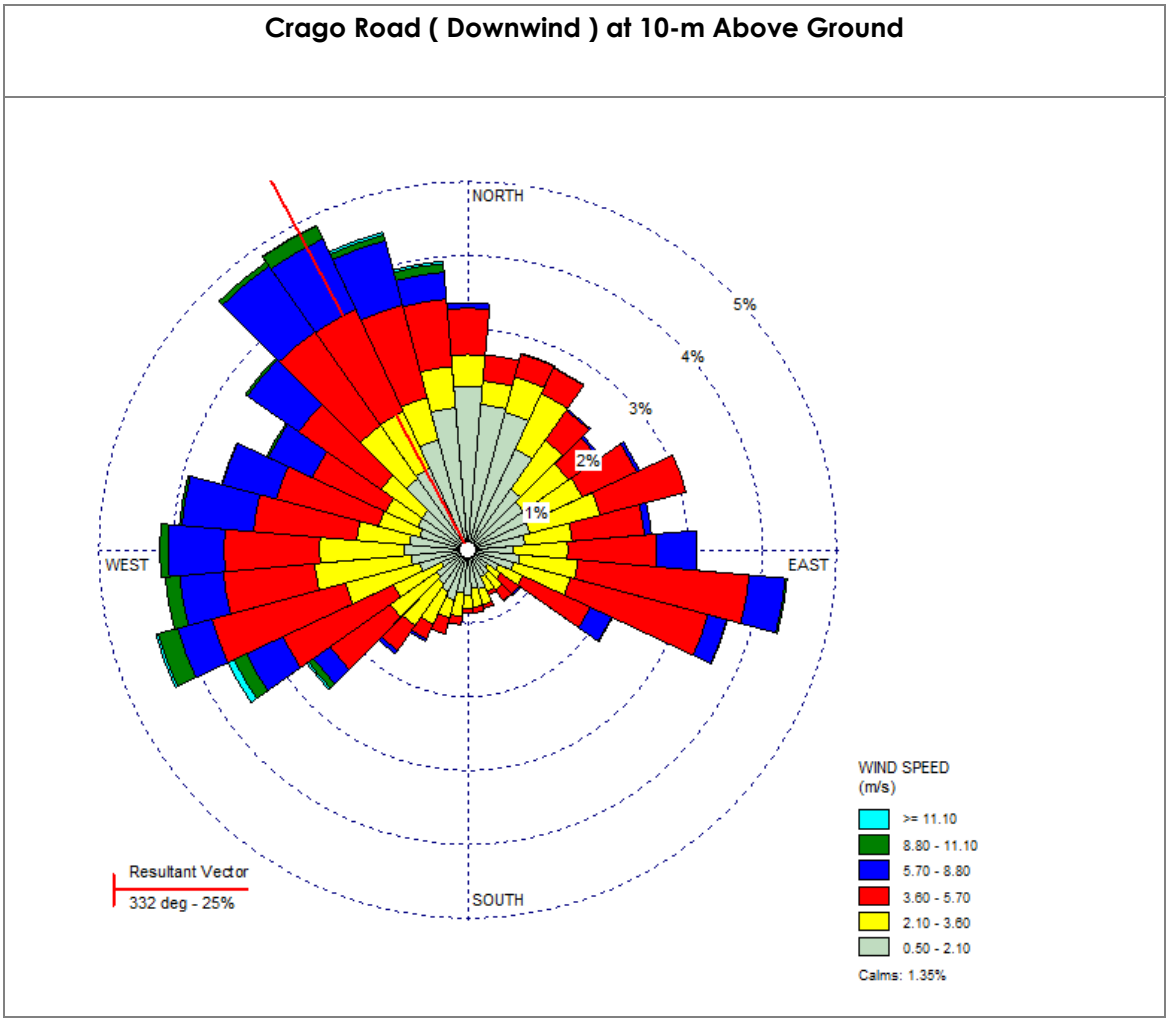
A. Pressure is not measured at the Crago Road Station.

B. Wind speed at the Crago Road Station is measured at a height of 10-m.

A wind rose showing the directionality and speed for 2015 at this location is presented in **Figure** 4-1. The length of the radial barbs gives the total percent frequency of winds blowing from the indicated direction, while portions of the barbs of different widths indicate the frequency associated with each wind speed category.

In 2015, winds at the Crago Road Station occurred predominantly from southwesterly to northwesterly and east-southeasterly directions. Winds blew infrequently from the south.

Figure 4-1 Wind Rose for the 2015 Monitoring Period



4.2 CAC AMBIENT AIR QUALITY MEASUREMENTS

A summary of the maximum, minimum, arithmetic mean, and standard deviation of the Criteria Air Contaminants (CAC) pollutant concentrations measured at the station are presented in **Table 4-2**. Also presented in **Table 4-2** is the number of exceedances (if any) of the relevant Ontario ambient air quality criteria (AAQC) or health-based standard for each contaminant.

The measured concentrations of the air contaminants monitored were all below their applicable hourly, 24-hour and annual average criteria during 2015.

The concentration of nitric oxide (NO) has no regulatory criteria as discussed in Section 4.2.2 below. The hourly and 24-hour AAQC values for NO_X are based on health effects of NO_2; therefore the AAQCs were compared to measured NO_2 concentrations in this report (MOECC, 2012a). However, as per the April 2012 version of O.Reg. 419 Summary of Standards and Guidelines (MOECC, 2012b), the Schedule 3 criteria for NO_X were also compared to the monitored NO_X levels.

A comparison of the maximum measured data to their respective air quality criteria is presented graphically in **Figure 4-2.**

Table 4-2 Summary of Ambient CAC Monitoring Data - 2015 Monitoring Period

Pollutant	Averaging Period	AAQC / HHRA Health-Based Standards			Crago Road Station (Downwind)	
		µg/m³	ppb		Concentration (µg/m³)	Concentration (ppb)
SO_2	1	690	250	Maximum	321.2	120.5
				Minimum	0.0	0.0
				Mean	3.1	1.1
				Standard Deviation	8.6	3.2
				# of Exceedances	0	0
	24	275	100	Maximum	53.1	19.9
				Minimum	0.0	0.0
				Mean	3.1	1.1
				Standard Deviation	4.5	1.6
				# of Exceedances	0	0
	Annual	55 / 29 [A]	20 / 11 [A]	Mean (Period)	3.1	1.1
				# of Exceedances	0	0
$PM_{2.5}$	24	28 [B]	N/A [G]	Maximum	45.8	-
				Minimum	0.4	-
				Mean	7.2	-
				98th Percentile [C]	22.7	-
				Standard Deviation	5.8	-
				# of Exceedances	N/A	-
	Annual	10 [D]	N/A [H]	Mean (Period)	7.2	-
				# of Exceedances	N/A	-

Table 4-2 Summary of Ambient CAC Monitoring Data - 2015 Monitoring Period

Pollutant	Averaging Period	AAQC / HHRA Health-Based Standards			Crago Road Station (Downwind)	
		µg/m³	ppb		Concentration (µg/m³)	Concentration (ppb)
NO_2	1	400 [E]	200 [E]	Maximum	91.8	44.0
				Minimum	0.0	0.0
				Mean	9.5	4.7
				Standard Deviation	13.4	6.5
				# of Exceedances	0	0
	24	200 [E]	100 [E]	Maximum	47.5	22.3
				Minimum	0.0	0.0
				Mean	9.5	4.7
				Standard Deviation	8.1	3.9
				# of Exceedances	0	0
	Annual	60	30	Mean	9.5	4.7
				# of Exceedances	0	0
NO [F]	1	NA	NA	Maximum	96.8	75.0
				Minimum	0.0	0.0
				Mean	2.1	1.6
				Standard Deviation	5.7	4.3
				# of Exceedances	0	0
	24	NA	NA	Maximum	19.6	15.1
				Minimum	0.0	0.0
				Mean	2.1	1.6
				Standard Deviation	2.9	2.2
				# of Exceedances	0	0

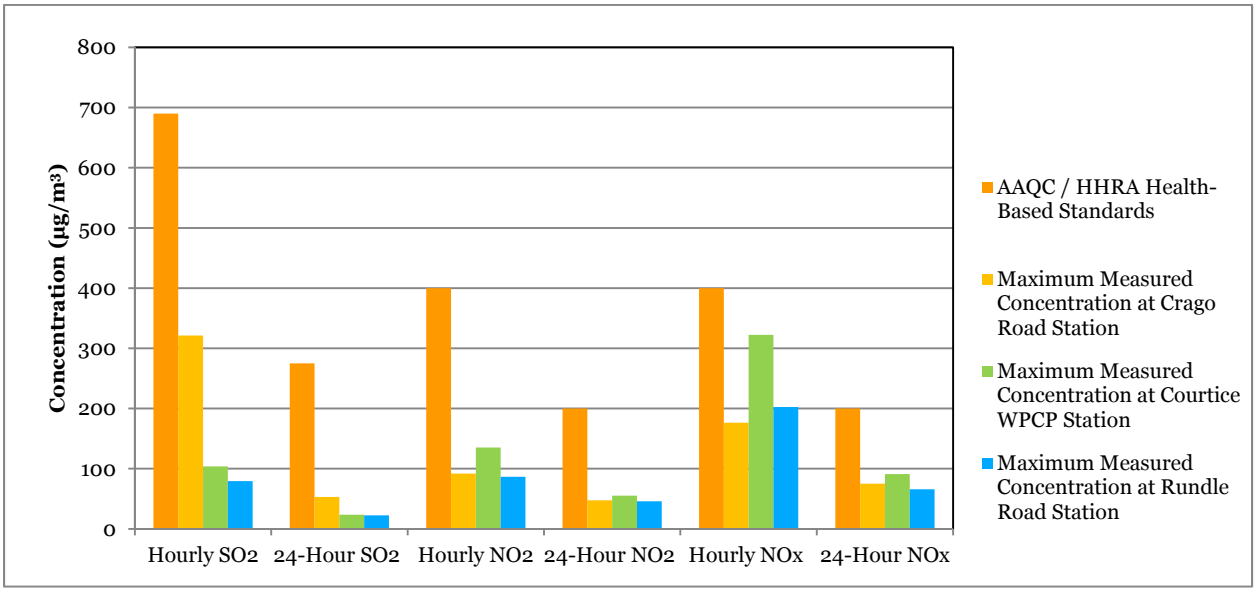
Table 4-2 Summary of Ambient CAC Monitoring Data - 2015 Monitoring Period

Pollutant	Averaging Period	AAQC / HHRA Health-Based Standards			Crago Road Station (Downwind)	
		µg/m³	ppb		Concentration (µg/m³)	Concentration (ppb)
NO_X	1	400 [E]	200 [E]	Maximum	176.3	83.1
				Minimum	0.0	0.0
				Mean	12.6	6.2
				Standard Deviation	19.8	9.7
				# of Exceedances	0	0
	24	200 [E]	100 [E]	Maximum	75.1	35.8
				Minimum	0.0	0.0
				Mean	12.6	6.2
				Standard Deviation	11.7	5.7
				# of Exceedances	0	0
	Annual	60	30	Mean	12.6	6.2
				# of Exceedances	0	0

Notes:

A. Annual AAQC / Annual HHRA.
B. Canadian Ambient Air Quality Standard for Respirable Particulate Matter, effective by 2015. The Respirable Particulate Matter Objective is referenced to the 98th percentile over 3 consecutive years.
C. The 98th percentile of the daily average $PM_{2.5}$ measurements in the period.
D. Annual Canadian Ambient Air Quality Standard for Respirable Particulate Matter, effective by 2015. The Respirable Particulate Matter Objective is referenced to a 3-year average of the annual average concentrations.
E. As per current version (April 2012) of Reg. 419 Summary of Standards and Guidelines, the air standard for NO_X is compared to a monitored NO_X concentration, although the Reg. 419 Schedule 3 standard for NO_X is based on health effects of NO_2.
F. NO has no regulatory criteria.
G. Daily $PM_{2.5}$ concentrations were not compared to the Canadian Ambient Air Quality Standard shown in this table, which requires averaging the 98th percentile concentrations over three consecutive years, as compared to the 12-month period covered by this report.
H. Annual $PM_{2.5}$ concentrations were not compared to the Canadian Ambient Air Quality Standard shown in this table, which requires a 3-year average of the annual average concentrations

Figure 4-2 Comparison of NO_2, NO_X and SO_2 Ambient Monitoring Data to Applicable Criteria – 2015 Monitoring Period



Additional details on the results for each measured contaminant are presented in the following sections.

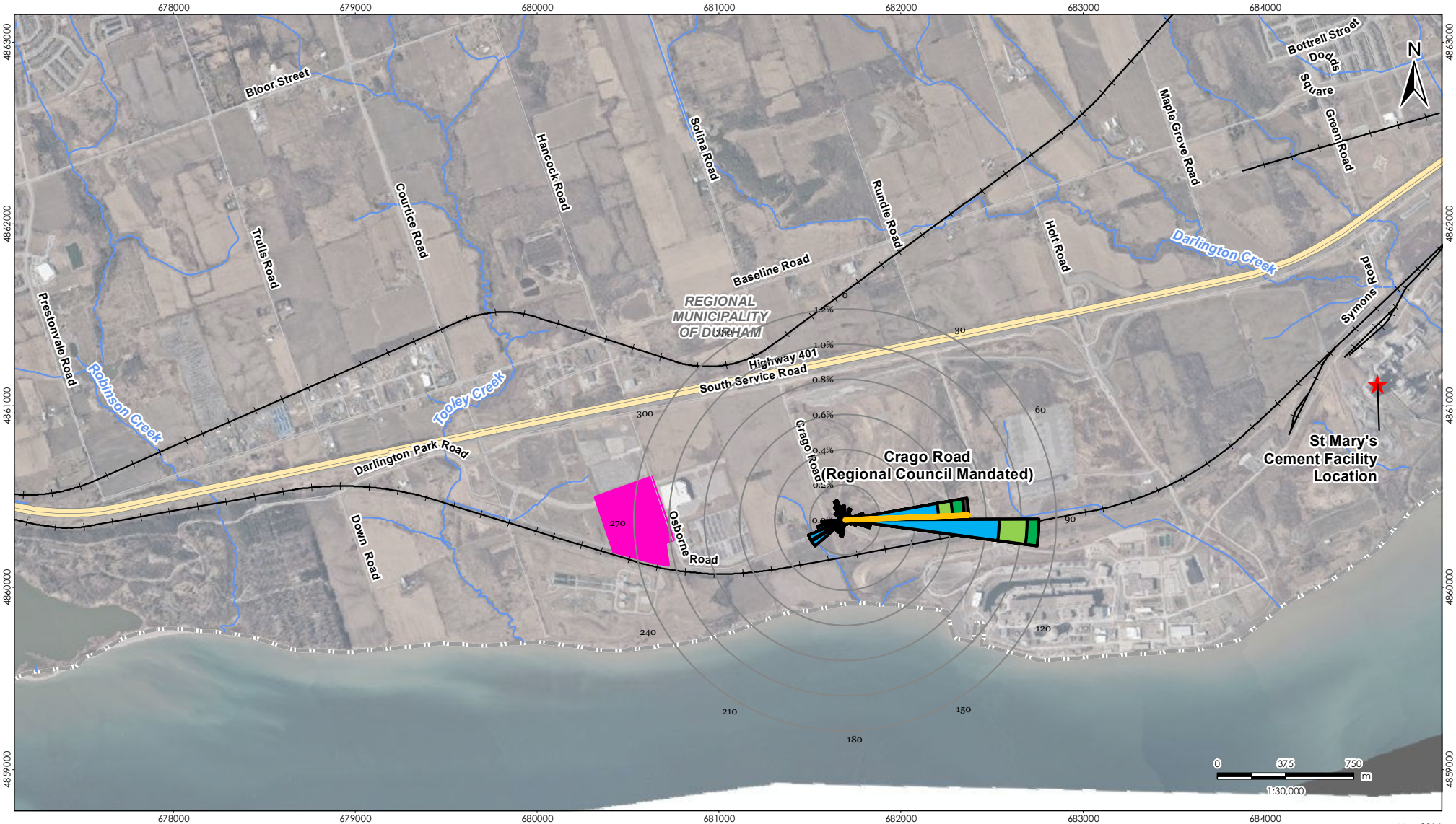
4.2.1 Sulphur Dioxide (SO_2)

Time history plots of the hourly and 24-hour average SO_2 concentrations over the measurement period are presented in **Appendix B, Figure B1**. For the hourly and 24-hour average plots in Appendix B, the Ontario AAQCs of 690 µg/m³ and 275 µg/m³ are shown with blue lines on their respective plot. The annual Ontario AAQC for SO_2 is 55 µg/m³, and the annual HHRA criterion is 29 µg/m³. As shown in these figures, measured ambient SO_2 concentrations were well below the criteria.

The maximum hourly, 24-hour and annual average concentrations measured at the Crago Road Station during the 2015 monitoring period were 321.2, 53.1 and 3.1 µg/m³, respectively, which are 46.6%, 19.3% and 5.7% of the applicable 1-hour, 24-hour and annual ambient air quality criteria.

A pollution rose of hourly average SO_2 concentrations measured at the Crago Road Station is presented in **Figure 4-3**. A pollution rose plot presents measured hourly average contaminant concentrations versus measured wind direction (over 10˚ wind sectors). In this figure, concentrations less than 10 µg/m^3, which account for about 94% of the measurements at the station, were removed from the plot to allow the distribution of maximum levels to be more clearly visible in the figure. A plot of the measured hourly average SO_2 concentrations versus wind direction is presented in **Appendix B, Figure B2**.

For the Crago Road Station, higher measured concentrations occurred from easterly directions. The maximum measured concentration at this station occurred from the east – a direction in which the Darlington Nuclear Generating Station and St. Mary's Cement are upwind of the monitoring station.



May 2016
160950528

V:\01609\Active\160950528\planning\drawing\MXD\Atmospheric\2015_Report_Crago_Rd_Station\160950528_Atm_Fig4-3_Rose_Chart_SO2.mxd
Revised: 2016-05-20 By: bcowper

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2013.
4. Concentrations less than 10µg/m3, which account for 94% of the measurements, have been removed from the plot to allow the distribution of maximum levels to be more clearly shown in the figure.

Legend

- St Mary's Cement Facility Location
- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse

Concentration (ug/m³)

- 200 - 325
- 100 - 200
- 50 - 100
- 10 - 50
- Direction of Maximum Measured Concentration

Client/Project

The Region of Durham
Durham York Energy Centre

Figure No.

4-3

Title

Pollution Rose of Measured Hourly Average SO_2 Concentrations - 2015 Monitoring Period

4.2.2 Nitrogen Dioxide (NO_2)

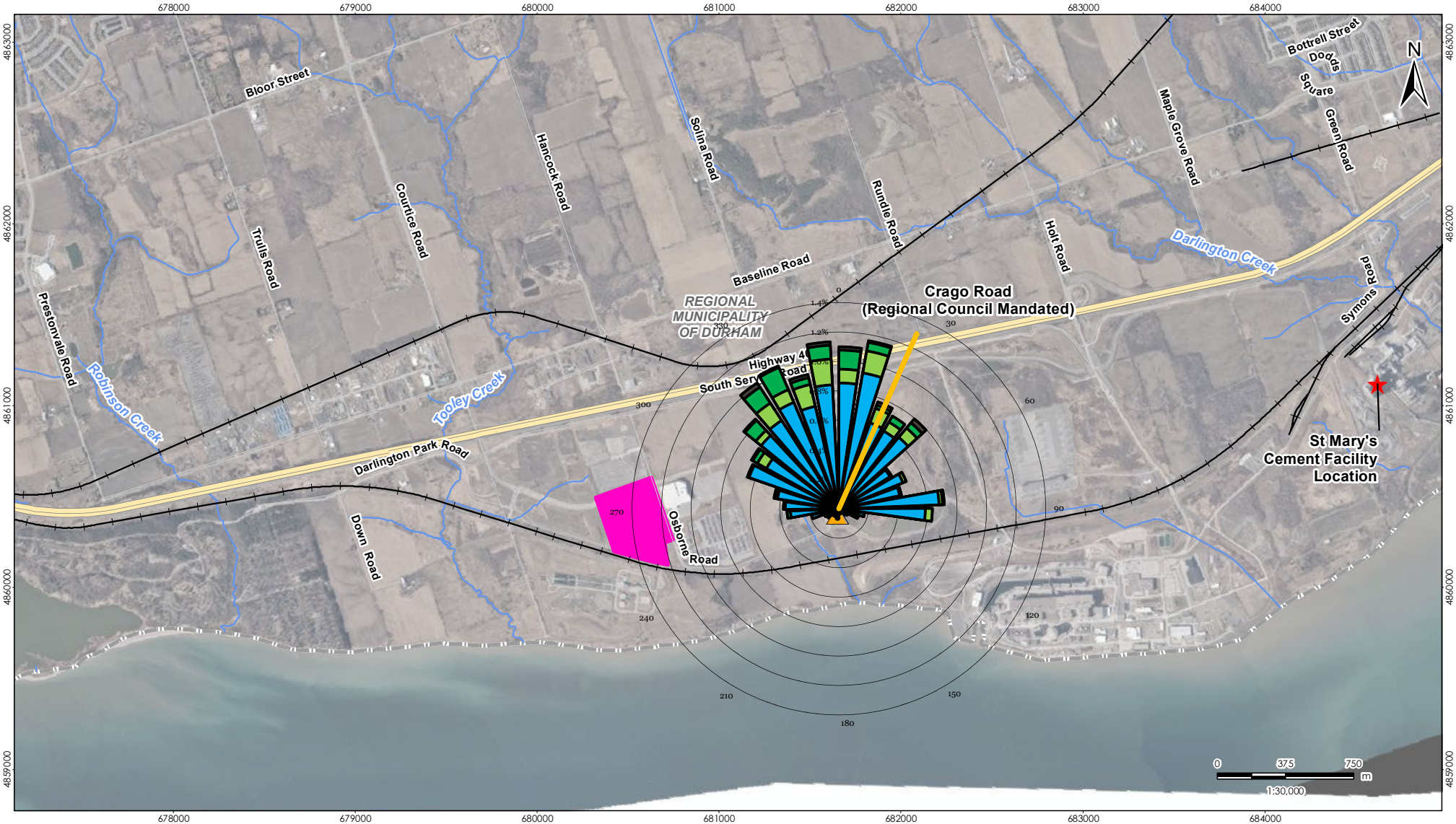
Nitrogen oxides (NO_X) are almost entirely made up of nitric oxide (NO) and nitrogen dioxide (NO_2). Together, they are often referred to as NO_X. Most NO_2 in the atmosphere is formed by the oxidation of NO, which is emitted directly by combustion processes, particularly those at high temperature and pressure. Exposure to both NO and NO_2 can result in adverse health effects to an exposed population. NO_2 is the regulated form of NO_X. Similar to other jurisdictions (e.g., Alberta Environment, World Health Organization), the O.Reg. 419/05 Schedule 3 standards for NO_X are based on health effects of NO_2, as health effects are seen at much lower concentrations of NO_2 than NO. In this report, because NO_2 is the regulated form of NO_X, the AAQC were compared to measured NO_2 concentrations (MOECC, 2012a). However, as per the current April 2012 version of O.Reg. 419 Summary of Standards and Guidelines (MOECC, 2012b), the NO_X Schedule 3 criteria were also compared to the monitored NO_X concentrations (see Section 4.2.3 below).

Time history plots of the hourly and 24-hour average NO_2 concentrations over the measurement period are presented in **Appendix C, Figure C1**. For hourly and 24-hour averages in Appendix C, the Ontario AAQCs of 400 µg/m^3 and 200 µg/m^3 are shown as blue lines on their respective time history plots. Measured ambient NO_2 concentrations were well below the criteria.

The maximum hourly, 24-hour and annual average NO_2 concentrations measured at the Crago Road Station during 2015 were 91.8, 47.5 and 9.5 µg/m^3 respectively, which are 22.9%, 23.7% and 15.8% of the applicable ambient 1-hour, 24-hour and annual air quality criteria.

A pollution rose of hourly NO_2 concentrations is presented in **Figure 4-4**. Concentrations less than 20 µg/m^3 which account for approximately 83% of measurements were removed from the plot to allow higher concentrations to be more clearly visible. A plot of measured hourly average NO_2 concentrations versus measured wind direction is presented in **Appendix C, Figure C2**.

Higher measured hourly concentrations for the Crago Road Station occurred most frequently from northwesterly to northeasterly directions. The maximum measured hourly average NO_2 concentration for the Crago Road Station occurred for a north-northeasterly wind - a direction in which the CN railway, Highway 401 and the Darlington Hydro Upper and Lower Soccer Fields are upwind of the station.



May 2016
160950528

V:\01609\Active\160950528\planning\drawing\MXD\Atmospheric\2015_Report_Crago_Rd_Station\160950528_Atm_Fig4-4_Rose_Chart_NO2.mxd
Revised: 2016-05-20 By: bcowper

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2013.
4. Concentrations less than 20µg/m3, which account for 83% of the measurements, have been removed from the plot to allow the distribution of maximum levels to be more clearly shown in the figure.

Legend

- St Mary's Cement Facility Location
- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse

Concentration

- 75 - 100
- 60 - 75
- 50 - 60
- 20 - 50
- Direction of Maximum Measured Concentration

Client/Project

The Region of Durham
Durham York Energy Centre

Figure No.

4-4

Title

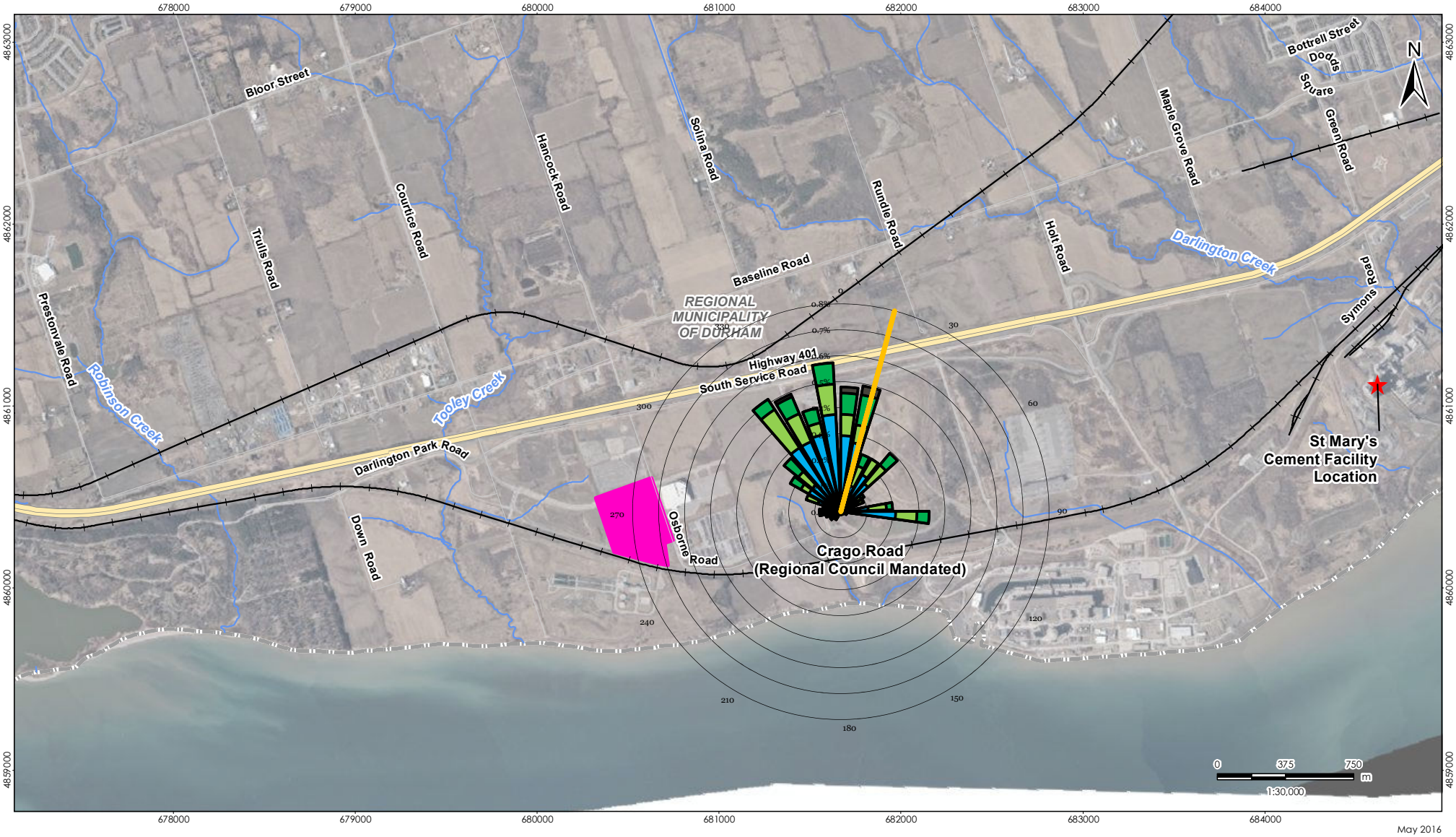
Pollution Rose of Measured Hourly Average NO_2 Concentrations - 2015 Monitoring Period

4.2.3 Nitrogen Oxides (NO_X)

Time history plots of hourly and 24-hour average NO_x concentrations over the measurement period are presented in **Appendix D, Figure D1**. For hourly and 24-hour averages in **Appendix D**, the Ontario Schedule 3 criteria of 400 µg/m^3 and 200 µg/m^3 are shown as blue lines on the corresponding time history plots. As indicated in the section above, although the criteria were compared to the measured NO_X concentrations in this report, the standards for NO_X are based on health effects of NO_2. As shown in these figures, the maximum measured ambient hourly and 24-hour average NO_X concentrations at the Crago Road Station were below the criteria during the monitoring period.

As presented in **Table 4-2**, the maximum hourly average NO_X concentration measured at the Crago Road Station was 176.3 µg/m^3, which is 44.1% of the 1-hour ambient criteria. The measured maximum 24-hour and annual average NO_X concentrations were 75.1 µg/m^3 and 12.6 µg/m^3, which are 37.6% and 20.9% of the applicable ambient air quality criteria.

A pollution rose of hourly average NO_X concentrations for the Crago Road Station is presented in **Figure 4-5**. The pollution rose in this figure presents measured concentrations above 50 µg/m^3 to allow higher levels to be more easily visible (concentrations less than 50 µg/m^3 accounted for 93% of the NOx measurements). A plot of wind direction versus measured NO_X concentrations is presented in **Appendix D, Figure D2**. Higher measured hourly average NO_X concentrations for the Crago Road Station typically occurred for winds blowing from northwesterly to north-northeasterly directions. The maximum measured concentration was for a wind blowing from the north-northeast, for which the Darlington Hydro Upper and Lower Soccer Fields, Highway 401 and a CN railway were upwind.



May 2016
160950528

V:\01609\Active\160950528\planning\drawing\MXD\Atmospheric\2015_Report_Crago_Rd_Station\160950528_Atm_Fig4-5_Rose_Chart_NOX.mxd
Revised: 2016-05-20 By: bcowper

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2013.
4. Concentrations less than 50µg/m3, which account for 93% of the measurements, have been removed from the plot to allow the distribution of maximum levels to be more clearly shown in the figure.

Legend

- St Mary's Cement Facility Location
- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse

Concentration

- 150 - 200
- 100 - 150
- 75 - 100
- 50 - 75
- Direction of Maximum Measured Concentration

Client/Project

The Region of Durham
Durham York Energy Centre

Figure No.

4-5

Title

Pollution Rose of Measured Hourly Average NO_x Concentrations – 2015 Monitoring Period

4.2.4 Particulate Matter Smaller than 2.5 Microns ($PM_{2.5}$)

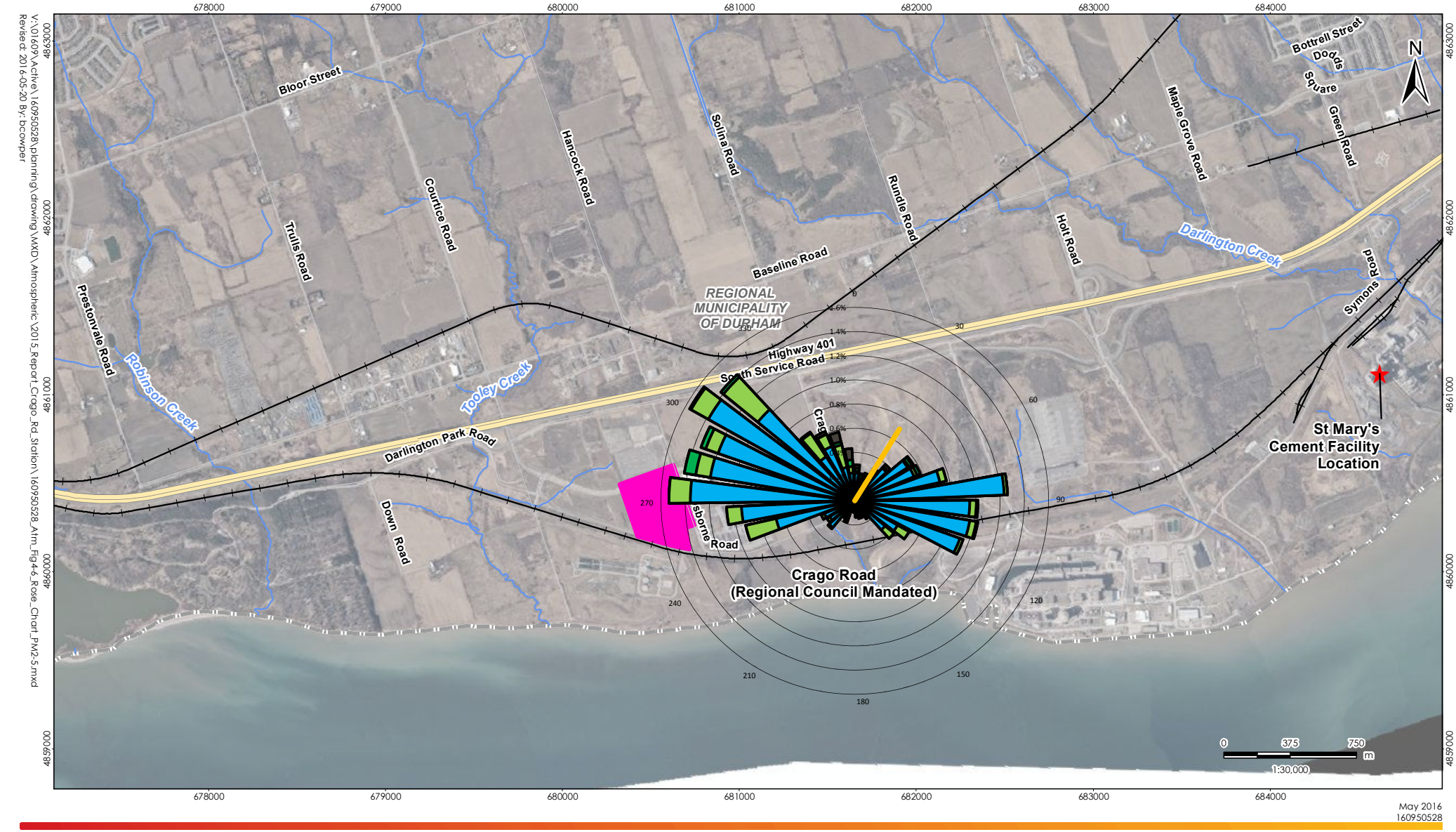
A time history plot of the measured 24-hour average $PM_{2.5}$ concentrations over the measurement period is presented in **Appendix E, Figure E1**.

The maximum 24-hour average $PM_{2.5}$ concentration measured at the Crago Road Station over the monitoring period was 45.8 µg/m^3. In 2015, the 98th percentile of the measured daily average $PM_{2.5}$ concentrations was 22.7 µg/m^3. This value was lower than the 98th percentile daily average measurements at the Courtice WPCP and Rundle Road stations (27.3 and 28.4 µg/m^3 respectively). As detailed below, this value for the 98th percentile should not be used for comparison against the Canadian Ambient Air Quality Standard.

A pollution rose showing measured 24-hour average ambient $PM_{2.5}$ concentrations versus wind direction is shown in **Figure 4-6**. Concentrations less than 10 µg/m^3, which accounted for approximately 77% of measurements, were not included in this figure to more clearly show the distribution of higher concentration levels. A plot of measured 24-hour average ambient $PM_{2.5}$ concentrations versus measured 24-hour average wind direction is presented in **Appendix E, Figure E-2**.

Higher measured $PM_{2.5}$ concentrations at the Crago Road Station occurred for northwesterly to northeasterly winds, with the maximum measured concentration occurring from the north-east for which the Darlington Hydro Upper and Lower Soccer Fields, the CN railway and Highway 401 were located upwind of the monitoring station.

The 24-hour and annual $PM_{2.5}$ CAAQS criteria both require a 3-calendar year average for comparison, with the data considered valid if an annual 98th percentile value is available for at least two of the required three calendar years. Since **Table 4-2** only covers the year 2015, the measurements were not explicitly compared to the CAAQS criteria as any such comparison would not be considered valid.



May 2016
160950528

V:\01609\Active\160950528\planning\drawing\MXD\Atmospheric\2015_Report_Crago_Rd_Station\160950528_Atm_Fig4-6_Rose_Chart_PM2-5.mxd
Revised: 2016-05-20 By: bcowper

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2013.
4. Concentrations less than 10µg/m3, which account for 77% of the measurements, have been removed from the plot to allow the distribution of maximum levels to be more clearly shown in the figure.

Legend

- St Mary's Cement Facility Location
- Durham York Energy Centre Site
- Railway
- Road
- Highway
- Watercourse

Concentration

- 40 - 50
- 30 - 40
- 20 - 30
- 10 - 20
- Direction of Maximum Measured Concentration

Client/Project

The Region of Durham
Durham York Energy Centre

Figure No.

4-6

Title

Pollution Rose of Measured 24-Hour Average $PM_{2.5}$ Concentrations – 2015 Monitoring Period

4.3 AMBIENT DIOXIN AND FURAN CONCENTRATIONS

At the request of the Regional Municipality of Durham, dioxin and furan sampling was resumed for the DYEC on October 21, 2015 (during commissioning of the facility). This additional sampling was outside the scope of the Ambient Monitoring Plan (Stantec, 2012). The sampling was conducted at 12-day intervals corresponding with the Ontario MOECC province-wide ambient sampling schedule. A summary of the maximum and minimum ambient dioxin and furan concentrations (for a daily averaging period) are presented in **Table 4-3** for the measurements collected between October 21st and the end of 2015. In this summary, both individual dioxin and furan concentrations (pg/m^3) as well as the total toxic equivalency concentration (TEQ) are reported.

The maximum measured toxic equivalent dioxin and furan concentration at the Crago Road Station was below the applicable 24-hour criteria AAQC of 0.1 pg TEQ/m^3 (as shown in **Table** 4-3).

Table 4-3 Summary of Measured Ambient Dioxin and Furan Concentrations

Contaminant	Units	MOECC Criteria	HHRA Health Based Standard	Crago Road (Predominately Downwind)		
				Max	Min	No. of Exceedances
2,3,7,8-Tetra CDD *	pg/m^3			3.53E-03 [A]	2.71E-03 [A]	
1,2,3,7,8-Penta CDD	pg/m^3			8.19E-03	2.96E-03 [A]	
1,2,3,4,7,8-Hexa CDD	pg/m^3			1.20E-02	2.96E-03 [A]	
1,2,3,6,7,8-Hexa CDD	pg/m^3			1.90E-02	3.10E-03 [A]	
1,2,3,7,8,9-Hexa CDD	pg/m^3			3.45E-02	3.39E-03 [A]	
1,2,3,4,6,7,8-Hepta CDD	pg/m^3			1.67E-01	3.59E-02	
Octa CDD	pg/m^3			6.05E-01	1.18E-01	
Total Tetra CDD	pg/m^3			1.51E-01	2.71E-03 [A]	
Total Penta CDD	pg/m^3			2.25E-01	3.53E-03 [A]	
Total Hexa CDD	pg/m^3			2.00E-01	1.33E-02	
Total Hepta CDD	pg/m^3			3.52E-01	7.79E-02	
2,3,7,8-Tetra CDF **	pg/m^3			3.66E-02 [A]	3.25E-03 [A]	
1,2,3,7,8-Penta CDF	pg/m^3	-	-	1.14E-02	2.88E-03 [A]	N/A
2,3,4,7,8-Penta CDF	pg/m^3			1.67E-02	2.88E-03 [A]	
1,2,3,4,7,8-Hexa CDF	pg/m^3			2.22E-02	2.82E-03 [A]	
1,2,3,6,7,8-Hexa CDF	pg/m^3			1.08E-02	2.71E-03 [A]	
2,3,4,6,7,8-Hexa CDF	pg/m^3			1.32E-02	2.88E-03 [A]	
1,2,3,7,8,9-Hexa CDF	pg/m^3			3.81E-03 [A]	3.19E-03 [A]	
1,2,3,4,6,7,8-Hepta CDF	pg/m^3			2.61E-02	7.82E-03	
1,2,3,4,7,8,9-Hepta CDF	pg/m^3			3.79E-03 [A]	2.40E-03 [A]	
Octa CDF	pg/m^3			3.88E-02	7.22E-03	
Total Tetra CDF	pg/m^3			2.52E-01	3.25E-03 [A]	
Total Penta CDF	pg/m^3			1.42E-01	3.81E-03 [A]	
Total Hexa CDF	pg/m^3			6.93E-02	3.39E-03 [A]	
Total Hepta CDF	pg/m^3			4.36E-02	7.82E-03	
TOTAL TOXIC EQUIVALENCY [B]	pg TEQ/m^3	0.1 [C] 1 [D]	-	0.034	0.012	0 0

Note:

A. Measured concentration was less than the laboratory method detection limit.
B. Total Toxicity Equivalent (TEQ) concentration contributed by all dioxins, furans calculated as per O. Reg. 419 methodology using corresponding WHO_{2005} toxic equivalency factors (TEFs) and a value of half the minimum detection limit (MDL) substituted for concentrations less than the MDL.
C. Ontario Ambient Air Quality Criteria
D. O. Reg. 419 Schedule 6 Upper Risk Thresholds

* CDD - Chloro Dibenzo-p-Dioxin, ** CDF - Chloro Dibenzo-p-Furan

5.0 AMBIENT AIR QUALITY TRENDS

Ambient air quality measurements at the Crago Road Station commenced in November 2014, therefore there is currently insufficient information to compare air quality trends with respect to the 2015 measurement data. Air quality trends will be discussed in future annual reports as additional data becomes available.

6.0 CONCLUSIONS

This report provides a summary of the ambient air quality data collected at the Crago Road Station for the 2015 monitoring period. The following observations and conclusions were made from a review of the measured ambient air quality monitoring data:

1. Measured concentrations of NO_2, SO_2 and $PM_{2.5}$ were below the applicable O.Reg. 419/05 criteria and/or human health risk assessment (HHRA) health-based standards presented in **Table 2-1** of this report for hourly, 24-hour and annual averaging periods.
2. The 98th percentile of the measured daily average $PM_{2.5}$ levels during the 2015 monitoring period was 22.7 µg/m^3 at the Crago Road Station. As detailed below, this value of the 98th percentile should not be used for comparison against the Canadian Ambient Air Quality Standard.
3. The 24-hour and annual $PM_{2.5}$ Canadian Ambient Air Quality Standards (CAAQS) criteria both require a 3-calendar year average for comparison, with the data considered valid if an annual 98th percentile value is available for at least two of the three calendar years. Since only 2015 data is available, the measurements were not explicitly compared to the CAAQS criteria as any comparison would not be valid.
4. Metals in TSP and PAHs were not measured in 2015 as per Section 1.2 of the Ambient Monitoring Plan (Stantec, 2012).
5. Dioxins and furans sampling was resumed on October 21, 2015 (during commissioning of the facility) for the DYEC as requested by the Regional Municipality of Durham. This additional sampling was not part of the Ambient Monitoring Plan and was conducted at 12-day intervals for the rest of 2015 (and into 2016). The maximum toxic equivalent dioxin and furan concentration measured over this period was well below the applicable criteria presented in **Table 2-2**.

In summary, the measured concentrations of all the air contaminants monitored were below their applicable MOECC criteria during the 2015 monitoring period. Furthermore, the measured levels of the monitored contaminants were below their applicable HHRA health-based standards. Air quality trends will be assessed in the next annual report after the collection of more data.

7.0 REFERENCES

Canadian Council of Ministers of the Environment (CCME), (2000). Canada-Wide Standards for Particulate Matter and Ozone, June 5-6, 2000.

Canadian Council of Ministers of the Environment (CCME), (2007). Guidance Document on Achievement Determination Canada-wide Standards for Particulate Matter and Ozone, Revised, PN 1391 978-1-896997-74-2 PDF, 2007.

Canadian Council of Ministers of the Environment (CCME), (2012). Guidance Document on Achievement Determination. Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (PN 1483) (978-1-896997-91-9 PDF)

Jacques Whitford, (2009). Final Environmental Assessment, December 4, 2009.

Ministry of the Environment and Climate Change(MOECC) Operations Division Technical Support Section, (2008). Operations Manual for Air Quality Monitoring in Ontario, March 2008 (PIBS 6687e).

Ontario Ministry of the Environment and Climate Change (MOECC), (2012a). Ontario's Ambient Air Quality Criteria, Standards Development Branch, April 2012 (PIBS # 6570e01).

Ontario Ministry of the Environment and Climate Change (MOECC), (2012b). Summary of Standards and Guidelines to Support Ontario Regulation 419: Air Pollution – Local Air Quality, April 2012 (PIBs 6569e01).

Ontario Regulation 419/05: Air Pollution – Local Air Quality.

Stantec Consulting Ltd. (2009). Final Environmental Assessment, Appendix C12: Site Specific Human Health and Ecological Risk Assessment Technical Study Report, December 4, 2009.

Stantec Consulting Ltd., (2012). Ambient Air Quality Monitoring Plan, Durham York Residual Waste Study, May 8, 2012.

Appendix A EQUIPMENT MAINTENANCE, CALIBRATION SCHEDULE AND SUMMARY OF EQUIPMENT ISSUES

Table A-1 Summary of Preventative Maintenance

Parameter	Equipment Make/Model	Description of Maintenance Activities	Required Schedule (to meet MOE and Ambient Monitoring Plan requirements)	Schedule / Comments	2015 Schedule Dates
					Crago Road Site
SO_2	Teledyne Monitor Labs	Change particulate filter	Monthly	During monthly calibration	See note 1
		Replace critical flow orifice and filters	As required	During monthly calibration	See note 1
		Exchange chemical – external zero air scrubber	3 months	During monthly calibration	See note 1
		Replace perm tube	As required	During annual maintenance	Changed at yearly maintenance Sept 23 - Sept 30
		Replace Pump diaphragm	Annual	During annual maintenance,	Changed at yearly maintenance Sept 23 - Sept 30. Diaphragm torn and replaced Dec 11.
		Clean sample chamber, windows and filters	As required	During annual maintenance,	Done at yearly maintenance Sept 23 - Sept 30
NOx	API Model 200E	Change particulate filter	Monthly	Done during monthly calibration	See note 1
		Exchange chemical – external zero air scrubber	3 months	During monthly calibration	See note 1
		Replace chemical – external dryer	3 months	During monthly calibration	See note 1
		Chemical change – ozone filter	Annually	During annual maintenance,	See note 1
		Clean reaction cell window (annually or as necessary)	Annually	During annual maintenance,	Done at yearly maintenance Sept 23 - Sept 30
		Change particulate DFU filter	Annually	During annual maintenance,	Done at yearly maintenance Sept 23 - Sept 30
		Replace reaction cell O-rings & sintered filters	Annually or as required	During annual maintenance,	Done at yearly maintenance Sept 23 - Sept 30
		Rebuild pump head	When RCEL pressures exceeds 10 in Hg	At annual maintenance,	Done at yearly maintenance Sept 23 - Sept 30
		Replace inline exhaust scrubber	Annually	During annual maintenance,	Changed at yearly maintenance Sept 23 - Sept 30
		Replace Perm Tube	As Required	During annual maintenance,	Changed at yearly maintenance Sept 23 - Sept 30
		Replace NO2 converter	Every 3 years or if conversion < 96%	Conversion checked every 6 months,	Convertor at 98%
$PM_{2.5}$	Thermo Sharp 5030	Replace filter tape	Upon 10% remaining	As required	As required
		Replace SHARP zeroing filters	6 months		February 10 and September 30
		Clean PM2.5 inlet	Monthly	During monthly calibration	See note 1
		Clean cyclone	Monthly	During monthly calibration	See note 1
		Clean air inlet system	Annually	During annual maintenance,	Done Sept 23 - Sept 30
		Rebuild vacuum pump	12-18 months	During annual maintenance,	Done Sept 23 - Sept 30
		Clean ambient temp/RH shield and assembly	Annually	During annual maintenance,	Done Sept 23 - Sept 30
TSP/metals	TE-5170	Ensure all gaskets sealing properly	Weekly	Check at weekly site visit	Not used in 2015
		Power cord checks for damage/cracks	Weekly	Check at weekly site visit	
		Inspect screen and remove foreign deposits	Weekly	Check at weekly site visit	
		Inspect holder frame gasket	Every sample	Check at weekly site visit	
		Replace motor brushes	Every 500 hours	Replace as needed	
		Check elapsed time meter	Weekly	Check at weekly site visit	
		Check flow recorder pen/tubing	Weekly	Check at weekly site visit	
		Ensure all gaskets sealing properly	Weekly	Check at weekly site visit	
PAH and D/F	TE-1000	Ensure all gaskets sealing properly	Weekly	Check at weekly site visit	D/F sampling started on October 21, 2015 at the request of Regional Municipality of Durham. Equipment checked and calibrated on October 20, 2015 prior to first sampling. Checked at every site visit and calibration day. (see Note 3)
		Power cord checks for damage/cracks	Weekly	Check at weekly site visit	
		Clean any dirt around module and filter holder	Weekly	Check at weekly site visit	
		Inspect dual sampling module gaskets	Every sample	Check at weekly site visit	
		Inspect and replace motor flange gasket and motor cushion	Routinely, minimum annually		
		Replace motor brushes	Every 400 hours	Replaced as needed	Not replaced in 2015.
Wind Speed and Direction	Met One 034B	Physical inspection of equipment for signs of damage/erratic behavior	Weekly	Check at weekly site visit	Checked weekly
		Replace wind speed sensor bearings and calibrate	Annually	During annual maintenance	Annual maintenance April 14, 2015
		Replace wind vane potentiometer and bearings	24-months	To be replaced at 2 years	N/A
		Complete factory overhaul	24-36 months	To be replaced at 2 to 3 years	N/A
Temperature	CS HMP60	Check radiation shield free from debris	Weekly	Checked at weekly site visit	Weekly
Rainfall	TE525M	Inspect funnel and bucket mechanism for debris	Weekly	During weekly site visit	Weekly
Relative Humidity	CS HMP60	Change INTERCAP® Sensor	On out of spec calibration	As required	Not required
		Sensor cleaning	As required	As required	See note 1
		Inspect/replace filter if blocked	Monthly	Done during monthly calibration	See note 1
Pod / others		Examine the external enclosure station conditions including the inlet probe for damage or blockage. Periodically review the station characteristics for any change or modification to the station	Weekly	Check at weekly site visit	Weekly
		Examine the manifold, the transfer lines and the inlet filters for dirt buildup and replace or clean as required. Examine the seals in the sampling system, the scrubbing and drying agents and replace as required	Weekly	Check at weekly site visit	Weekly
		Replace zero and span calibration cylinders when pressure is below 1,500 kPa (215 psig)		Check at weekly site visit	Not needed during 2015
		Ensure shelters and gates are locked upon departure	Weekly	Check at weekly site visit	Weekly

1. Crago monthly calibration and maintenance dates in 2015: January 23, February 27, March 26, April 23, May 11, June 30, July 3, July 31, August 20, September 23, October 20, November 18, December 11.
2. Crago calibration dates for TE-1000: October 20, November 24, December 18.

Table A-2 Summary of Equipment Calibration

Parameter	Equipment Make/Model	Description of Maintenance Activities	Required Schedule	Schedule / Comments	2015 Schedule Dates
					Crago
SO_2	API Model 100E	Verify test functions	Weekly	Checked weekly	Checked weekly
		Evaluate Zero/Span check	Weekly	Checked daily	Checked weekly
		Zero/span external check	Monthly	Checked monthly	See note 1
		Zero/span calibration	3 months	Calibrated monthly	See note 1
		Flow check	6 months	Checked monthly	See note 1
		Pneumatic leak check	Annually or after repairs	Done when flow drops or checked annually	March 26 and Sept 23
		Calibrate UV lamp output	Prior to zero/span cal	Done prior to zero/span cal	See note 1
		PMT sensor hardware cal	On PMT/preamp changes or slope changes as specified	Done when instrument slope is outside of acceptable range	not needed
NOx	API Model 200E	Verify test functions	Weekly	Checked weekly	Checked weekly
		Evaluate Zero/Span check	Weekly	Checked daily	Checked weekly
		Zero/span external check	Monthly	Checked monthly	See Note 1
		Zero/span calibration	3 months	Calibrated monthly	See Note 1
		Pneumatic sub-system check	Annually or after repairs	Checked after repairs	See Note 1
		PMT sensor hardware cal	On PMT/preamp changes or slope changes as specified	Done when slope exceeds the acceptable range	See Note 1
$PM_{2.5}$	Thermo Sharp 5030	Ambient temperature	Audit monthly, calibrate annually	Audit monthly.	See Note 1
		Ambient pressure	Audit monthly, calibrate annually	Audit monthly.	See Note 1
		Flow	Audit monthly, calibrate annually	Audit monthly.	See Note 1
		Leak check	Monthly	Leak check is not possible on this make/model.	N/A
		Analog output	Annually	Done annually	See note 1
		Proportional Counter	Audit annually	Done annually	See note 1
		Nephelometer zero	Audit quarterly	Done monthly	Checked at monthly calibrations. Adjusted when required.
TSP/metals	TE-5170	Flow calibration	Upon installation, monthly, or after any motor maintenance	Calibrated monthly and after motor maintenance.	Not used in 2015
PAH and D/F	TE-1000	Flow calibration	Upon installation, monthly, or after any motor maintenance	Calibrated monthly and after motor maintenance.	D/F sampling resumed on October 21, 2015 at request of Regional Municipality of Durham. Equipment checked and calibrated on Oct 20 prior to first sampling and monthly thereafter (see Note 2) .
Wind Speed and Direction	Met One 034B	Wind speed calibration	Annually	Annually	Done April 14, 2015
		Potentiometer calibration	Annually	Annually	Done April 14, 2015
Temperature	CS HMP60	External calibration	Annually	Annually	Done April 14, 2015
Rainfall	TE525M	Field Calibration. Factory calibration if field calibration not passed.	Annually	Annually	Done April 14, 2015
Relative Humidity	CS HMP60	Calibration (annually)	Annually	Annually	Done April 14, 2015
Data Acquisition	CS CR1000	Calibration every three years	3- years	To be done at 3 years	not needed

1. Crago monthly calibration and maintenance dates in 2015: January 23, February 27, March 26, April 23, May 11, June 30, July 3, July 31, August 20, September 23, October 20, November 18, December 11.
2. Crago calibration dates for TE-1000: October 20, November 24, December 18.

Table A-3 Summary of Instrument Issues at Crago Road Station (Downwind)

Parameter	Issues	Time Frame	Remedial Action
SO_2	Analog output failed	December 25, 2014 – January 29, 2015	Replaced motherboard under warranty from manufacturer
	High readings – determined to be caused by faulty connectors	September 9, 2015 - September 23, 2015	Replaced with new parts from manufacturer under warranty
NO_X	None		
$PM_{2.5}$	C rate and beta detector error	December 3, 2014 - January 23, 2015	Instrument removed for manufacturer repairs and replacement of motherboard
	Data not being stored	March 15, 2015 – March 26, 2015	Cleaned beta detector and recalibrated monitor
	Beta detector failed	April 10 – April 23, 2015	New beta detector ordered and installed/calibrated on April 23.
	Intermittent failure of the external analog output channel to CRX1000 DAS.	April 2–10, May 9–11, May18-19, May 26-31, June 5-6, June 8-30	$PM_{2.5}$ measurements from the instrument's internal data logger were used to replace invalid data recorded by the external CRX1000 DAS.
	Output to data logger intermittently reading 0 $\mu g/m^3$	July 1, 2015 - September 16, 2015	Reset heater inlet temperature after consultations with the manufacturer. Data downloaded directly from the analyzer's internal datalogger– no data lost
	Moisture leaking into monitor	October 29 – November 12, 2015	Sealed leak. All data intact.
Rain gauge	None		
Data logger	None		
TSP/ Metals [A]	None		
PAHs/ D/Fs [B]	None		

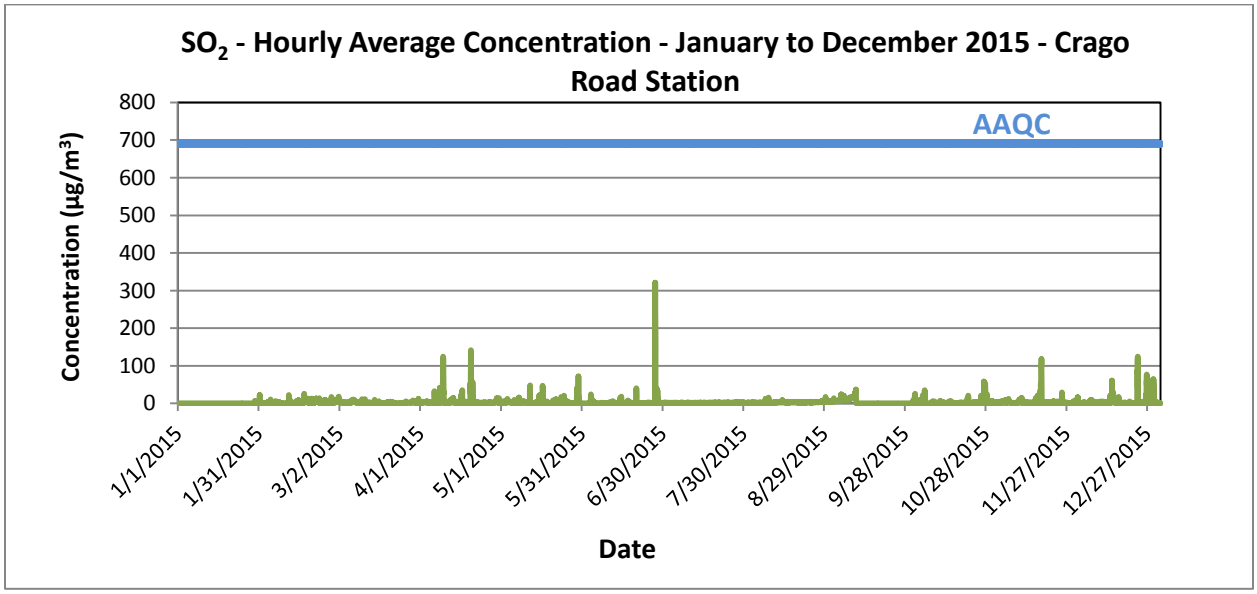
Note:

A. Not used this year

B. D/F sampling resumed on October 21, 2015. No PAH sampling.

Appendix B SO_2 PLOTS

Figure B-1 Time History Plots of Measured Hourly Average and 24-Hour Average SO_2 Concentrations – Crago Road Station



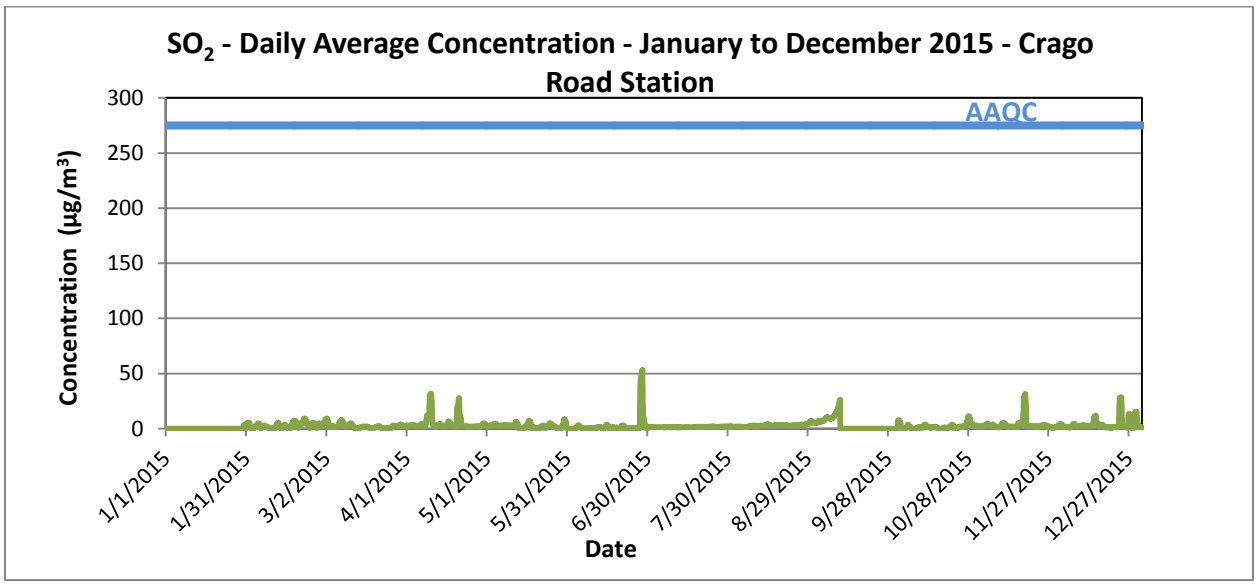
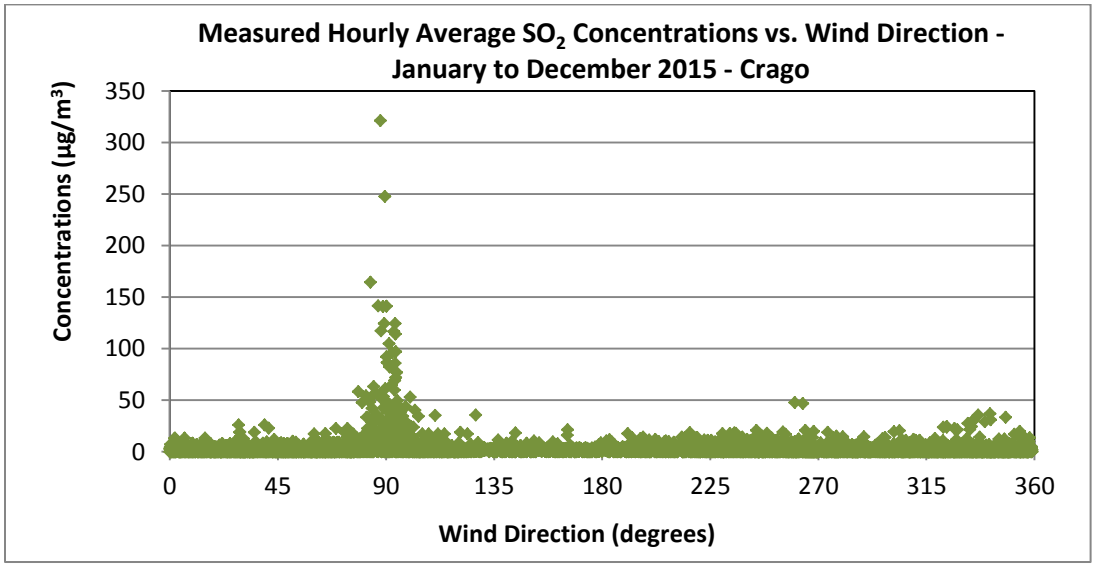
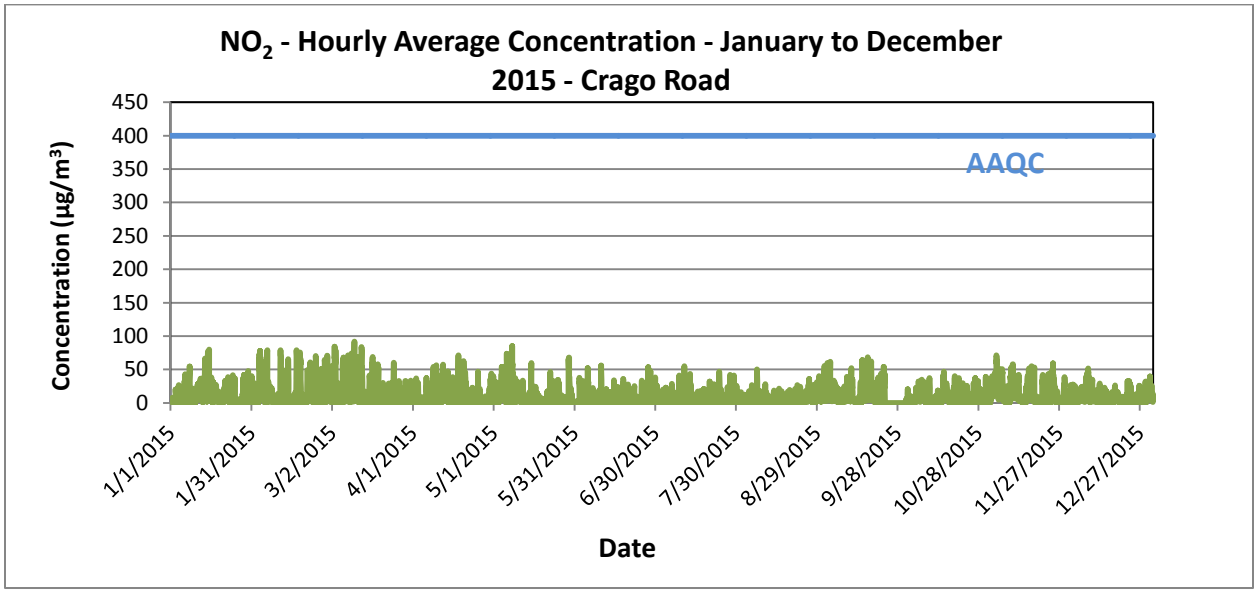


Figure B-2 Measured Hourly Average SO_2 Concentrations vs. Wind Direction – Crago Road Station



Appendix C NO_2 PLOTS

Figure C-1 Time History Plots of Measured Hourly Average and 24-Hour Average NO_2 Concentrations – Crago Road Station



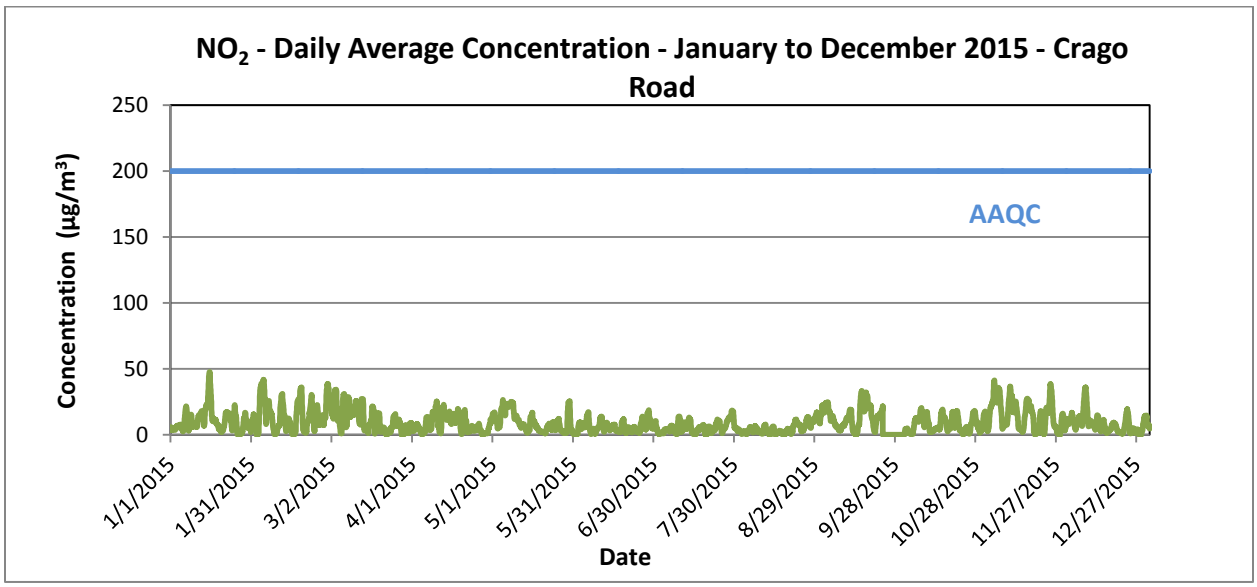
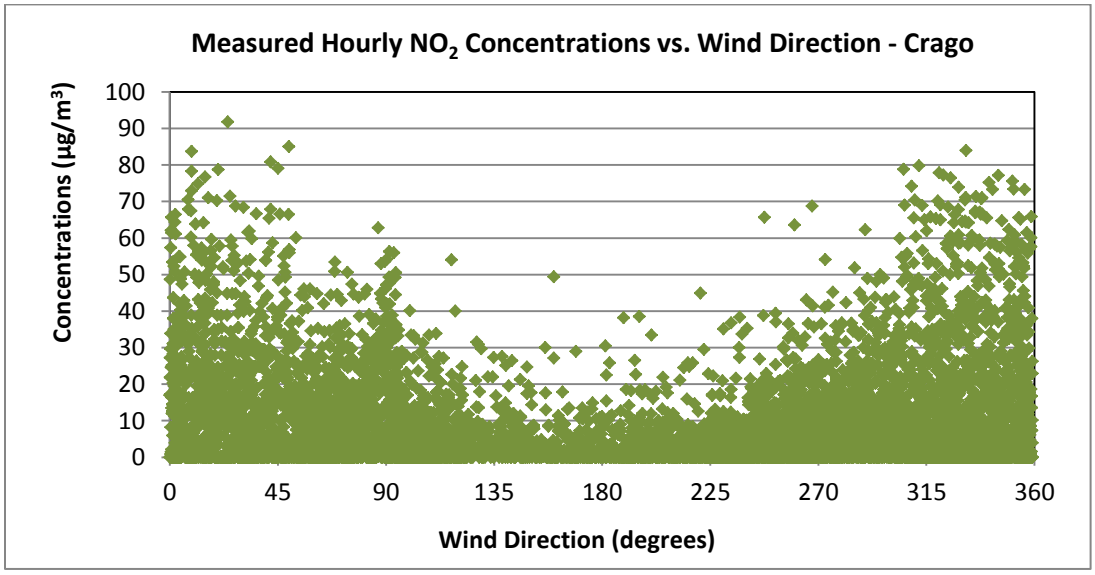
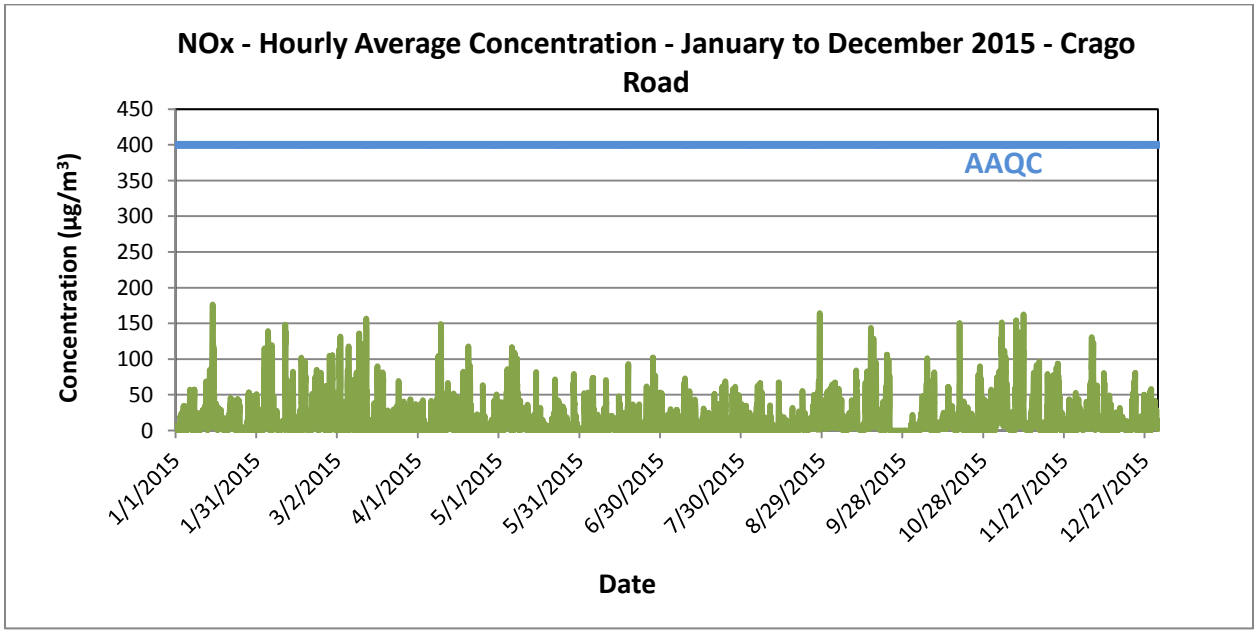


Figure C-2 Measured Hourly Average NO_2 Concentrations vs. Wind Direction – Crago Road Station



Appendix D NO_X PLOTS

Figure D-1 Time History Plots of Measured Hourly Average and 24-Hour Average NO_x Concentrations– Crago Road Station



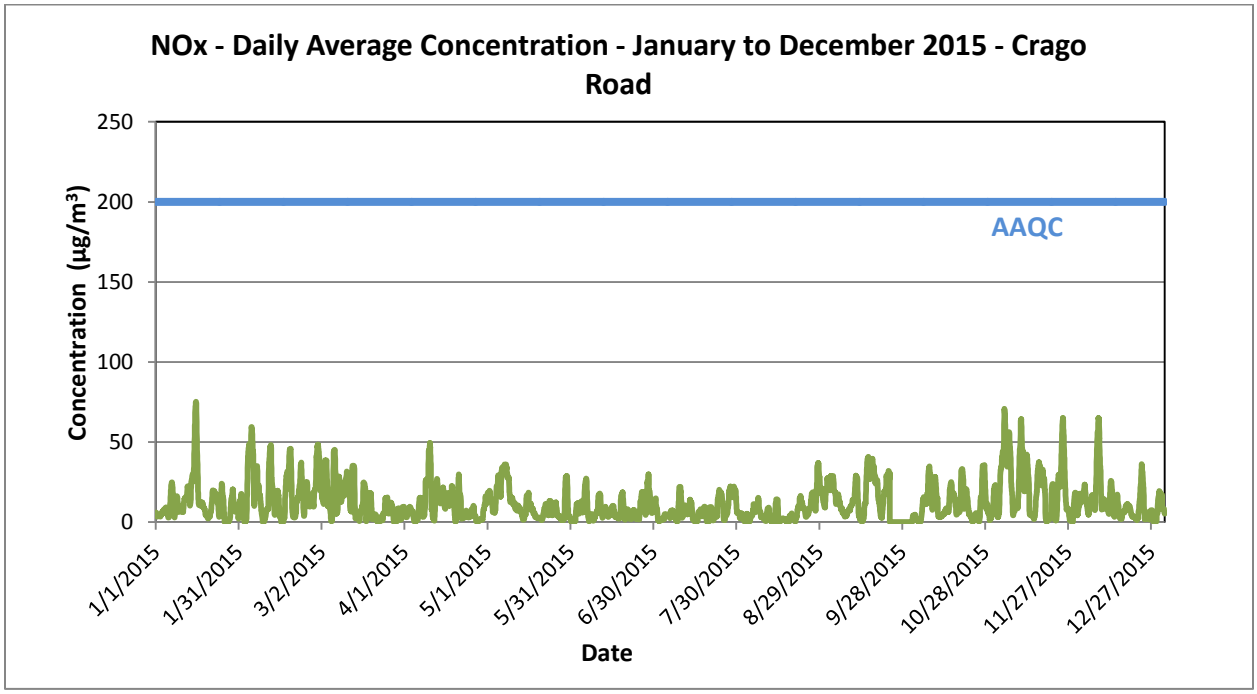
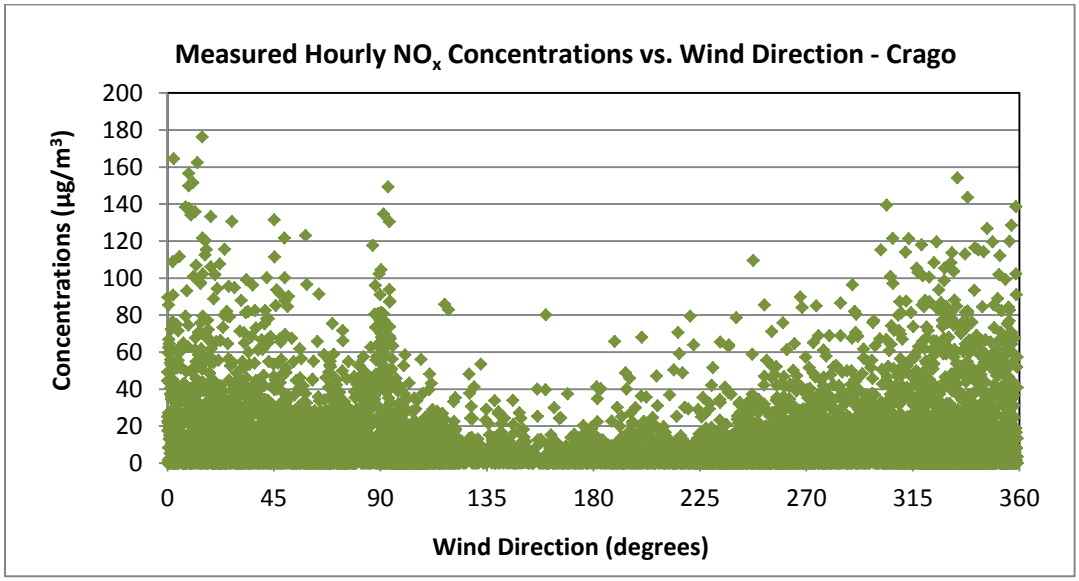


Figure D-2 Measured Hourly NO_X Concentrations vs. Wind Direction – Crago Road Station



Appendix E $PM_{2.5}$ PLOT

Figure E-1 Time History Plot of Measured 24-Hour Average $PM_{2.5}$ Concentrations– Crago Road Station

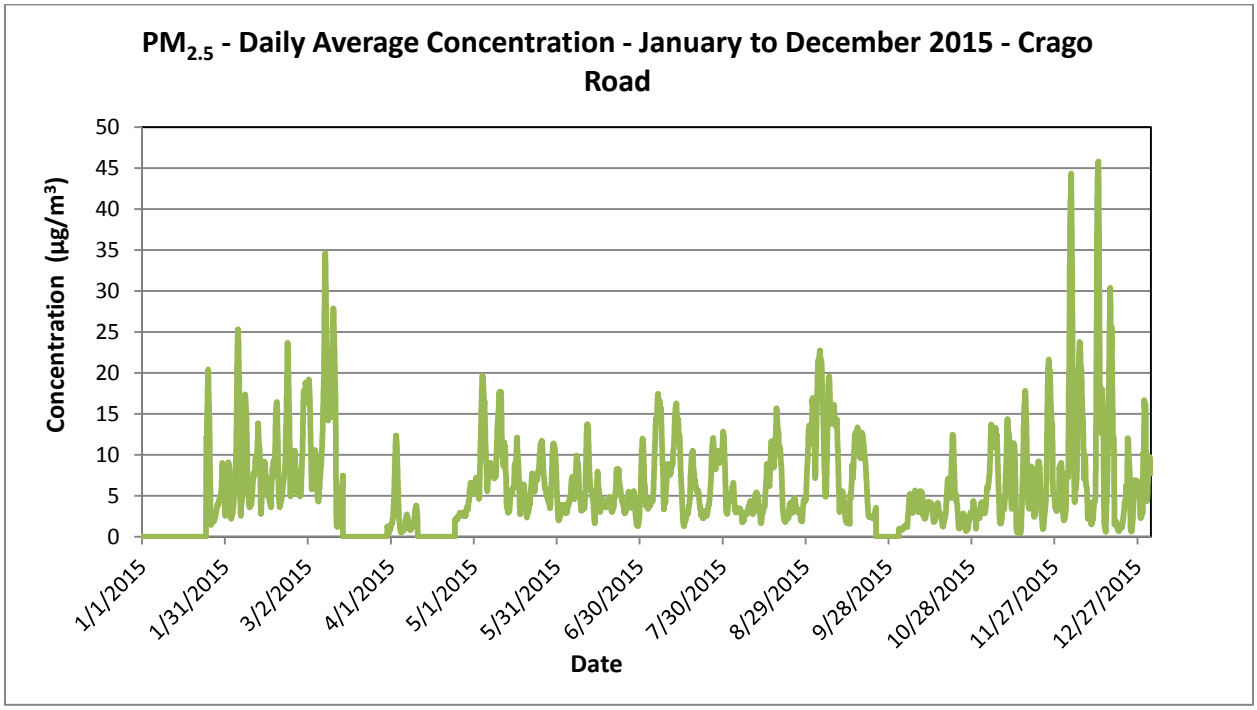
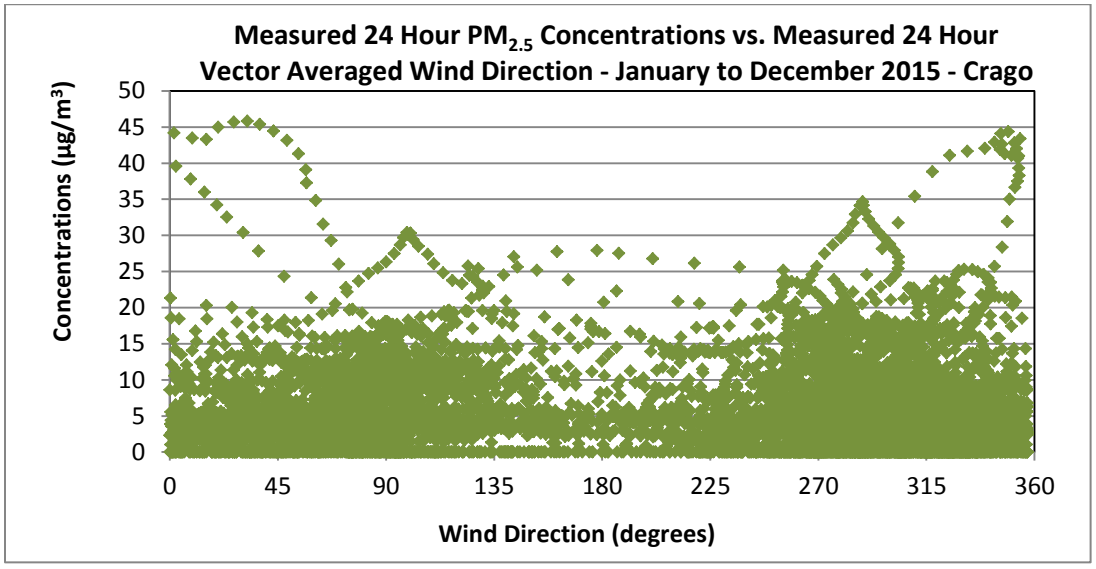


Figure E-2 Measured 24-Hour Average $PM_{2.5}$ Concentrations vs. Measured 24-Hour Vector Averaged Wind Direction - Crago Road Station



Appendix F DIOXINS AND FURANS DATA SUMMARY

Dioxins and Furans	Crago Road Station	2015																
Location		Crago			Crago			Crago			Crago			Crago			Crago	
Date	dd/mm/yyyy	22/10/2015			2/11/2015			14/11/2015			26/11/2015			08/12/2015			20/12/2015	
Start Time	hh:mm	0:00			0:00			0:00			0:00			0:00			0:00	
Sample Duration	minutes	23.09			24.55			23.35			23.27			23.4			23.21	
Technician		JL			TH			TH			TH			TH			TH	
Filter Number		BEB811-01			BFN681-01			BFN875-01			BFS954-01			BLF 196-01			BNI174-01	
Maxaam ID																		
Analytical Report #																		
Total Volumetric Flow	Am^3/sample	332.52			354.08			341.92			354.41			346.23			329.53	
Analytical Results	Units	Value	EDL	WHO_{2005} TEF	Value	EDL	WHO_{2005} TEF	Value	EDL	WHO_{2005} TEF	Value	EDL	WHO_{2005} TEF	Value	EDL	WHO_{2005} TEF	Value	EDL	WHO_{2005} TEF
2,3,7,8-Tetra CDD *	pg	<1.8	1.8	1	<2.5	2.5	1	<2.0	2.0	1	<2.2	2.2	1	<2.4	2.4	1	<1.9	1.9	1
1,2,3,7,8-Penta CDD	pg	<2.6	2.6	1	<2.5	2.5	1	2.8	2.1	1	<2.1	2.1	1	<2.5	2.5	1	<2.7	2.7	1
1,2,3,4,7,8-Hexa CDD	pg	<2.0	2.0	0.1	<2.6	2.6	0.1	4.1	2.1	0.1	<2.1	2.1	0.1	<2.4	2.4	0.1	<2.4	2.4	0.1
1,2,3,6,7,8-Hexa CDD	pg	<2.2	2.2	0.1	<2.8	2.8	0.1	6.5	2.3	0.1	<2.2	2.2	0.1	4.4	2.5	0.1	<2.5	2.5	0.1
1,2,3,7,8,9-Hexa CDD	pg	2.8	1.9	0.1	<2.4	2.4	0.1	11.8	2.0	0.1	2.3	2.0	0.1	7.9	2.2	0.1	<3.4 (1)	3.4	0.1
1,2,3,4,6,7,8-Hepta CDD	pg	15.4	2.1	0.01	12.7	1.9	0.01	57.1	2.1	0.01	18.6	2.0	0.01	53.7	2.2	0.01	23.3	2.2	0.01
Octa CDD	pg	46.8	2.1	0.0003	41.9	2.5	0.0003	207	2.1	0.0003	68.6	2.0	0.0003	191	2.2	0.0003	70.5	2.3	0.0003
Total Tetra CDD	pg	<1.8	1.8		<2.5	2.5		51.7	2.0		<2.2	2.2		<2.4	2.4		<1.9	1.9	
Total Penta CDD	pg	<2.6	2.6		<2.5	2.5		76.8	2.1		11.3	2.1		<4.3 (1)	4.3		<2.7	2.7	
Total Hexa CDD	pg	5.8	2.0		4.7	2.6		68.3	2.1		19.6	2.1		37.9	2.4		12.3	2.4	
Total Hepta CDD	pg	32.6	2.1		27.6	1.9		119	2.1		41.7	2.0		122	2.2		51.4	2.2	
2,3,7,8-Tetra CDF **	pg	<3.4	3.4	0.1	<2.3	2.3	0.1	<25 (1)	25	0.1	4.5	2.0	0.1	4.8	2.4	0.1	<3.4 (2)	3.4	0.1
1,2,3,7,8-Penta CDF	pg	<2.4	2.4	0.03	<2.7	2.7	0.03	3.9	2.1	0.03	<2.1	2.1	0.03	<2.2	2.2	0.03	<1.9	1.9	0.03
2,3,4,7,8-Penta CDF	pg	<2.4	2.4	0.3	<2.7	2.7	0.3	5.7	2.1	0.3	<2.1	2.1	0.3	<2.2	2.2	0.3	<1.9	1.9	0.3
1,2,3,4,7,8-Hexa CDF	pg	2.0	1.9	0.1	<2.3	2.3	0.1	7.6	2.1	0.1	<2.0	2.0	0.1	3.7	2.3	0.1	3.8	1.9	0.1
1,2,3,6,7,8-Hexa CDF	pg	<1.8	1.8	0.1	<2.3	2.3	0.1	3.7	2.0	0.1	<2.0	2.0	0.1	<2.2	2.2	0.1	<1.8	1.8	0.1
2,3,4,6,7,8-Hexa CDF	pg	<2.0	2.0	0.1	<2.5	2.5	0.1	4.5	2.1	0.1	<2.2	2.2	0.1	<2.3	2.3	0.1	<1.9	1.9	0.1
1,2,3,7,8,9-Hexa CDF	pg	<2.2	2.2	0.1	<2.7	2.7	0.1	<2.3	2.3	0.1	<2.3	2.3	0.1	<2.5	2.5	0.1	<2.1	2.1	0.1
1,2,3,4,6,7,8-Hepta CDF	pg	2.6	1.6	0.01	2.8	1.5	0.01	8.0	1.9	0.01	5.5	1.9	0.01	6.9	1.9	0.01	8.6	2.1	0.01
1,2,3,4,7,8,9-Hepta CDF	pg	<1.8	1.8	0.01	<1.7	1.7	0.01	<2.2	2.2	0.01	<2.2	2.2	0.01	<2.3	2.3	0.01	<2.5	2.5	0.01
Octa CDF	pg	2.4	1.6	0.0003	2.6	1.4	0.0003	8.8	2.1	0.0003	11.6	2.2	0.0003	11.4	2.2	0.0003	12.8	2.2	0.0003
Total Tetra CDF	pg	3.4	2.2		<2.3	2.3		86.1	2.1		7.3	2.0		8.2	2.4		6.0	1.9	
Total Penta CDF	pg	2.9	2.4		<2.7	2.7		48.5	2.1		4.6	2.1		4.5	2.2		6.5	1.9	
Total Hexa CDF	pg	4.4	2.0		<2.4	2.4		23.7	2.1		3.3	2.1		8.2	2.3		7.7	1.9	
Total Hepta CDF	pg	2.6	1.7		2.8	1.6		14.9	2.0		8.3	2.0		12.3	2.1		8.6	2.3	
Toxic Equivalency	pg																		

Calculated Concentrations	Quarter 4 2015			Crago	Crago	Crago	Crago	Crago	Crago
				1	2	3	4	5	6
	Units	Maximum	Minimum	22/10/2015	2/11/2015	14/11/2015	26/11/2015	08/12/2015	20/12/2015
2,3,7,8-Tetra CDD *	pg/m3	3.53E-03	2.71E-03	0.003	0.004	0.003	0.003	0.003	0.003
1,2,3,7,8-Penta CDD	pg/m3	8.19E-03	2.96E-03	0.004	0.004	0.008	0.003	0.004	0.004
1,2,3,4,7,8-Hexa CDD	pg/m3	1.20E-02	2.96E-03	0.003	0.004	0.012	0.003	0.003	0.004
1,2,3,6,7,8-Hexa CDD	pg/m3	1.90E-02	3.10E-03	0.003	0.004	0.019	0.003	0.013	0.004
1,2,3,7,8,9-Hexa CDD	pg/m3	3.45E-02	3.39E-03	0.008	0.003	0.035	0.006	0.023	0.005
1,2,3,4,6,7,8-Hepta CDD	pg/m3	1.67E-01	3.59E-02	0.046	0.036	0.167	0.052	0.155	0.071
Octa CDD	pg/m3	6.05E-01	1.18E-01	0.141	0.118	0.605	0.194	0.552	0.214
Total Tetra CDD	pg/m3	1.51E-01	2.71E-03	0.003	0.004	0.151	0.003	0.003	0.003
Total Penta CDD	pg/m3	2.25E-01	3.53E-03	0.004	0.004	0.225	0.032	0.006	0.004
Total Hexa CDD	pg/m3	2.00E-01	1.33E-02	0.017	0.013	0.200	0.055	0.109	0.037
Total Hepta CDD	pg/m3	3.52E-01	7.79E-02	0.098	0.078	0.348	0.118	0.352	0.156
2,3,7,8-Tetra CDF **	pg/m3	3.66E-02	3.25E-03	0.005	0.003	0.037	0.013	0.014	0.005
1,2,3,7,8-Penta CDF	pg/m3	1.14E-02	2.88E-03	0.004	0.004	0.011	0.003	0.003	0.003
2,3,4,7,8-Penta CDF	pg/m3	1.67E-02	2.88E-03	0.004	0.004	0.017	0.003	0.003	0.003
1,2,3,4,7,8-Hexa CDF	pg/m3	2.22E-02	2.82E-03	0.006	0.003	0.022	0.003	0.011	0.012
1,2,3,6,7,8-Hexa CDF	pg/m3	1.08E-02	2.71E-03	0.003	0.003	0.011	0.003	0.003	0.003
2,3,4,6,7,8-Hexa CDF	pg/m3	1.32E-02	2.88E-03	0.003	0.004	0.013	0.003	0.003	0.003
1,2,3,7,8,9-Hexa CDF	pg/m3	3.81E-03	3.19E-03	0.003	0.004	0.003	0.003	0.004	0.003
1,2,3,4,6,7,8-Hepta CDF	pg/m3	2.61E-02	7.82E-03	0.008	0.008	0.023	0.016	0.020	0.026
1,2,3,4,7,8,9-Hepta CDF	pg/m3	3.79E-03	2.40E-03	0.003	0.002	0.003	0.003	0.003	0.004
Octa CDF	pg/m3	3.88E-02	7.22E-03	0.007	0.007	0.026	0.033	0.033	0.039
Total Tetra CDF	pg/m3	2.52E-01	3.25E-03	0.010	0.003	0.252	0.021	0.024	0.018
Total Penta CDF	pg/m3	1.42E-01	3.81E-03	0.009	0.004	0.142	0.013	0.013	0.020
Total Hexa CDF	pg/m3	6.93E-02	3.39E-03	0.013	0.003	0.069	0.009	0.024	0.023
Total Hepta CDF	pg/m3	4.36E-02	7.82E-03	0.008	0.008	0.044	0.023	0.036	0.026
Toxic Equivalency	pg/m3								
TOTAL TOXIC EQUIVALENCY	pg TEQ/m^3	0.034	0.012	0.012	0.012	0.034	0.012	0.017	0.013

Calculated TEQ Concentrations	Units			Crago	Crago	Crago	Crago	Crago	Crago
				22/10/2015	2/11/2015	14/11/2015	26/11/2015	08/12/2015	20/12/2015
2,3,7,8-Tetra CDD *	pg TEQ/m^3			0.003	0.004	0.003	0.003	0.003	0.003
1,2,3,7,8-Penta CDD	pg TEQ/m^3			0.004	0.004	0.008	0.003	0.004	0.004
1,2,3,4,7,8-Hexa CDD	pg TEQ/m^3			0.0003	0.0004	0.0012	0.0003	0.0003	0.0004
1,2,3,6,7,8-Hexa CDD	pg TEQ/m^3			0.0003	0.0004	0.0019	0.0003	0.0013	0.0004
1,2,3,7,8,9-Hexa CDD	pg TEQ/m^3			0.0008	0.0003	0.0035	0.0006	0.0023	0.0005
1,2,3,4,6,7,8-Hepta CDD	pg TEQ/m^3			0.0005	0.0004	0.0017	0.0005	0.0016	0.0007
Octa CDD	pg TEQ/m^3			0.00004	0.00004	0.00018	0.00006	0.00017	0.00006
Total Tetra CDD	pg TEQ/m^3								
Total Penta CDD	pg TEQ/m^3								
Total Hexa CDD	pg TEQ/m^3								
Total Hepta CDD	pg TEQ/m^3								
2,3,7,8-Tetra CDF **	pg TEQ/m^3			0.0005	0.0003	0.0037	0.0013	0.0014	0.0005
1,2,3,7,8-Penta CDF	pg TEQ/m^3			0.0001	0.0001	0.0003	0.0001	0.0001	0.0001
2,3,4,7,8-Penta CDF	pg TEQ/m^3			0.001	0.001	0.005	0.001	0.001	0.001
1,2,3,4,7,8-Hexa CDF	pg TEQ/m^3			0.0006	0.0003	0.0022	0.0003	0.0011	0.0012
1,2,3,6,7,8-Hexa CDF	pg TEQ/m^3			0.0003	0.0003	0.0011	0.0003	0.0003	0.0003
2,3,4,6,7,8-Hexa CDF	pg TEQ/m^3			0.0003	0.0004	0.0013	0.0003	0.0003	0.0003
1,2,3,7,8,9-Hexa CDF	pg TEQ/m^3			0.0003	0.0004	0.0003	0.0003	0.0004	0.0003
1,2,3,4,6,7,8-Hepta CDF	pg TEQ/m^3			0.00008	0.00008	0.00023	0.00016	0.00020	0.00026
1,2,3,4,7,8,9-Hepta CDF	pg TEQ/m^3			0.00003	0.00002	0.00003	0.00003	0.00003	0.00004
Octa CDF	pg TEQ/m^3			0.000002	0.000002	0.000008	0.000010	0.000010	0.000012
Total Tetra CDF	pg TEQ/m^3								
Total Penta CDF	pg TEQ/m^3								
Total Hexa CDF	pg TEQ/m^3								
Total Hepta CDF	pg TEQ/m^3								
TOTAL TOXIC EQUIVALENCY	pg TEQ/m^3			0.012	0.012	0.034	0.012	0.017	0.013

Notes:
RDL = Reportable Detection Limit
* CDD = Chloro Dibenzo-p-Dioxin, ** CDF = Chloro Dibenzo-p-Furan
TEF = Toxic Equivalency Factor, TEQ = Toxic Equivalency Quotient
WHO(2005): The 2005 World Health Organization, Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds