Northwest Territories Air Quality Report 2015

Government of
Northwest Territories

TABLE OF CONTENTS

INTRODUCTION

The Department of Environment and Natural Resources (ENR) monitors air quality in the Northwest Territories (NWT). ENR maintains and operates the NWT Ambient Air Quality Monitoring Network, consisting of four monitoring stations located in Yellowknife, Inuvik, Fort Smith and Norman Wells. Each station is capable of continuously sampling and analysing a variety of air pollutants and meteorological conditions. The Yellowknife and Inuvik stations are operated in partnership with the National Air Pollution Surveillance (NAPS) program – a joint federal/provincial/territorial monitoring network with the objective of tracking regional air quality trends throughout Canada. A secondary overall objective of the stations is to establish baseline levels of SO_2, NO_x, O_3 and PM ahead of development as well as track the trends and cumulative impacts from source emissions should they occur.

Deposition monitoring is also conducted in the NWT, in cooperation with the federal Canadian Air and Precipitation Monitoring Network (CAPMoN). One station is located in Wood Buffalo National Park and the other at the Snare Rapids Hydro Facility. The latter is operated in partnership with the Northwest Territories Power Corporation (NTPC).

The 2015 Annual Air Quality Report summarizes the air quality information collected in 2015, along with some discussion of trends. Data capture and select statistical information is in Appendix A. The report provides information on network operations, the air pollutants monitored and the air quality standards used in assessing the monitoring results. Additional information, including 'near real-time' air pollutant readings, are on the NWT Air Quality Monitoring Network web site at http://air.enr.gov.nt.ca.

For more information, contact:
Environment Division
Department of Environment and Natural Resources
Government of the Northwest Territories
P.O. Box 1320
Yellowknife, NT X1A 2L9

Telephone: (867) 767-9236 ext. 53177
Facsimile: (867) 873-0221

This report is also available online at
www.enr.gov.nt.ca/programs/air-quality

OPERATIONS (NETWORK)

The NWT Air Quality Monitoring Network consists of four permanent monitoring stations located in Yellowknife, Inuvik, Fort Smith and Norman Wells. The stations are climate-controlled structures with state-of-the-art monitoring equipment capable of continuously sampling and analysing a variety of air pollutants and meteorological conditions. Pollutants monitored vary by station, but include sulphur dioxide (SO_2), fine particulate ($PM_{2.5}$), coarse particulate (PM_{10}), ground level ozone (O_3), carbon monoxide (CO) and nitrogen oxides (NO_x). Wind speed, wind direction and temperature are also monitored. For additional information on air pollutants see **Appendix C**.

Figure 1:
Map of the Air Quality Monitoring Network

Table 1 shows the breakdown of the NWT Air Quality Monitoring Network by substances and meteorological parameters monitored at each station.

Table 1 – Parameters Monitored by Station

Stations	Particulate Matter		Gaseous				Precipitation	Meteorlogical Monitoring	
	$PM_{2.5}$ – Fine Particulate	PM_{10} – Coarse Particulate	SO_2 – Sulphur Dioxide	NO_x – Nitrogen Oxides	O_3 – Ground Level Ozone	CO – Carbon Monoxide	Deposition	Wind Speed and Direction	Air Temperature
Yellowknife	√	√	√	√	√	√		√	√
Inuvik	√	√	√	√	√	√		√	√
Norman Wells	√	√	√	√	√			√	√
Fort Smith	√	√	√	√	√	√		√	√
Snare Rapids					√		√		
Wood Buffalo					√		√		

Data from each station is automatically transmitted every hour to ENR headquarters in Yellowknife using a sophisticated data acquisition system (DAS) and communications software. This allows for review of community air quality on a near real-time basis. The data also undergoes a series of 'on the fly' validity checks before being archived by the data management, analysis and reporting system.

The Yellowknife and Inuvik stations are part of a larger national network monitoring the criteria air pollutants in communities across Canada. The National Air Pollution Surveillance (NAPS) Network is a joint federal/provincial/territorial program, incorporating approximately 286 stations in 203 communities across the country. ENR operates the Inuvik station in partnership with the Aurora Research Institute (ARI), who provides on-the-ground technical operations of the station. Data from the Yellowknife and Inuvik stations, along with data from other cities, is summarized and assessed, with results published in the NAPS annual data reports available at http://www.ec.gc.ca/rnspa-naps/default.asp?lang=En&n=77FECF05-1#reports.

The NAPS Network has a stringent quality assurance/quality control (QA/QC) program, ensuring Canada-wide data is comparable. Participation in the NAPS program requires ENR to follow these QA/QC procedures at the Yellowknife and Inuvik sites, and ENR applies these procedures at all NWT stations.

The Fort Smith and Norman Wells stations are territorial stations set up in response to increasing resource development activity in the NWT and Alberta, and the potential for the associated emissions to affect air quality. The primary territorial objective of these stations is to establish baseline levels of SO_2, NO_x, O_3 and PM ahead of development as well as to track the trends and cumulative impacts from source emissions as or should they occur. Although not part of the NAPS network, these stations fulfill NAPS' national urban monitoring objective. Fort Smith annual data was reported for the first time in the 2014 sampling year.

ENR is also involved in the Canadian Air and Precipitation Monitoring Network (CAPMoN). CAPMoN is a non-urban monitoring network with 35 measurement sites in Canada and one in the United States designed to study the regional patterns and trends of atmospheric pollutants such as acid rain, smog, particulate matter and mercury, in both air and precipitation. Unlike NAPS, CAPMoN locates sites to limit the effect of anthropogenic sources. Most sites are remote and data is considered representative of background values. Two CAPMoN stations are operated in the NWT, at the Wood Buffalo National Park approximately 80 kilometres northwest of Fort Smith and the Snare Rapids Hydro Facility approximately 150 kilometres northwest of Yellowknife. ENR, with assistance from the NTPC staff, operates the Snare Rapids CAPMoN station consisting of an acid precipitation collector and an ozone analyzer. The Wood Buffalo station uses an automated precipitation collector and monitors continuous ozone. Daily rain and snow samples are collected and forwarded to the CAPMoN laboratory for analysis, and the data is used by Environment and Climate Change Canada (ECCC) and ENR.

Table 2: The partnerships and affiliations with the air quality monitoring stations in the NWT.

	Partnership/ Contract	Stations	Network
Government of the Northwest Territories		Yellowknife	Environment Canada National Air Pollution Surveillance
	Aurora Research Institute	Inuvik	Environment Canada National Air Pollution Surveillance
		Fort Smith and Norman Wells	Northwest Territories Stations
	NWT Power Corporation	Snare Rapids	Environment Canada Canadian Air and Precipitation Monitoring
		Wood Buffalo	

Table 2 –
NWT Air Quality Monitoring Network

Air quality monitoring in the NWT has evolved over time, beginning with a single particulate monitor in Yellowknife in 1974, progressing through various monitoring locations and equipment to reach the current stage of development.

Appendix B traces the history of air quality monitoring in the NWT. Previous ENR Annual Air Quality Reports can be found at www.enr.gov.nt.ca.

Change to Government of the Northwest Territories and insert black and white logotype with signature

DEVELOPMENTS IN 2015

To ensure the GNWT is current with technological advancements and serving the needs of the NWT, continuous improvement of the monitoring network is required. Upgrades conducted in 2015 include:

- Deployable particulate monitoring instruments for short-term monitoring in communities during wildfire events. Data from these instruments was used to inform the Department of Health and Social Services and Emergency Management staff during smoke events. Only four of the 33 communities in the NWT have permanent air monitoring stations. As a result, information from an exposure perspective is limited. These deployable units will complement the monitoring network and assist in filling that gap.
- Upgrades to data servers in advance of the planned data acquisition system upgrades.
- Installation of a Black Carbon Aethalometer at the Yellowknife station in spring 2015. Black carbon is a light-absorbing, carbon-containing component of particular matter in air pollution affecting human health and climate change. Some sources of black carbon in the NWT are from forest fires, vehicle exhaust and other diesel combustion sources.
- An official NAPS audit on the Yellowknife station was conducted in July 2015. ENR mirrored the process and conducted an internal audit of the Norman Wells station in August.
- As part of the QA/QC improvements, ENR increased the frequency of station visits and calibrations per year from three to four. Quarterly visits have assisted in catching issues in a timely fashion and improved station operations. This travel and calibration schedule will continue indefinitely.

FUTURE PLANS

Updates to the air quality monitoring network in 2016 include:

- The Yellowknife station has been identified by NAPS for advancement to Tier 1 status in the national network. The suite of parameters being monitored at the station will be expanded to include volatile organic compounds (VOC) monitoring and particulate speciation monitoring. The Yellowknife station will be the only station in the NWT to monitor these parameters.
- The data acquisition system (DAS) is slated for upgrades in 2016. New industrial loggers will be installed in each of the four stations, in addition to upgrades to the software.
- The Fort Smith air monitoring station will begin reporting the Air Quality Health Index (AQHI) beginning in May 2016. This will be the third station in the network to report the AQHI, along with Yellowknife and Inuvik.

NWT AIR QUALITY STANDARDS

The Government of the Northwest Territories has adopted a number of concentration limits to protect ambient (outdoor) air quality in the NWT. These limits apply to select pollutants in the "Guideline for Ambient Air Quality Standards in the Northwest Territories", established under the *NWT Environmental Protection Act*. They are summarized in **Table 3** below.

The NWT Ambient Air Quality Standards (AAQS) are used to assess air quality monitoring data and determine the acceptability of emissions from proposed and existing developments. Where NWT standards are not available for a particular pollutant, the Canadian National Ambient Air Quality Objectives (national standards) or limits established in other jurisdictions are used.

Table 3 – NWT Ambient Air Quality Standards (AAQS)

Parameter and Standard	Concentration (µg/m³)*	Concentration (ppbv)**
Sulphur Dioxide (SO_2)		
1-hour average	450	172
24-hour average	150	57
Annual arithmetic mean	30	11
Ground Level Ozone (O_3)		
8-hour running average	126	63
Total Suspended Particulate (TSP)		
24-hour average	120	
Annual geometric mean	60	
Fine Particulate Matter ($PM_{2.5}$)		
24-hour average	28	
Annual arithmetic mean	10	
Nitrogen Dioxide (NO_2)		
1-hour average	400	213
24-hour average	200	106
Annual arithmetic mean	60	32
Carbon Monoxide (CO)		
1-hour average	15,000 *(15mg/m³)*	13,000
8-hour average	6,000 *(6mg/m³)*	5,000

* Micrograms per cubic metre

** Parts per billion by volume

The "Guideline for Ambient Air Quality Standards in the Northwest Territories" provides additional information on the application of the NWT standards and the pollutants of concern. For more information on air pollutants, see **Appendix C**.

Additional criteria from other jurisdictions are in Table 4.

Table 4 – Additional Ambient Air Quality Standards (AAQS)

Parameter and Standard	Concentration	Concentration
Coarse Particulate Matter (PM_{10}) 24-hour average	50 ug/m^3	Ontario Ambient Air Quality Criteria, Apr/12 B.C. Ambient Air Quality Objectives, Oct/14

YELLOWKNIFE AIR QUALITY

Figure 2:
Sir John Franklin Station

ENR, in partnership with the Canadian NAPS Program, operates the air quality monitoring station in Yellowknife.

This station is located at the École Sir John Franklin High School (Sir John Franklin station) and continuously monitors criteria air contaminants (CACs). This includes fine particulate ($PM_{2.5}$), coarse particulate (PM_{10}), SO_2, O_3, NO_2 and CO. The station also monitors wind speed, wind direction and temperature, assisting in identifying possible sources of unusual or elevated readings.

Particulate Matter

Yellowknife's greatest source of particulate is typically dust from roads, especially in the spring when the snow cover disappears and exposes winter sand and gravel on city streets. Once the sand and gravel is exposed, wind and vehicle activity can cause the dust to become suspended in the air. Forest fires, combustion products from vehicles, and heating and electricity generation also raise particulate levels. *Wildland fire events are observed and documented by regional ENR staff as they occur (i.e. visible smoke and olfactory indications of smoke). This qualitative data serves as a validation to the conclusions drawn from measured $PM_{2.5}$ readings.*

ENR uses Beta Attenuation Mass Monitors (BAM) to sample for fine ($PM_{2.5}$) and coarse (PM_{10}) fractions of particulate matter in Yellowknife. The BAM methodology provides continuous, near real-time (hourly) analysis of particulate concentrations in the fine and coarse particle sizes. The BAM technology measures hourly concentrations on a mass basis. Non-continuous particulate monitoring is also conducted at the Sir John Franklin station and uses a Partisol 2000i-D filter-based sampler.

Fine Particulate Matter ($PM_{2.5}$)

The BAM operating in Yellowknife for the $PM_{2.5}$ fraction is a Federal Equivalency Method (FEM) model.

There were eight episodes of $PM_{2.5}$ readings at the Sir John Franklin station in 2015 that exceeded the NWT 24-hour AAQS of 28µg/m^3. All eight episodes were a result of smoke from active forest fires. Fires burning in Wood Buffalo National Park impacted the readings during June and July, while fires burning near Reid Lake impacted the August readings. The annual $PM_{2.5}$ average was 8.6ug/m^3, which was below the annual standard of 10ug/m^3.

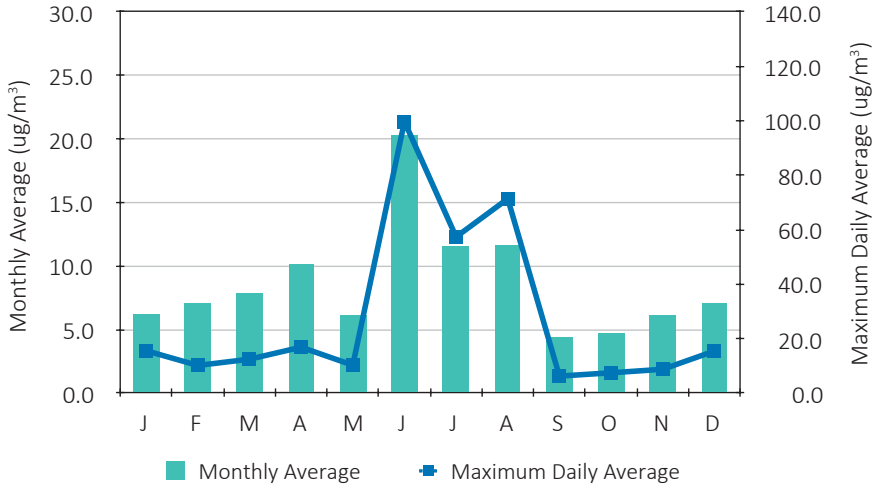


Figure 3:
2015 Yellowknife $PM_{2.5}$

Figure 3 shows the monthly averages and maximum daily average per month measured at the Sir John Franklin station in 2015 on the FEM BAM $PM_{2.5}$. The highest daily average concentration was 99.7µg/m^3, measured in June.

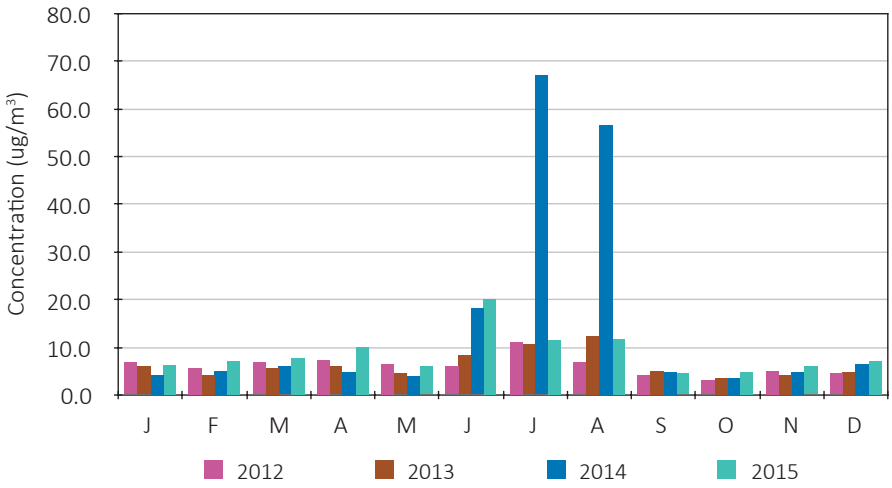


Figure 4:
2012 to 2015 Summary:
Yellowknife Monthly $PM_{2.5}$

Figure 4 summarizes the monthly average $PM_{2.5}$ data over the last four years. The overall trends indicate $PM_{2.5}$ levels increase during the summer months, typically attributed to forest fires occurring at that time of year. To date, the 2014 summer season recorded the highest $PM_{2.5}$ levels experienced in Yellowknife since continuous $PM_{2.5}$ monitoring began in 2003.

Coarse Particulate Matter (PM_{10})

The NWT does not have an AAQS for PM_{10}. Instead, it adopts a 24-hour average criterion of 50µg/m^3. This level is used in several Canadian jurisdictions, including British Columbia and Ontario.

Figure 5 presents the PM_{10} data for 2015. Generally, the annual spring-time "dust event" occurs during the month of April and is responsible for the highest levels seen in the year. This is due to residual gravel on the roads following the spring snow thaw. There were 18 exceedances of the adopted standard of 50µg/m^3 in 2015, half of which were attributed to forest fire smoke during the months of June, July and August. The other nine exceedances occurred in April and were typical of the annual spring-time "dust event".

Figure 5:
2015 Yellowknife BAM PM_{10}

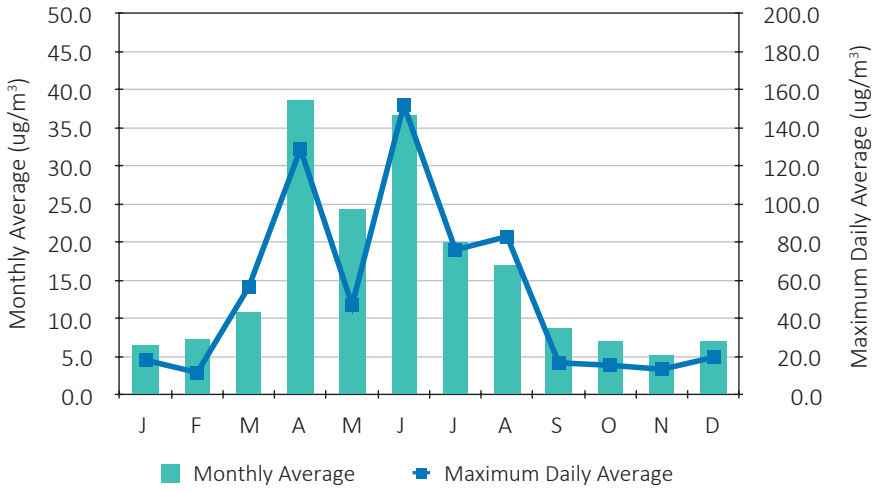


Figure 5 shows the PM_{10} monthly averages and maximum daily averages per month measured at the Yellowknife station in 2015. The highest maximum daily concentration was 151.9µg/m^3, occurring in June.

Sulphur Dioxide (SO_2)

Continuous monitoring for SO_2 has been conducted in Yellowknife since 1992, at a variety of locations, primarily to monitor the effects from the former gold mine operations. The current SO_2 monitoring location at the Sir John Franklin station has been in place since 2004 and uses an API 100 series UV fluorescence analyzer.

There were no exceedances of the NWT hourly AAQS (172ppb) or the 24-hour AAQS (57ppb) in 2015 in Yellowknife. The annual average SO_2 concentration was less than 1ppb, a level that is well below the NWT AAQS (11ppb).

The majority of the hourly concentrations recorded in 2015 registered at background levels or slightly greater. These concentrations are similar to the years since 1999 when the last gold mine in Yellowknife closed, and reflect naturally occurring SO_2 and/or small amounts from the burning of fossil fuels.

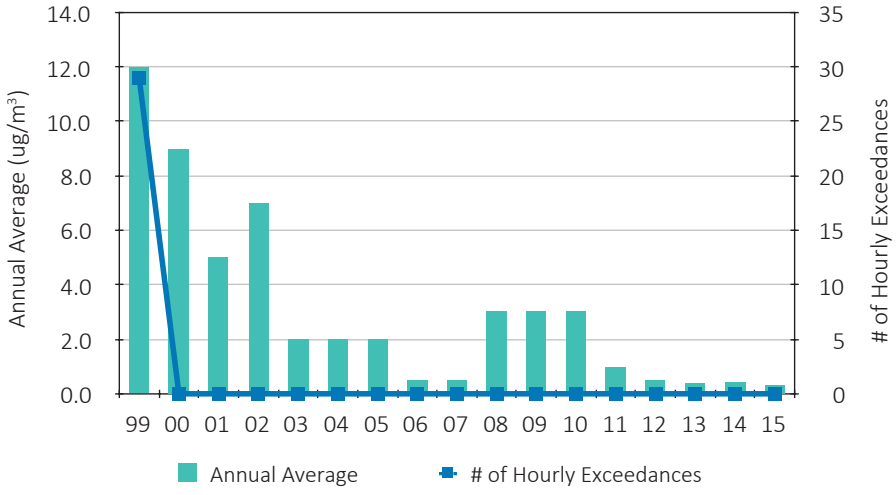


Figure 6:
1999 to 2015 Summary:
Yellowknife Sulphur Dioxide

Figure 6 shows the general trends in SO_2 levels measured in Yellowknife from 1999 to 2015. As illustrated, the number of exceedances has fallen to zero since the closure of Giant Mine in 1999. The 2015 data continues the trend of recent years.

Ground Level Ozone (O_3)

Continuous ozone monitoring has been conducted in Yellowknife since 1998, with the current location in operation at the Sir John Franklin station since February of 2003. Ozone is monitored with an API 400 series UV absorption analyzer.

The maximum 8-hour average in 2015 was 49.9ppb, in May, and was below the 8-hour NWT AAQS (63ppb). The maximum 1-hour average was 56.5ppb, which also occurred in May, and was below the national maximum acceptable level of 82ppb. The 2015 annual hourly average was 24.8ppb.

Detectable concentrations of ozone exist even in remote areas due to naturally occurring sources of the precursor gases, such as volatile organic compounds (VOC) emissions from trees, and the introduction of stratospheric ozone to lower elevations resulting from atmospheric mixing processes. These background concentrations typically are in the range of 20 to 40ppb. In large urban areas (and areas downwind), ozone concentrations can be much higher due to the additional emissions of precursor gases from anthropogenic sources (see **Appendix C**).

Figure 7:
2015 Yellowknife Ozone

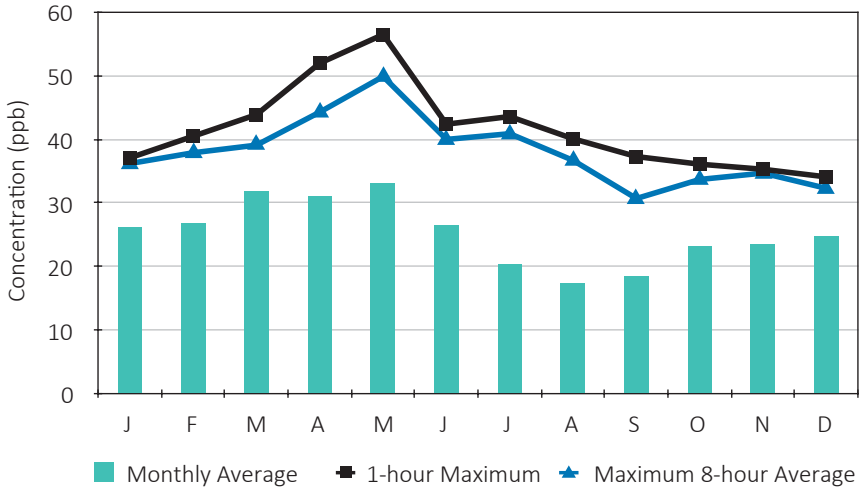


Figure 7 shows the maximum hourly ozone readings and maximum 8-hour averages per month as well as the monthly averages recorded in 2015.

Typically, ozone concentrations in Yellowknife and across the north are highest in the spring, coinciding with the increased sunlight, and natural and anthropogenic sources of precursor compounds. **Figure 7** illustrates 2015 ozone levels were highest in the spring-time as indicated by the 1-hour and 8-hour maximums. The highest monthly average was in May, which is common at remote monitoring stations located in mid to high latitudes in the Northern hemisphere. Typical monthly ozone concentrations at remote sites in Canada range between 20 and 45ppb[1] and Yellowknife concentrations in 2015 fell within or below this range.

1. Vingarza, R. "A review of surface ozone background levels and trends". Atmospheric Environment, Vol 38, Issue 21, pp 3431-3442 (2004).

Nitrogen Dioxide (NO_2)

The NO_x gas analyzer provides continuous information on NO, NO_2 and NO_x. However, the focus is on NO_2 due to the greater health concerns associated with this pollutant and the availability of national air quality standards for comparison (see **Appendix C**). NO_x is monitored with an API 200 series chemiluminescence analyzer.

The 2015 results indicated there were no exceedances of the 1-hour, 24-hour or annual AAQS for NO_2 (213ppb, 106ppb and 32ppb, respectively). The maximum 1-hour average was 34.3ppb, the maximum 24-hour average was 16.8ppb, while the annual average was 3.1ppb.

Figure 8:
2015 Yellowknife Nitrogen Dioxide

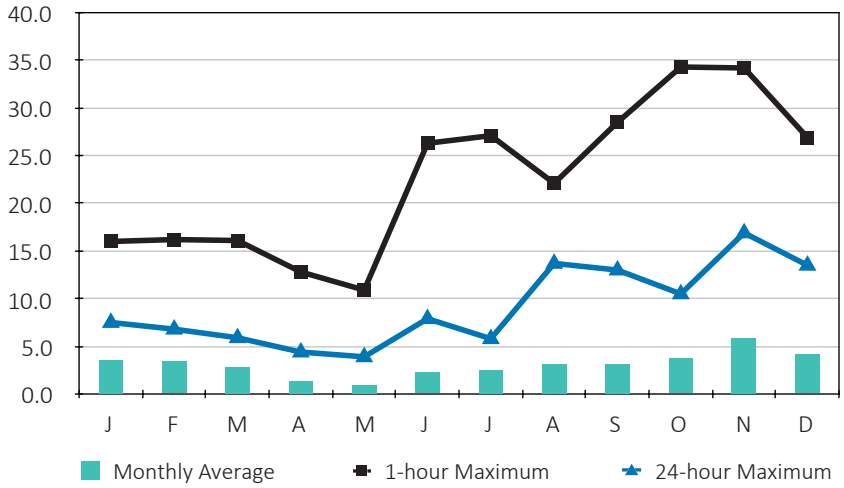


Figure 8 shows the 2015 maximum hourly, maximum daily and monthly averages of NO_2 in Yellowknife. Generally, the highest monthly averages and the highest hourly concentrations occurred during the winter months. This is likely due to increased emissions from fuel combustion for residential and commercial heating and idling vehicles as well as short-term "rush hour" traffic influences. The June and July hourly spikes were caused by work being conducted at the City Lift Station next to the air quality station. The effects of these combustion emissions on winter-time air quality can be increased when combined with stagnant meteorological conditions. Cold, calm days can result in an atmospheric situation where the normal decrease in air temperature with elevation is reversed and a zone of colder air is present at ground level. This zone of colder air and the lack of wind act to restrict dispersion and trap pollutants close to the ground.

Carbon Monoxide (CO)

CO has been monitored in Yellowknife since 2003, using the API 300 series gas filter correlation analyzer. The 2015 data continued the pattern of low CO readings measured in 2014, with the exception of elevated concentrations in August due to forest fire smoke. CO is often attributed to mobile sources; however, forest fire smoke can also contain CO due to the fire conditions and incomplete combustion within the blaze.

The overall concentrations were below the NWT 1-hour and 8-hour average AAQS (13ppm and 5ppm respectively). In 2015, the maximum 1-hour average was 3.164ppm and coincided with the highest $PM_{2.5}$ concentration of the year, which was directly attributed to forest fire smoke. The maximum 8-hour average for CO was 1.768ppm, occurring in early August, but was below the AAQS of 5ppm. The annual CO average was 0.342ppm.

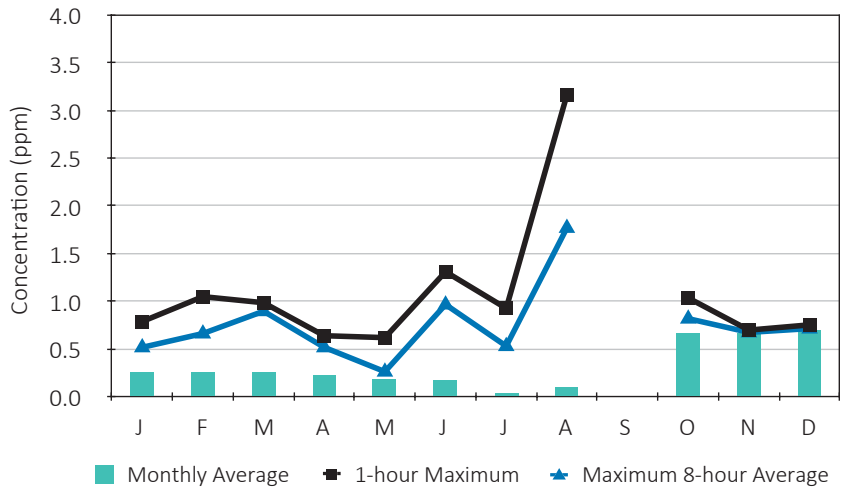


Figure 9:
2015 Yellowknife Carbon Monoxide

Figure 9 shows the 2015 monthly averages and highest hourly and 8-hour concentrations for CO in Yellowknife. Data was not available for the month of September due to an instrument malfunction.

INUVIK AIR QUALITY

Figure 10:
Inuvik Station

The focus of the monitoring station in Inuvik is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time. In January 2006, the station was incorporated into the National Air Pollution Surveillance (NAPS) Network to provide air quality information for comparison to other communities in Canada.

This station has been in operation since 2003, but was moved from its original location at Samuel Hearne School to its present location on Bompas Street in 2009. The following parameters are measured at the Inuvik station: $PM_{2.5}$, PM_{10}, SO_2, O_3, NO_2 and CO.

Fine Particulate Matter ($PM_{2.5}$)

The BAM operating in Inuvik for the $PM_{2.5}$ fraction is a Federal Equivalency Method (FEM) model.

The 2015 annual $PM_{2.5}$ average was 4.6µg/m^3, which is below the AAQS of 10ug/m^3. There were three exceedances of the NWT 24-hour AAQS (28µg/m^3) for $PM_{2.5}$, all occurring in the month of June as a result of forest fire smoke from fires burning in Alaska and the Yukon. As expected, the highest daily average concentration was 106.1µg/m^3, also measured in the month of June.

Figure 11:
2015 Inuvik BAM $PM_{2.5}$

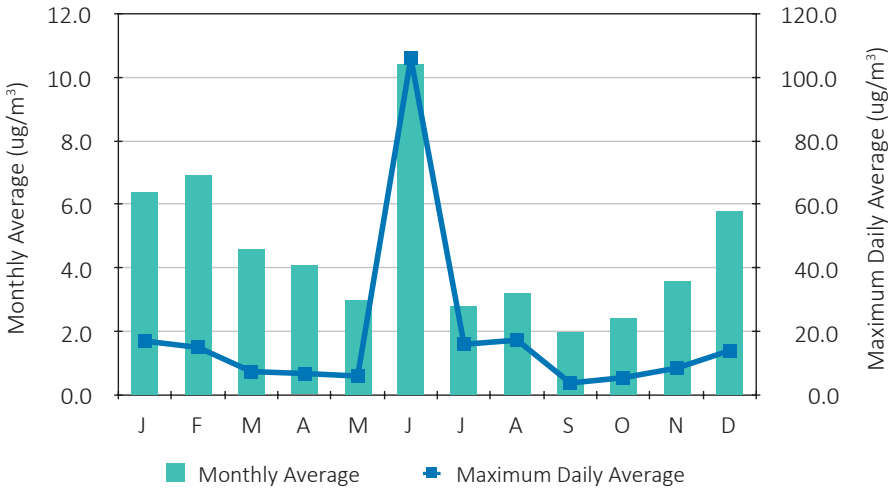


Figure 11 shows the monthly averages and maximum daily average per month, measured at the Inuvik station in 2015 on the FEM BAM $PM_{2.5}$. Only the month of June saw elevated concentrations associated with forest fire smoke, which clearly illustrates the direct relationship between forest fire smoke and $PM_{2.5}$ levels.

Coarse Particulate Matter (PM_{10})

The maximum daily average measured from the PM_{10} BAM in Inuvik in 2015 was 160.2µg/m^3, which occurred in June, and the highest hourly maximum was 697µg/m^3, which occurred in May. There were 23 exceedances of the adopted 24-hour AAQS of 50µg/m^3, all occurring in the months of April, May and June. Similar to previous years, the spring-time PM_{10} levels were elevated due to dust and particulate matter from recently exposed gravel and dirt roads. Road dust impacted the PM_{10} readings throughout the summer months due to proximity of the dirt roads to the monitoring station. The month of June was strongly influenced by the same fires in Alaska and the Yukon that also impacted the $PM_{2.5}$ readings.

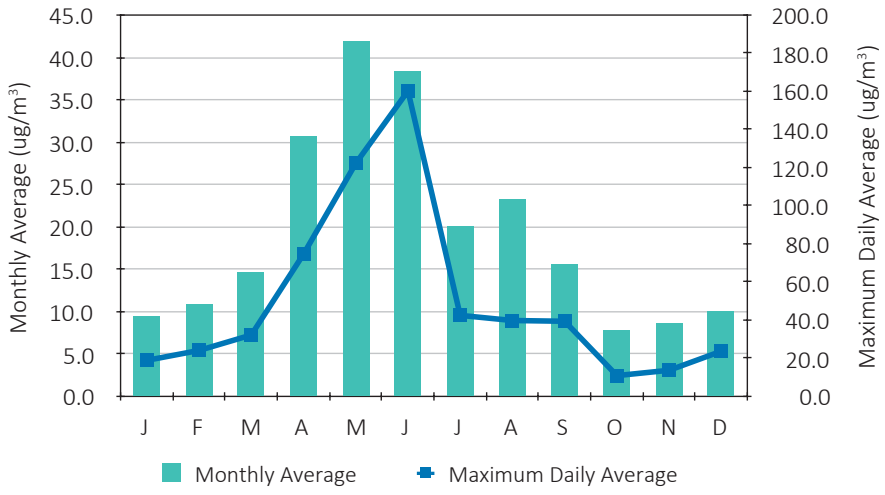


Figure 12:
2015 Inuvik BAM PM_{10}

Figure 12 shows the monthly averages and the maximum daily average concentrations of PM_{10} in Inuvik.

Sulphur Dioxide (SO_2)

The annual average of SO_2 in Inuvik was less than 1ppb, and the maximum 1-hour average was 1.6ppb. The SO_2 concentrations measured in 2015 were very low and similar to previous years' results, which did not exceed the NWT hourly, 24-hour or annual average AAQS of 172ppb, 57ppb and 11ppb, respectively.

Ground Level Ozone (O_3)

The maximum 1-hour average in 2015 was 51.3ppb, while the maximum 8-hour average was 44.8ppb. Neither the 1-hour national maximum acceptable level (82ppb) nor the 8-hour AAQS (63ppb) for ground level ozone was exceeded in 2015. The annual average was 24.9ppb, which is typical of background levels.

Figure 13:
2015 Inuvik Ozone

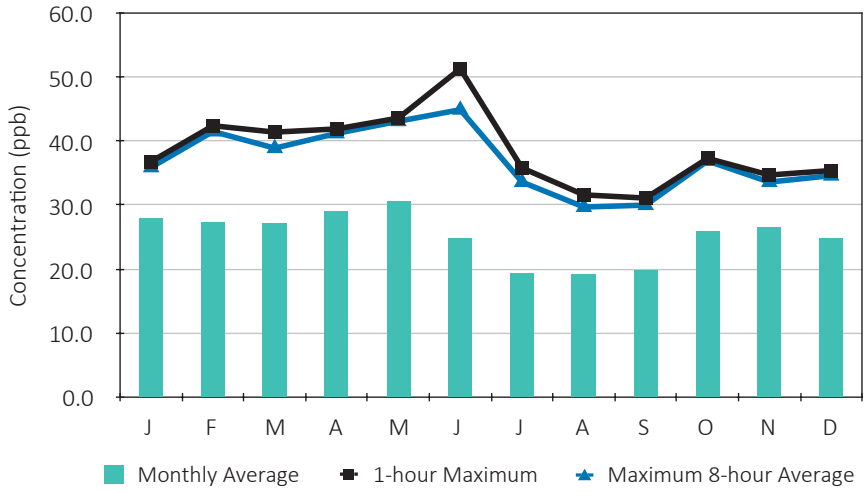


Figure 13 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in 2015 in Inuvik.

Nitrogen Dioxide (NO_2)

The NO_2 results for Inuvik in 2015 show that the maximum 1-hour average was 36.6ppb, the maximum 24-hour average was 14.5ppb and the overall annual average was 3.0ppb; all of which were within the AAQS (213ppb, 106ppb and 32ppb, respectively).

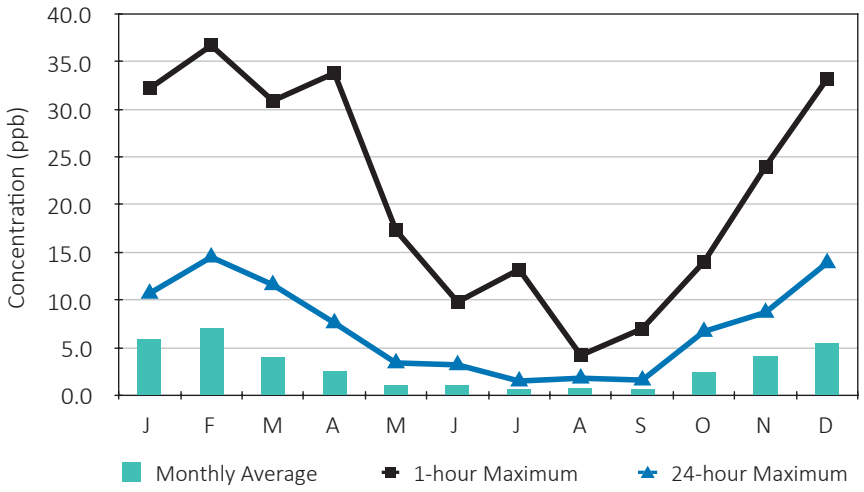


Figure 14:
2015 Inuvik
Nitrogen Dioxide

Figure 14 shows the maximum hourly, maximum daily and monthly averages of NO_2 for Inuvik in 2015. Average concentrations are observed to be higher in the colder months and when there is activity (i.e. vehicle or construction) near the station. This is similar to previous years and is likely a result of idling vehicles and other combustion sources during inversions (stagnant air masses).

Carbon Monoxide (CO)

The levels of CO were extremely low and were well below the NWT 1-hour and 8-hour AAQS (13ppm and 5ppm, respectively). In 2015, the maximum 1-hour average was 1.439ppm, the maximum 8-hour average was 0.903ppm and the annual average was 0.237ppm. Low levels of CO are typically expected due to the limited combustion sources in Inuvik. The June hourly peak was due to the influence of forest fire smoke, while the December hourly peak was associated with combustion from industrial activity near the station.

Figure 15:
2015 Inuvik
Carbon Monoxide

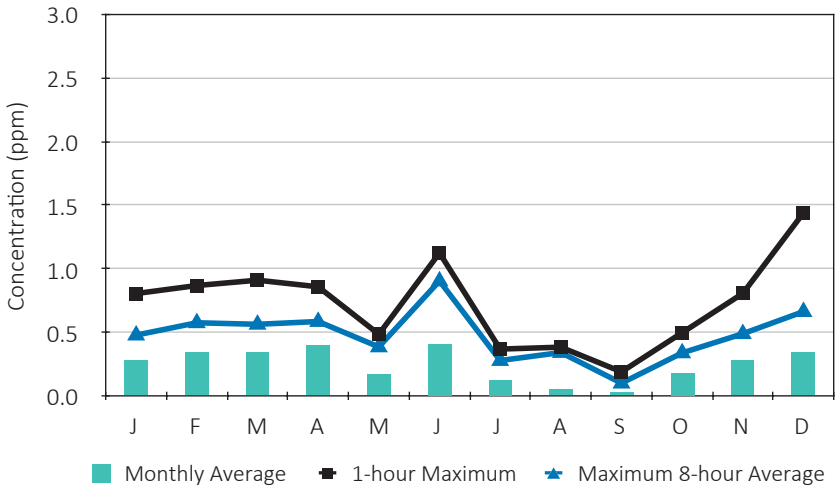


Figure 15 shows the 2015 monthly averages, and highest hourly and 8-hour concentrations for CO in Inuvik.

NORMAN WELLS AIR QUALITY

The focus of the monitoring station in Norman Wells is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time.

The station is located at the ENR compound on Forestry Drive and measures $PM_{2.5}$, PM_{10}, SO_2, O_3 and NO_2. It has been in operation since 2003.

Fine Particulate Matter ($PM_{2.5}$)

The BAM operating in Norman Wells for the $PM_{2.5}$ fraction is a Federal Equivalency Method (FEM) model.

There was only one exceedance of the NWT 24-hour AAQS for $PM_{2.5}$ (28µg/m^3). This occurred in August and was attributed to the forest fires burning near the Mackenzie Mountains. The annual average was 3.4µg/m^3, which is below the AAQS of 10ug/m^3.

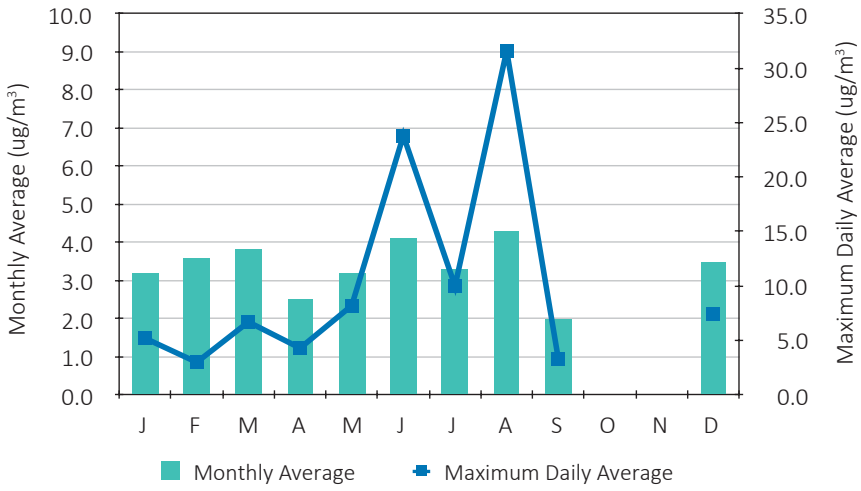


Figure 16 shows the monthly averages and maximum daily averages of $PM_{2.5}$ measured from the BAM at the Norman Wells station in 2015. The elevated readings in the summer are typical and are associated with the forest fire season. The maximum daily average concentration of $PM_{2.5}$ was 31.6µg/m^3, occurring in August. Data was not available for the months of October and November due to an instrument malfunction.

Figure 16:
2015 Norman Wells BAM $PM_{2.5}$

Coarse Particulate Matter (PM_{10})

The PM_{10} 1-hour maximum concentration measured in Norman Wells was 301µg/m^3 and the 24-hour maximum concentration was 57.3µg/m^3. Both events occurred in May and are consistent with the annual spring-time "dust event". The annual average concentration of PM_{10} was 9.1µg/m^3. There were two exceedances of the adopted 24-hour average standard of 50µg/m^3. Both of these exceedances occurred in May. Data was not available for the months of June, July and August due to a major system malfunction; however, the spring dust event was captured in the May readings.

Figure 17:
2015 Norman Wells BAM PM_{10}

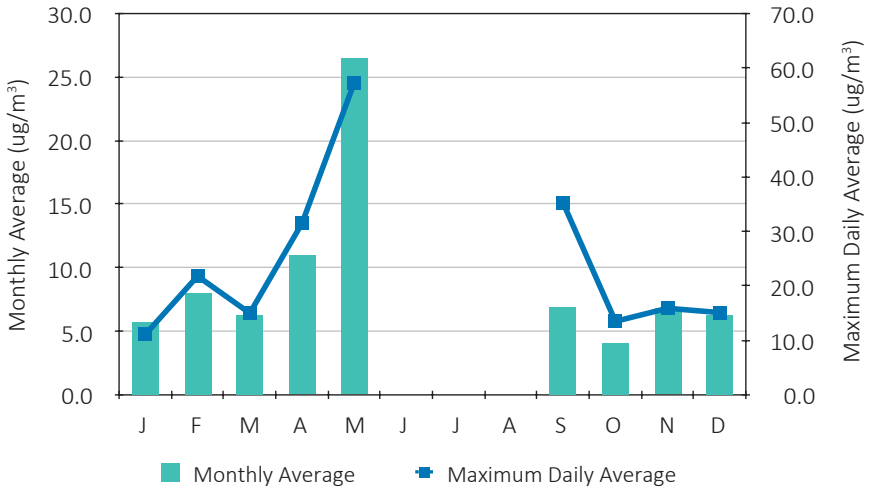


Figure 17 shows the monthly averages and the maximum daily average concentrations of PM_{10} measured in Norman Wells in 2015.

Sulphur Dioxide (SO_2)

Overall, SO_2 concentrations in Norman Wells were generally very low. The 1-hour maximum SO_2 reading was 1.6ppb, the maximum 24-hour average was 1.2ppb and the annual average was less than 1ppb. No exceedances of the AAQS occurred (1-hour average of 172ppb, 24-hour average of 57ppb and annual average of 11ppb). This is consistent with previous years.

Ground Level Ozone (O_3)

In 2015, the maximum 1-hour average for ozone was 53.5ppb, while the maximum 8-hour average was 47.9ppb. Neither the 1-hour national maximum acceptable level (82ppb) nor the 8-hour AAQS (63ppb) for ground level ozone was exceeded in 2015. The annual average was 23.5ppb, which is within the range of what is considered background levels. The highest monthly average occurred in the spring (May). This is typical of ozone at higher latitude locations and is consistent with historical data.

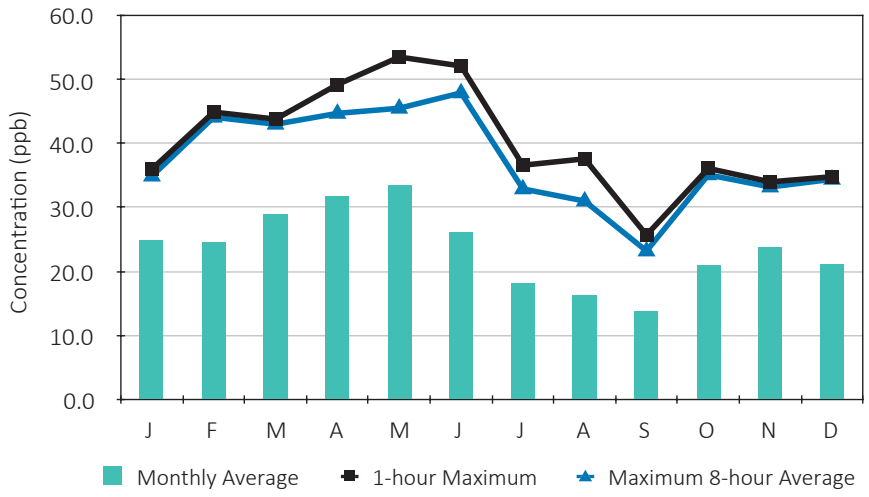


Figure 18:
Norman Wells Ozone

Figure 18 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in Norman Wells in 2015.

Nitrogen Dioxide (NO_2)

The 2015 NO_2 results for Norman Wells show the maximum 1-hour average was 30.4ppb, the maximum 24-hour average was 12.7ppb and the overall annual average was 1.8ppb, which were well below the NWT AAQS (213ppb, 106ppb and 32ppb, respectively).

Figure 19:
2015 Norman Wells Nitrogen Dioxide

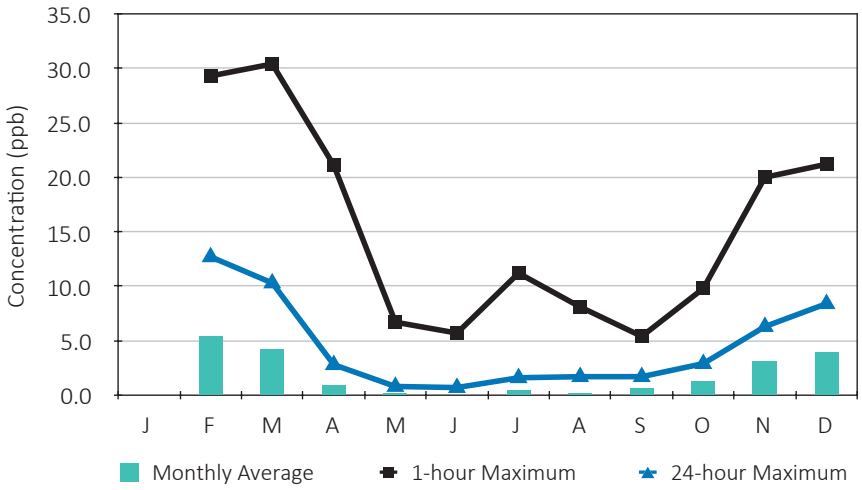


Figure 19 shows the 2015 monthly averages, maximum 24-hour averages and maximum 1-hour concentrations of NO_2 in Norman Wells. As with previous years, NO_2 levels increased in the winter months as a function of vehicle idling and other combustion sources during inversions (stagnant air masses).

FORT SMITH AIR QUALITY

The focus of the monitoring station in Fort Smith is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time.

The station is located on the southwest end of the Paul William Kaeser High School property and measures $PM_{2.5}$, PM_{10}, SO_2, O_3, NO_2 and CO.

Fine Particulate Matter ($PM_{2.5}$)

There were 12 exceedances of the NWT 24-hour AAQS for $PM_{2.5}$ (28µg/m^3) in Fort Smith in 2015, with a maximum daily average of 119µg/m^3. The annual average was 7.2µg/m^3, which was just below the AAQS of 10ug/m^3. Forest fires burning in Wood Buffalo National Park were responsible for the elevated summer readings during the months of July and August.

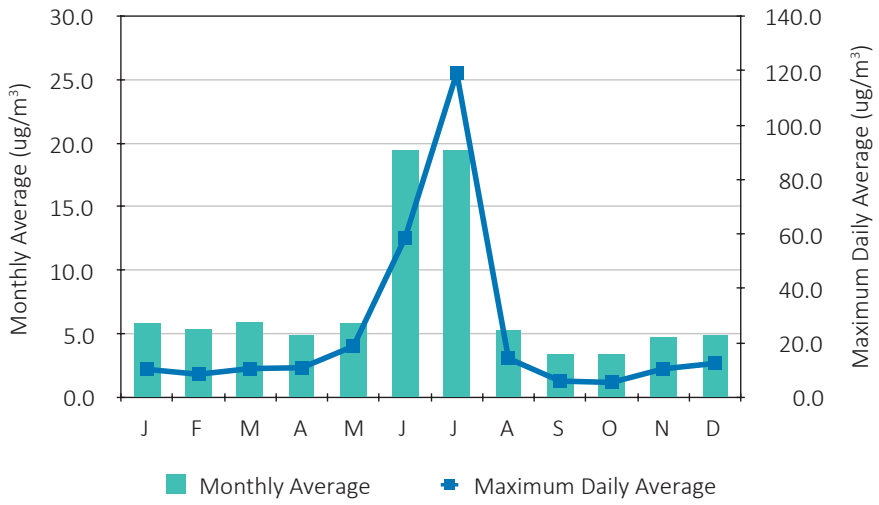


Figure 20 shows the monthly averages and maximum daily averages of $PM_{2.5}$ measured from the BAM at the Fort Smith station in 2015. The elevated readings in the summer are associated with the forest fire season and are typical of the trends observed in other monitored communities.

Figure 20:
2015 Fort Smith BAM $PM_{2.5}$

Coarse Particulate Matter (PM_{10})

The 1-hour maximum concentration for PM_{10} in Fort Smith in 2015 was 343µg/m^3, which occurred in July and coincided with a forest fires burning in Wood Buffalo National Park. The 24-hour maximum concentration was 130µg/m^3, also occurring in July. The annual average concentration was 9.7µg/m^3. There were eight exceedances of the adopted 24-hour average standard of 50µg/m^3. These exceedances occurred in the months of June and July and were attributed to forest fire smoke. Data was not available for the month of January due to an instrument issue.

Figure 21:
2015 Fort Smith BAM PM_{10}

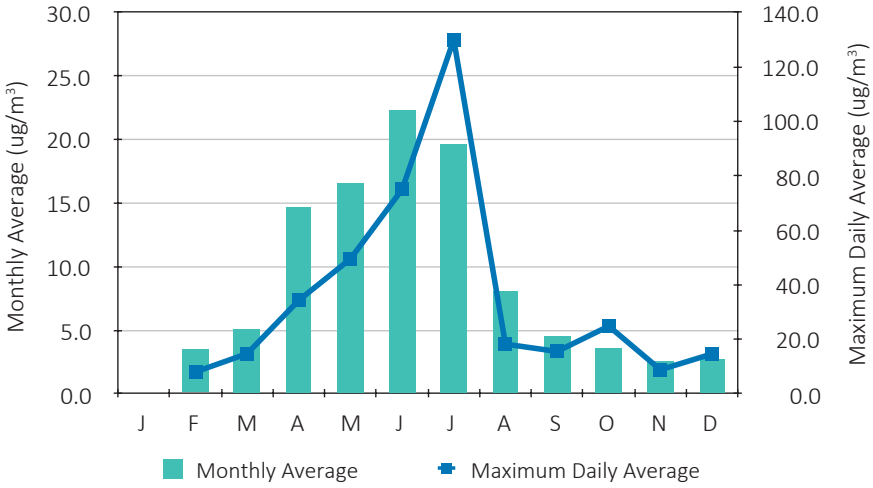


Figure 21 shows the maximum daily average per month as well as the monthly averages for PM_{10} recorded in Fort Smith in 2015.

Sulphur Dioxide (SO_2)

SO_2 levels in Fort Smith were similar to those recorded at other NWT monitoring stations, which are generally very low. The 1-hour maximum SO_2 reading was 2.9ppb, the maximum 24-hour average was 1.8ppb and the annual average was less than 1ppb. No exceedances of the AAQS occurred.

Ground Level Ozone (O_3)

The maximum 1-hour average in 2015 was 58.3ppb, while the maximum 8-hour average was 56.3ppb. These maximums occurred in the months of May and June respectively and are typical of the spring-time elevated ozone levels. Neither the 1-hour national maximum acceptable level (82ppb) nor the 8-hour AAQS (63ppb) for ground level ozone was exceeded in 2015. The annual average was 26.2ppb, which is typical of background levels.

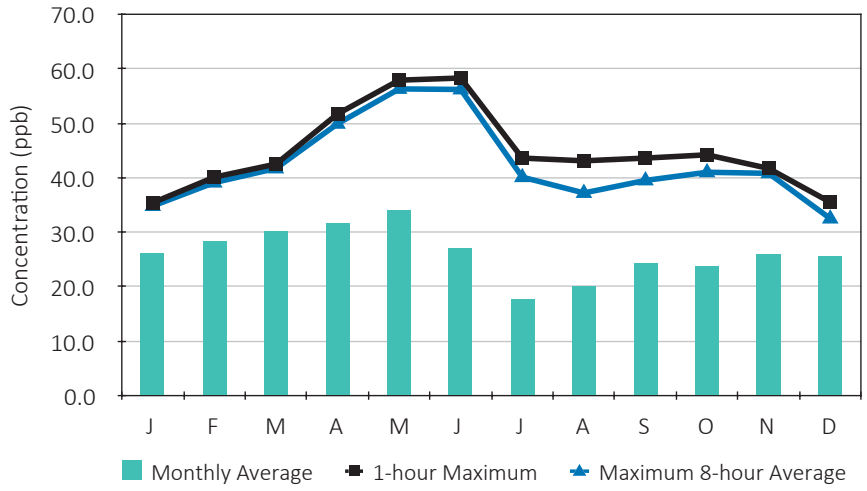


Figure 22:
2015 Fort Smith Ozone

Figure 22 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in Fort Smith in 2015.

Nitrogen Dioxide (NO_2)

The 2015 NO_2 results for Fort Smith show the maximum 1-hour average was 33.3ppb, the maximum 24-hour average was 10.1ppb and the overall annual average was 1.9ppb, which were all below the AAQS (213ppb, 106ppb and 32ppb, respectively).

Figure 23:
2015 Fort Smith Nitrogen Dioxide

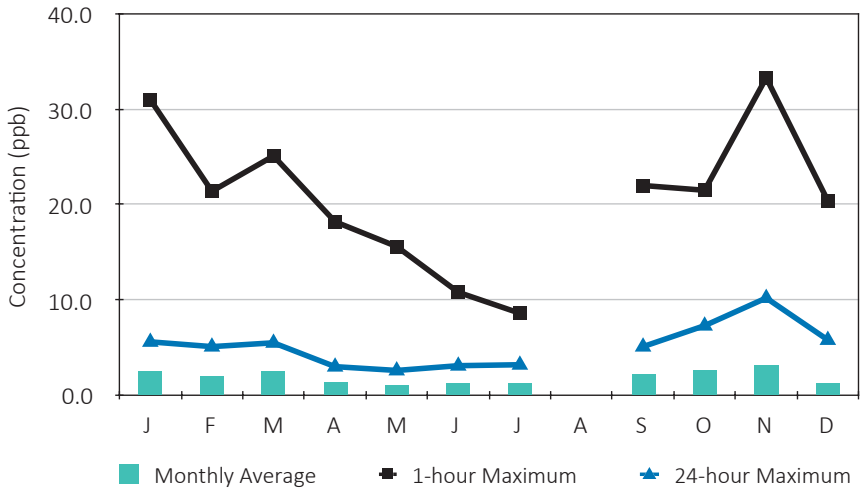


Figure 23 shows the 2015 monthly averages, maximum 24-hour averages and maximum 1-hour concentrations of NO_2 in Fort Smith. As is the trend with the other three stations, NO_2 levels increased in the winter months as a function of vehicle idling and other combustion sources during inversions (stagnant air masses). The March and July spikes are most likely associated with localized activity near the station. Data was not available for the month of August due to an instrument malfunction.

Carbon Monoxide (CO)

The CO analyzer wasn't installed in Fort Smith until September of 2014, so 2015 is the first full year in which CO data was collected. The levels of CO were low, overall, with a peak concentration occurring in July, which correlated with the highest $PM_{2.5}$ hourly concentration of 2015. As with $PM_{2.5}$, forest fire smoke was responsible for the highest 2015 CO concentrations. The maximum 1-hour average was 2.645ppm and an 8-hour maximum of 1.452ppm, both of which are below the NWT 1-hour and 8-hour AAQS (13ppm and 5ppm, respectively). Aside from the summer forest fire influences, CO levels in Fort Smith were observed to be similar to those at the other NWT stations.

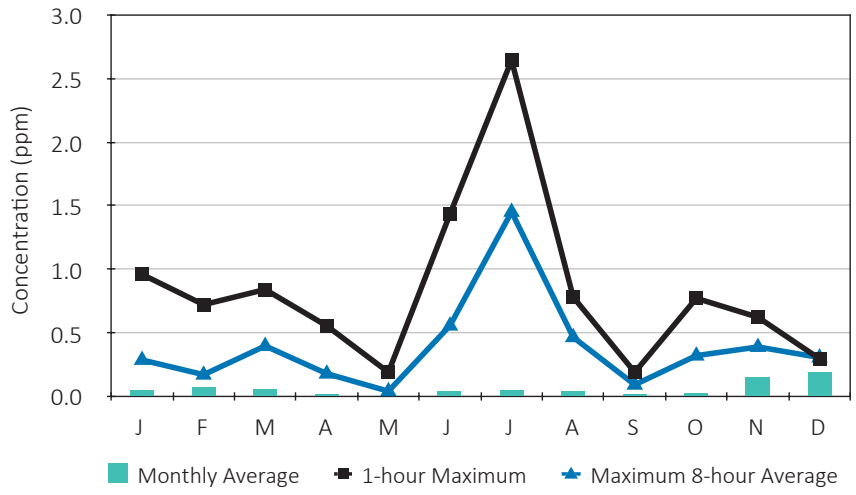


Figure 24:
2015 Fort Smith Carbon Monoxide

Figure 24 shows the 2015 monthly averages and highest hourly concentrations for CO in Fort Smith.

LONG-TERM TRENDS

The GNWT Ambient Air Quality Monitoring Network has been in operation for over a decade, and there is sufficient data to conduct longer term trend analyses. Comparisons of the annual averages of select parameters are presented below. In cases where no GNWT AAQS exists, standards from other jurisdictions have been adopted for reference.

Figure 25:
2005 to 2015 – $PM_{2.5}$ Trends

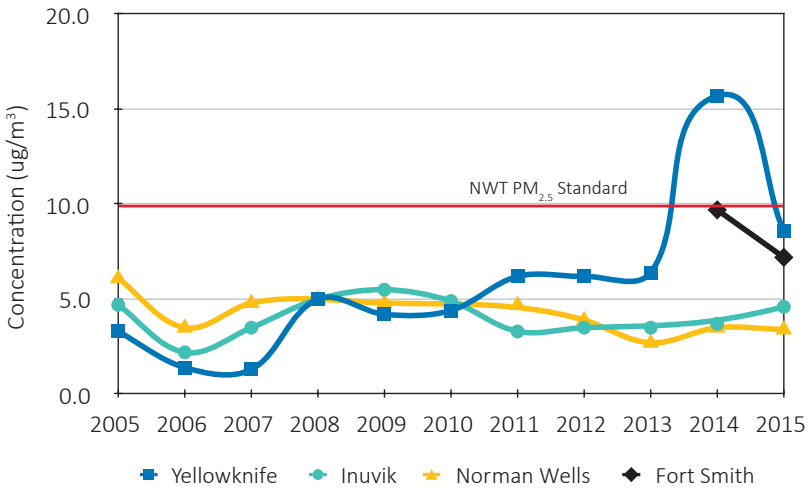


Figure 25 compares the annual $PM_{2.5}$ average concentrations from each of the NWT monitoring stations from 2005 to 2015, except Fort Smith, which has only two years of data. The instruments in use over the time period presented were calibrated for consistency (BAM1020), with upgrades conducted as required. The Yellowknife and Inuvik stations were upgraded to a Federal Equivalency Method (FEM) version between 2010 and 2011, while the Norman Wells and Fort Smith stations were upgraded to the FEM in 2013.

The results demonstrate that the $PM_{2.5}$ levels in the NWT fluctuate annually, which could be due to the major influence of seasonal forest fires whose effects vary annually. The Yellowknife station has the only data demonstrating an upward trend in $PM_{2.5}$ levels over the observed period. This may be attributed to a variety of factors, including the variation year to year in driving forces such as forest fire events. 2014 represents that scenario well.

In order to assess the data without the natural and variable/fluctuating influences from fires, the following figure presents the $PM_{2.5}$ averages for the years 2005 to 2015, excluding the May to August timeframes.

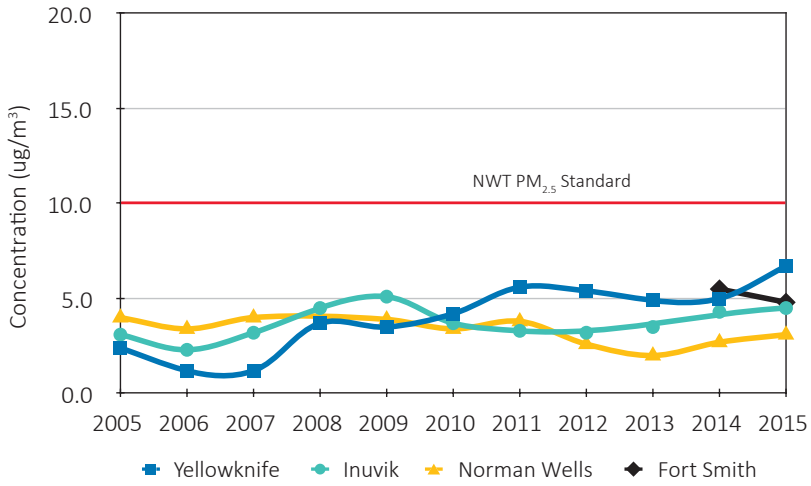


Figure 26:
2005 to 2015 – $PM_{2.5}$ Trends, excluding May to August

Figure 26 demonstrates that when the seasonal influences from forest fire smoke are eliminated, the $PM_{2.5}$ levels in each of the NWT communities are generally consistent from year to year, with the exception of Yellowknife, which shows a gradual increase of $PM_{2.5}$ levels. Data collection over a longer time period will be required to properly assess this trend.

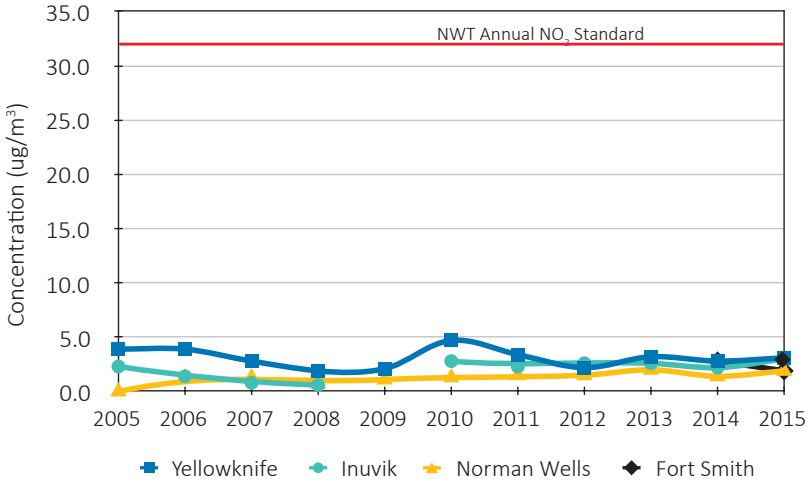


Figure 27:
2005 to 2015 – Annual NO_2 Averages

Figure 27 compares the annual NO_2 average concentrations from each of the NWT monitoring stations from 2005 to 2015. The Fort Smith data was included as two points because this station has only been collecting data since 2014. Results indicate Yellowknife generally has slightly higher NO_2 levels than the other communities. This is to be expected given the larger population size and resulting combustion

sources. All results are below the NWT AAQS of 32ppb. The trend over this time period for each monitoring station is relatively stable. This is to be expected given the absence of any major changes to emission sources or population growth in these communities.

Figure 28:
2005 to 2015 –
4th Highest 8-hour O_3

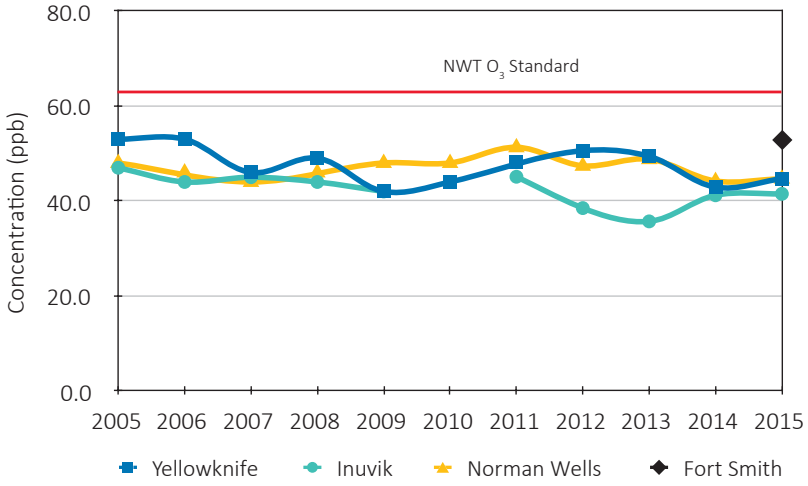


Figure 28 shows the O_3 comparison according to the Canadian Ambient Air Quality Standards (CAAQS) method of calculation; the year's 4th highest 8-hour average is compared to the NWT AAQS and CAAQS of 63ppb. The results indicate O_3 levels are fairly consistent from year to year and between the communities, and are consistently below the AAQS. This was the first year where a full set of O_3 data was collected at the Fort Smith station. It is represented as a single point.

NATIONAL COMPARISONS

This report compares air quality data within the NWT and against air quality data in other parts of the country. There are many influences to local air quality, including geographic considerations, population size and density, local industrial sources, transboundary considerations, and others. For comparison purposes, Yellowknife air quality was compared against select jurisdictional capitals and compared to cities of similar population, regardless of the types and sources of their air emissions.

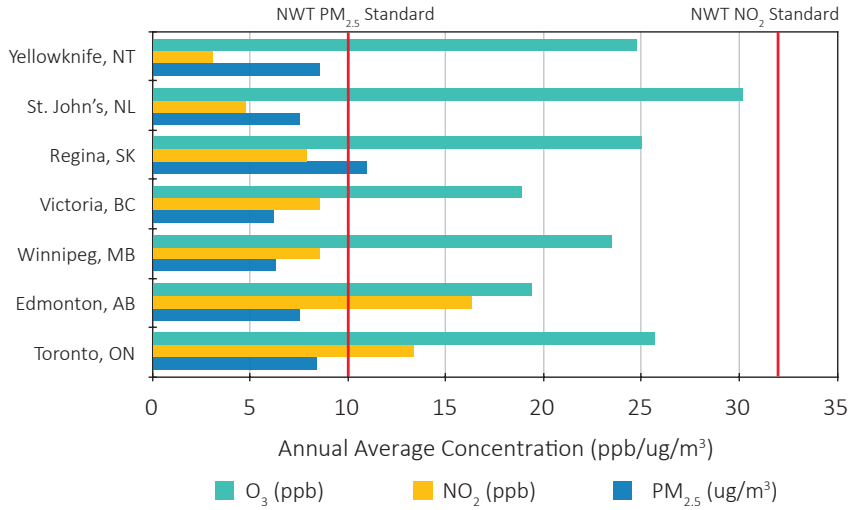


Figure 29:
2015 National Comparisons – Jurisdictional Capitals

Figure 29 compares the 2015 annual average concentrations of O_3, NO_2 and $PM_{2.5}$ between select capital cities across Canada. The values are measured against the NWT AAQS for $PM_{2.5}$ and NO_2; no criteria are available for annual O_3.

The data shows Yellowknife O_3 levels in 2015 were slightly higher than half of the comparison cities. Yellowknife NO_2 levels were significantly lower than all the comparison cities, presumably as a result of a much smaller size city with fewer combustion emission sources. The reverse ranking between Yellowknife's O_3 and NO_2 concentrations is to be expected, in part since localized NO_x levels contribute to ozone reduction through a chemical process known as scavenging. Therefore, higher O_3 levels may be expected in areas with lower NO_2 concentrations. NO_2 levels for all comparison cities were below the NWT AAQS.

The $PM_{2.5}$ levels in Yellowknife were the second highest after Regina, but were below the NWT AAQS. Regina was the only city that had $PM_{2.5}$ levels in exceedance of the presented criteria. Both the Yellowknife and Regina levels in 2015 were affected by forest fire smoke.

Figure 30:
2015 National Comparisons – Similar Population Size

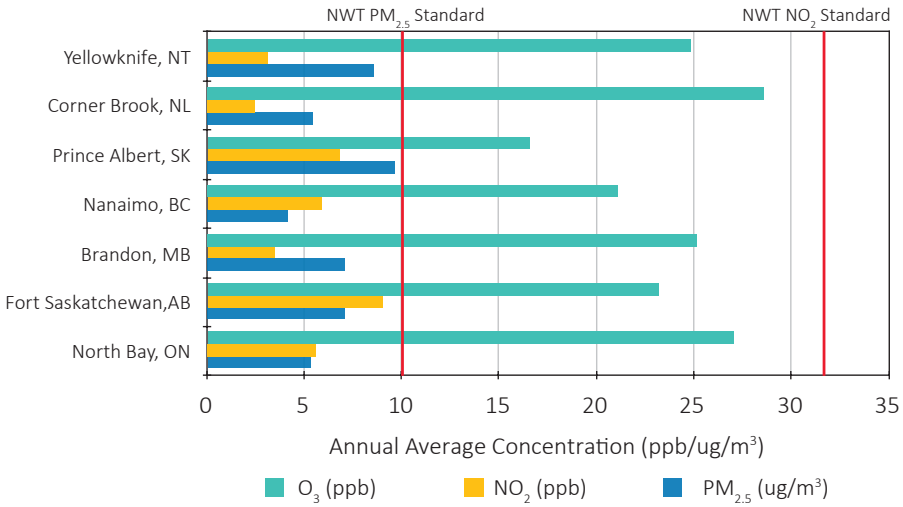


Figure 30 compares Yellowknife's annual average concentrations of O_3, NO_2 and $PM_{2.5}$ to select cities across Canada of a similar population size (<100,000). The results show Yellowknife O_3 levels are middle of the range relative to the comparison cities, while Yellowknife NO_2 levels were lower than all of the comparison cities except for Corner Brook. All the NO_2 levels were below the NWT AAQS. Yellowknife $PM_{2.5}$ levels in 2015 were second highest after Prince Albert. The elevated $PM_{2.5}$ results for both cities are attributed to forest fire smoke.

SNARE RAPIDS

Since 1989, ENR has operated a Canadian Air and Precipitation Monitoring (CAPMoN) station at the Northwest Territories Power Corporation's Snare Rapids hydro-electric generating site. This site is located approximately 150 kilometres northwest of Yellowknife. Rain and snow samples are collected on a daily basis and sent to Environment and Climate Change Canada's (ECCC) CAPMoN laboratory in Toronto for analysis of precipitation chemistry. Select results are presented below.

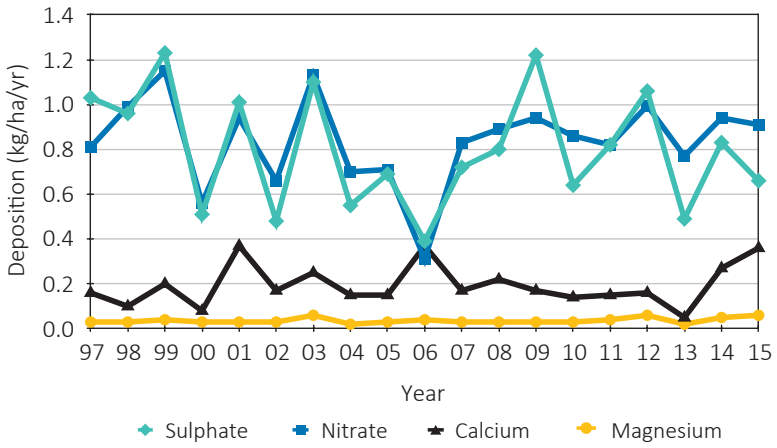


Figure 31:
Snare Rapids: Acid Deposition

Figure 31 shows the deposition rates for sulphate, calcium, nitrate, and magnesium from 1997 to 2015.

The geology of the NWT is mostly characterized by non-carbonate bedrock resistant to weathering and/or shallow, coarse-textured soils with low cation exchange capacity, low sulphate adsorption capacity and low pH. The sulphate level of deposition considered to be protective of sensitive ecosystems in the NWT is 7 kg/ha/yr. In areas of eastern Canada, where acid rain is a more serious environmental problem, sulphate deposition has been measured by CAPMoN in excess of 20 kg/ha/yr. Nitrate deposition at Snare Rapids is also low relative to eastern Canada.

Sulphate and nitrate deposition rates measured at Snare Rapids remain below levels expected to cause a significant environmental effect in sensitive ecosystems.

In 2014, a second CAPMoN station was opened in the NWT, in the Wood Buffalo National Park, approximately 80 kilometres northwest of Fort Smith. The area was of interest to CAPMoN due to the remote nature of the park and its location relative to the oil sands operations in Alberta. The site uses a state-of-the-art, automated daily collection sampler for precipitation chemistry and a continuous ambient analyzer for ozone monitoring. In 2015, the first complete set of precipitation raw data was captured. Environment and Climate Change Canada were still conducting QAQC analysis on that data at the time of publication of this report.

NWT 2015 FOREST FIRE SEASON

The 2015 forest fire season was active, but was moderate compared to the intense 2014 fire season. There were notable episodes of poor air quality from forest fire smoke across the territory.

Fires burning in Wood Buffalo National Park created intermittent smoky conditions in the South Slave region (Fort Smith), mainly during June and July, with a few minor episodes persisting into August. The highest 2015 $PM_{2.5}$ hourly average in Fort Smith was 351µg/m^3, recorded on July 1.

The South Slave fires affected Yellowknife air quality during June and July, while fires burning near Reid Lake affected the August readings. The highest 2015 $PM_{2.5}$ hourly average in Yellowknife was 312 µg/m^3, recorded on August 5.

Norman Wells saw the effects from 19 fires burning near the Mackenzie Mountains. $PM_{2.5}$ concentrations rose near the end of June and, for the most part, dissipated during July. August saw elevated levels in the first three days of the month, where the highest hourly average of 51µg/m^3 occurred on August 2.

Forest fires burning in Alaska and the Yukon affected the Inuvik $PM_{2.5}$ readings, mainly throughout the month of June, with some moderately elevated concentrations occurring in the first couple of days in July and August. The highest concentrations in 2015 for $PM_{2.5}$ in Inuvik was 176 ug/m^3, occurring on June 27.

Reid Lake Fire – summer 2015

Figure 32:
Summer 2015 24-hour Average $PM_{2.5}$ Concentrations for Yellowknife, Fort Smith, Norman Wells and Inuvik

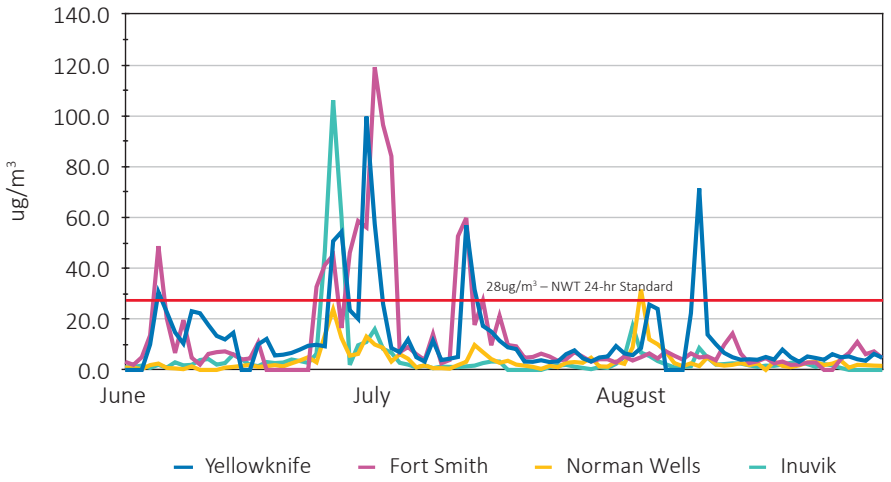
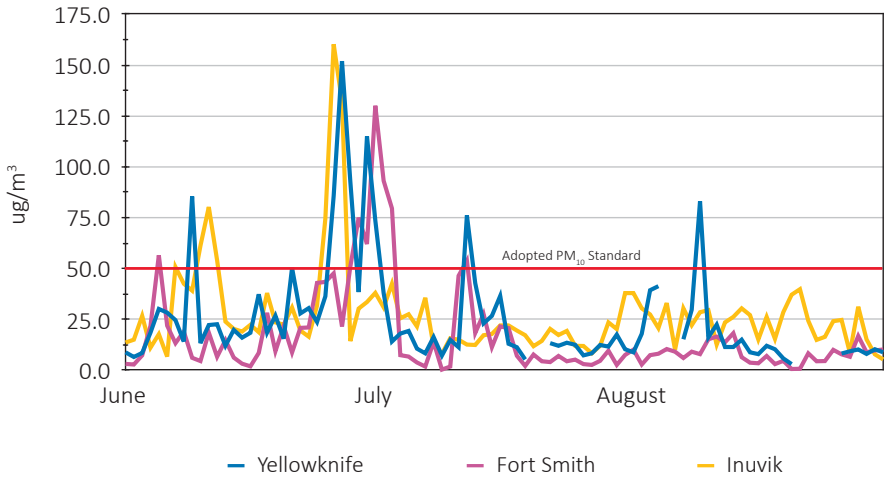


Figure 33:
Summer 2015 24-hour Average PM_{10} Concentrations for Yellowknife, Fort Smith and Inuvik



Figures 32 and 33 illustrate the elevated particulate concentrations throughout the summer months of 2015. Between all four affected communities, there were a total of 24 exceedances of the NWT $PM_{2.5}$ 24-hour AAQS. Between all of the communities except Norman Wells, there were 24 exceedances of the adopted PM_{10} 24-hour standard Due to an instrument malfunction, Norman Wells PM_{10} data was not available for June, July and August.

Another effect from forest fire smoke is an increase in CO levels. This was observed at the Fort Smith, Yellowknife and Inuvik stations during specific daily smoke events. Normal CO concentrations in these regions are typically between 0 and 1.0ppm. During the 2015 summer season, when there was smoke in the air, the CO concentrations did not approach the standard (1-hour standard of 13ppm); however, an increase was evident. The relationship between the increase in CO and the presence of smoke is illustrated in the following figures showing $PM_{2.5}$ and CO monitored in Fort Smith, Yellowknife and Inuvik.

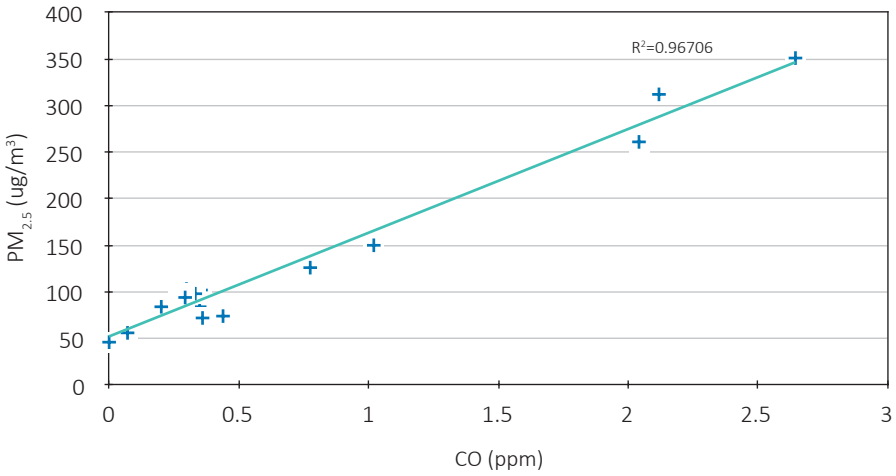


Figure 34:
Hourly $PM_{2.5}$ and CO, Fort Smith – July 1, 2015

Figure 35:
Hourly $PM_{2.5}$ and CO,
Yellowknife – August 5, 2015

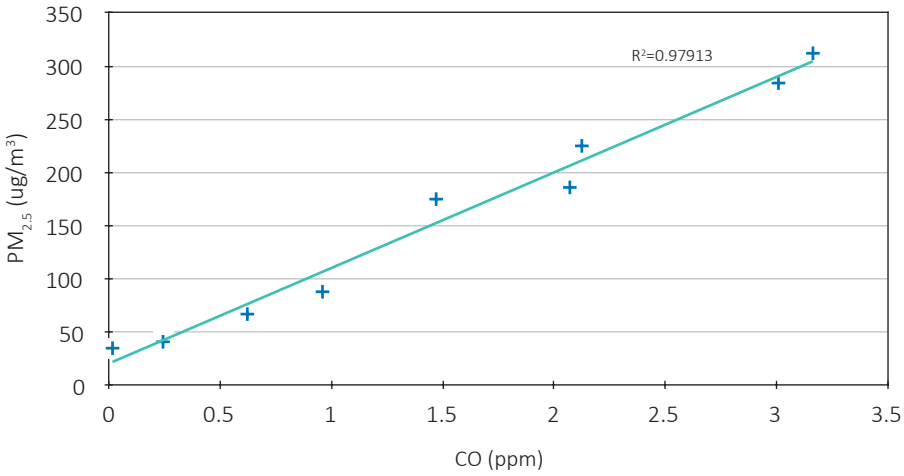
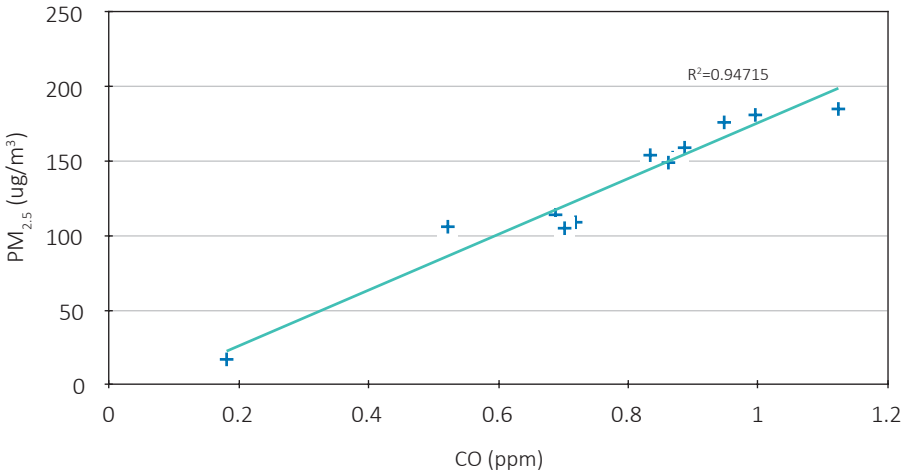


Figure 36:
Hourly $PM_{2.5}$ and CO,
Inuvik – June 27, 2015



Figures 34, 35 and 36 demonstrate that CO concentrations correlated well with $PM_{2.5}$ concentrations in Fort Smith, Yellowknife and Inuvik during forest fire events between the months of June and August.

Health Messaging from Forest Fires

The Air Quality Health Index (AQHI) is a health risk communication tool developed by Environment and Climate Change Canada (ECCC) and Health Canada. The AQHI, available in Yellowknife and Inuvik in 2015, forecasts health risks related to air quality for the current and following day. It translates air quality monitoring data into a health scale from 1 to 10, and provides associated health-based messaging for the public, such as suggestions to adjust your activity level to protect yourself when the air quality is poor.

Figure 35:
Air Quality Health Index

The AQHI was a useful tool for the public during the 2015 forest fire season. The following figure presents the AQHI results for that timeframe.

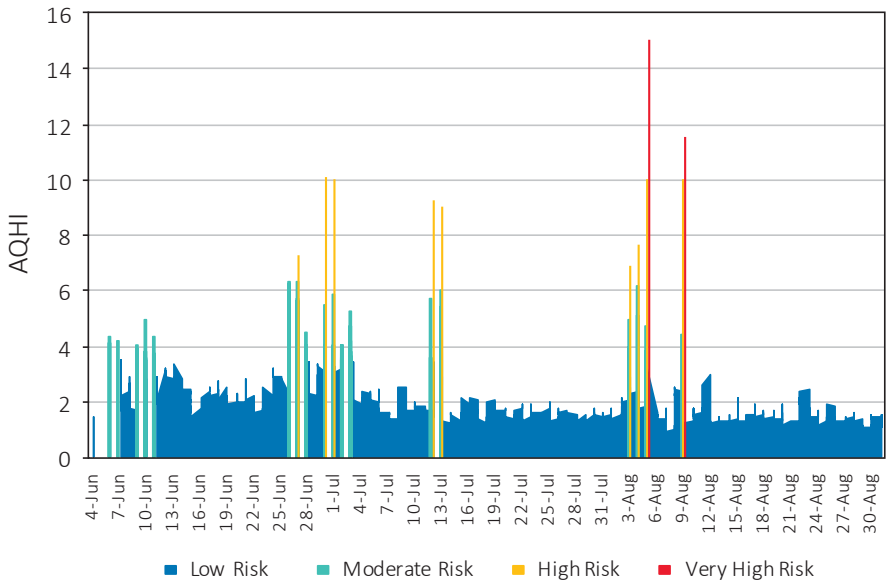
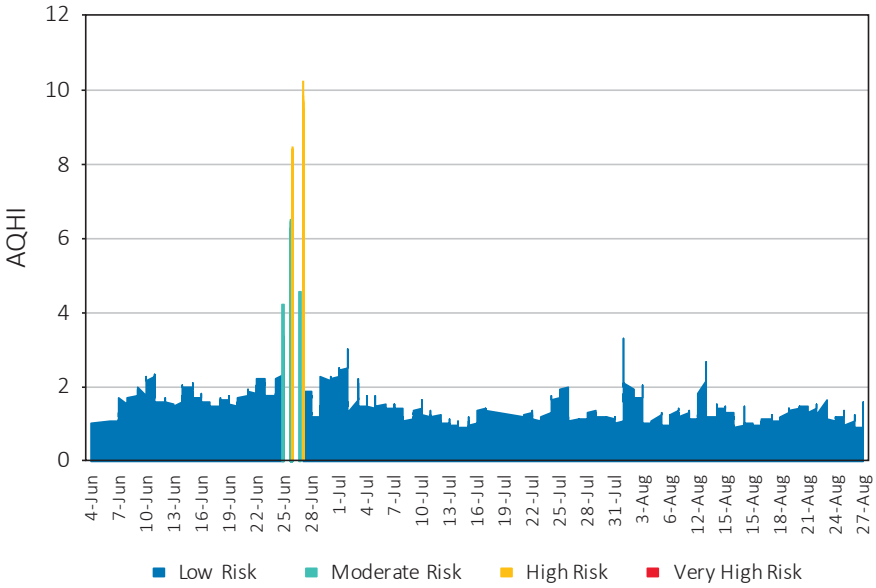


Figure 37:
Summer 2015 Hourly AQHI for Yellowknife

Figure 38:
Summer 2015 Hourly AQHI for Inuvik



Figures 37 and 38 demonstrate the frequency the AQHI reached the various levels of risk throughout the summer of 2015 in Yellowknife and Inuvik. The AQHI was in the high risk range for 45 hours in Yellowknife and for 30 hours in Inuvik. The maximum AQHI of 10 or greater (i.e. 10+, very high risk) occurred for eight hours in Yellowknife during this time period. There were no exceedances of the AQHI in Inuvik. The extreme AQHI values observed during the past two fire seasons have prompted action to develop additional tools in the GNWT and at Environment and Climate Change Canada (ECCC) to assist with health messaging and public awareness.

Since the AQHI is only available in Yellowknife and Inuvik, there is a gap in health-related messaging for the rest of the territory. ECCC is continuing to develop and expand on the Public Weather Alerts system, which will help to address that gap. The Public Weather Alerts system is a tool that provides weather-related, as well as air quality-related information, for regions across Canada, including all the regions of the NWT. It uses meteorological information and smoke modeling software to predict and disseminate real-time and predicted conditions for a geographic area. For more information on the Public Weather Alerts system for the NWT visit https://weather.gc.ca/warnings/index_e.html?prov=nt.

This tool will be valuable to complement the Air Quality Monitoring Network, and assist the GNWT and NWT residents to make health-related decisions based on air quality during forest fire seasons.

Future Monitoring Activities for Forest Fire Events

After the intense wildfire season the NWT experienced in 2014, ENR acquired four portable particulate matter (PM) instruments (ENR procured two Met One E-BAMs and retained two DustTraks on loan from Health Canada) to monitor for wildfire smoke in communities that do not have a GNWT air quality monitoring station. ENR proposed this would occur on an as and when needed basis to help inform emergency and public health decision making.

During the summer of 2015, ENR initiated an instrument verification trial to test the new portable PM monitors. The goal of this trial was to determine the performance, accuracy and usability of these monitors in outdoor ambient and indoor settings. To accomplish this, ENR co-located the portable monitors with the Federal Equivalent Method PM monitor (BAM 1020) installed at the Yellowknife NAPS station for approximately one month (July to August 2015). During this time, ENR also co-located a DustTrak and an E-BAM in an office building in downtown Yellowknife. A few brief wildfire smoke episodes occurred in Yellowknife over the trial period. This helped test the monitors at various PM concentrations.

The results of the instrument trial indicated that the E-BAMs correlated well with the NAPS BAM 1020, especially at higher readings in ambient outdoor environments. However, they tended to perform poorly indoors, giving highly variable readings at lower PM concentrations. In contrast, the DustTrak performed well indoors, providing credible and stable readings even at lower PM concentrations. However, the unit tended to over read significantly during elevated PM episodes in the outdoor environment. ENR determined for the purposes of deployable wildfire smoke monitoring, the E-BAMs will be used for outdoor ambient air quality monitoring, while the DustTraks will be employed for indoor air quality monitoring. This arrangement is anticipated to yield the most representative and accurate results for ENR's needs in future deployments.

Yellowknife during extreme smoke event – August 16, 2015.

Photo credit: John McKay.

APPENDIX A: 2015 DATA CAPTURE

$PM_{2.5}$ Data								Percentile (24-hr)			>28 ug/m^3	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	Max 24-hr	25	50	75	# days	% days
Yellowknife	318	87.1	7801	89.1	8.6	312.0	99.7	4.7	6.3	8.5	8	2.2
Inuvik	348	95.3	8404	95.9	4.6	185.0	106.1	2.1	3.3	5.3	3	0.8
Norman Wells	242	66.3	6013	68.4	3.4	51.0	31.6	1.9	2.7	3.6	1	0.3
Fort Smith	350	95.9	8376	95.6	7.2	351.0	119.0	3.4	4.7	6.5	12	3.3

PM_{10} Data								Percentile (24-hr)			>50 ug/m^3	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	Max 24-hr	25	50	75	# days	% days
Yellowknife	335	91.8	8122	92.7	16.2	625.0	151.9	5.9	9.0	17.9	18	4.9
Inuvik	359	98.4	8583	98.0	19.4	697.0	160.2	8.5	13.0	23.5	23	6.3
Norman Wells	272	74.5	6545	74.7	9.1	301.0	57.3	3.8	6.0	9.9	2	0.5
Fort Smith	320	87.7	7674	87.6	9.7	343.0	130.0	2	5.1	10.2	8	2.2

O_3								Percentile (8-hr)			>63 ppb	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	Max 8-hr	25	50	75	# 8-hrs	% 8-hrs
Yellowknife	335	91.8	8016	91.5	24.8	56.5	49.9	19.3	24.7	30.2	0	0.0
Inuvik	332	91.0	7709	88.0	24.9	51.3	44.9	19.6	25.1	30.0	0	0.0
Norman Wells	362	99.2	8327	95.1	23.6	53.5	47.9	17.4	23.6	29.5	0	0.0
Fort Smith	365	100.0	8348	95.3	26.2	58.3	56.3	21.6	26.8	31.0	0	0.0

NO_2							Percentile (1-hr)			>213 ppb	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	25	50	75	# 1-hrs	% 1-hrs
Yellowknife	337	92.3	8067	92.1	3.1	34.3	0.8	1.7	3.7	0	0.0
Inuvik	364	99.7	8346	95.3	3.0	36.7	0.7	1.5	3.5	0	0.0
Norman Wells	334	91.5	7673	87.6	1.9	30.4	0.0	0.4	2.2	0	0.0
Fort Smith	344	94.2	7994	91.3	1.9	33.3	0.5	1.1	2.1	0	0.0

NO_2		Percentile (24-hr)			>106 ppb	
Location	Max 24-hr	25	50	75	# days	% days
Yellowknife	16.9	1.3	2.3	4.2	0	0.0
Inuvik	14.5	0.8	1.9	4.2	0	0.0
Norman Wells	12.7	0.2	0.9	2.6	0	0.0
Fort Smith	10.2	0.9	1.5	2.6	0	0.0

SO_2							Percentile (1-hr)			>172 ppb	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	25	50	75	# 1-hrs	% 1-hrs
Yellowknife	336	92.1	8030	91.7	0.3	3.9	0.05	0.21	0.56	0	0.0
Inuvik	294	80.5	6812	77.8	0.2	1.6	0.0	0.0	0.3	0	0.0
Norman Wells	350	95.9	8153	93.1	0.4	1.6	0.0	0.3	0.6	0	0.0
Fort Smith	365	100.0	8369	95.5	0.2	2.9	0.0	0.0	0.3	0	0.0

SO_2		Percentile (24-hr)			>57 PPB	
Location	Max 24-hr	25	50	75	# days	% days
Yellowknife	1.2	0.07	0.22	0.53	0	0.0
Inuvik	0.9	0.0	0.0	0.3	0	0.0
Norman Wells	1.3	0.2	0.4	0.7	0	0.0
Fort Smith	1.8	0.0	0.0	0.3	0	0.0

CO								Percentile (1-hr)			>13 PPM	
Location	Valid Days	% Valid Days	Valid Hrs	% Valid Hrs	Mean	Max 1-hr	Max 24-hr	25	50	75	# 1-hrs	% 1-hrs
Yellowknife	300	82.2	7264	82.9	0.342	3.164	0.811	0.176	0.224	0.649	0	0.0
Inuvik	347	95.1	8295	94.7	0.237	1.440	0.766	0.115	0.248	0.336	0	0.0
Fort Smith	365	100.0	8709	99.4	0.060	2.645	0.662	0.000	0.011	0.060	0	0.0

CO		Percentile (8-hr)			>5 PPB	
Location	Max 8-hr	25	50	75	# 8-hrs	% 8-hrs
Yellowknife	1.769	0.180	0.230	0.652	0	0.0
Inuvik	0.904	0.114	0.256	0.341	0	0.0
Fort Smith	1.452	0.000	0.018	0.067	0	0.0

APPENDIX B: MONITORING HISTORY

History of Air Quality Monitoring in the Northwest Territories

1974	• Government of the NWT starts monitoring air quality in Yellowknife with the installation of a high-volume air sampler at the Post Office site.
1989	• Monitoring of acid precipitation at the Snare Rapids hydro-electric site begins.
1992	• SO_2 analyzer installed at the City Hall site.
1997	• SO_2 monitoring in N'dilo begins and continues until 2000.
1998	• O_3 analyzer added in Yellowknife to the City Hall site.
2000	• A SO_2 analyzer was installed in the ENR building in Fort Liard in March, followed by a H2S analyzer in October.
2002	• Daring Lake summer sampling of PM_{10} begins. • City Hall SO_2 analyzer relocated to new air monitoring trailer located at École Sir John Franklin High School.
2003	• Daring Lake summer sampling of $PM_{2.5}$ begins (the same sampler is used for PM_{10} and $PM_{2.5}$ monitoring). • Air monitoring trailers are installed in Inuvik, Norman Wells and Fort Liard. • CO and NO_x analyzers added to the Yellowknife station as well as a continuous fine particulate sampler ($PM_{2.5}$). • Norman Wells station monitors SO_2 and H_2S. • Inuvik station monitors SO_2, H_2S, NO_x and $PM_{2.5}$. • Fort Liard station monitors SO_2 and H_2S. A $PM_{2.5}$ sampler is installed late in the year. • The O_3 analyzer that was operating at the Yellowknife City Hall location is relocated to the new Sir John Franklin station. • ENR initiates the upgrade of the Data Acquisition System, moving to a specialized air monitoring system, which will allow more efficient and quality controlled data collection. • Continuous $PM_{2.5}$ samplers are installed in Inuvik and Fort Liard. • A second high-volume sampler is installed at the Sir John Franklin station in Yellowknife.
2004	• $PM_{2.5}$ sampler is installed in Norman Wells. • Data Acquisition System (DAS) is significantly upgraded. New components are installed inside the stations and a new data management, analysis and reporting system is brought on-line.
2005	• NO_x analyzer is installed in March at the Fort Liard station. • O_3 and NO_x analyzers are installed at the Norman Wells station in April. • O_3 analyzer purchased by Environment Canada (Yellowknife office) is installed at the Inuvik station in April. • Due to years of significant data loss caused by extreme cold, the Partisol Dichotomous fine particulate sampler at the Yellowknife Post Office station is relocated indoors at the Sir John Franklin station. • The Yellowknife Post Office station is officially closed after the last TSP sample ran on December 6, 2005. • Development of an Air Quality web site begins. The web site will link with the data management, analysis and reporting system to provide public access to air quality data for each monitoring location. Access to archived data will also be available by querying the database using web-based tools.

2006	• Yellowknife – A BAM Particulate Matter (PM_{10}) monitor is installed and begins collecting data in April. • Inuvik – A BAM Particulate Matter (PM_{10}) monitor is installed and begins collecting data in October. • The Air Quality Monitoring Network web site is officially released.
2007	• Fort Liard – A BAM Particulate Matter (PM_{10}) monitor and an Ozone (O_3) analyzer are installed and begin collecting data in late August. • Completed the second phase of the Air Quality Monitoring Network web site, which included database related modifications as well as web design improvements.
2008	• No significant changes to the network.
2009	• Norman Wells – PM_{10} BAM installed to complete particulate sampling throughout the network. • Yellowknife – Hi-vol sampler discontinued. • Daring Lake particulate monitoring temporarily discontinued due to malfunction.
2010	• Norman Wells – PM_{10} BAM installation completed. • Inuvik – Entire station is relocated to a more representative location due to ongoing construction activities in the original location. • Yellowknife – $PM_{2.5}$ monitor upgraded to BAM FEM (Federal Equivalency Method).
2011	• Inuvik – $PM_{2.5}$ monitor upgraded to BAM FEM (Federal Equivalency Method). • Data acquisition and management system upgraded in Yellowknife, Norman Wells and Inuvik, including Envista ARM software and PC-based industrial data loggers. • Manual Partisol Dichotomous sampler installed in Yellowknife. • BAMs at all stations begin reporting in actual conditions instead of STP, as per federal protocol.
2012	• Entered into partnership with Aurora Research Institute (ARI) to provide technical operations of the Inuvik station. • Installed CO monitoring in Inuvik (end of 2012). • Discontinued H_2S monitoring in Inuvik (end of 2012). • Switched to trace level SO_2 monitoring in Yellowknife. • New Air Quality Monitoring Network web site launched to provide current and historic data to users (http://aqm.enr.gov.nt.ca/).
2013	• AQHI launched for the City of Yellowknife. • $PM_{2.5}$ FEM installed in Norman Wells. • Fort Liard Station closed in November 2013. • New air quality station installed in Fort Smith in December 2013. • Yellowknife and Inuvik stations equipped with trace level CO analyzers. • Filter-based particulate sampler (Partisol 2000i-D) installed at the Yellowknife station.
2014	• H_2S monitoring discontinued at Norman Wells station. • Replaced Yellowknife station with a larger 10’ x 25’ building. • AQHI launched in Inuvik.
2015	• New deployable units added to inventory: 2 x E-BAMs and 2 x DustTraks. • Black Carbon Aetholometer installed in Yellowknife station.

APPENDIX C: AIR POLLUTANTS

The NWT Air Quality Monitoring Network tracks a number of different air pollutants. With the exception of H_2S, these pollutants are known nationally as Criteria Air Contaminants (CACs). They represent the gases and compounds most often affecting community air quality and targeted by monitoring programs.

Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP) is a general term for dust. TSP includes a wide variety of solid and liquid particles found floating in the air, with a size range of approximately 50 micrometers (µm) in diameter and smaller (a human hair is approximately 100 µm in diameter). While TSP can have environmental and aesthetic impacts, it is the smaller particles contained within TSP that are of concern from a human health perspective (see Particulate Matter ($PM_{2.5}$) and (PM_{10}) later in section). Road dust, forest fires, mining activities and combustion products from vehicles, heating and electricity generation contribute to TSP levels.

The NWT AAQS for TSP is 120µg/m^3 over a 24-hour period. The standard for the annual average is 60µg/m^3 (geometric mean).

TSP monitoring has not been conducted in the NWT network since 2005, since particulate monitoring has instead been focused on $PM_{2.5}$ and PM_{10} monitoring.

Particulate Matter ($PM_{2.5}$) and (PM_{10})

A sub-portion of TSP, these very small particulates are named for the diameter size of the particles contained in each group – PM_{10} contains particles with a diameter of 10 microns (1 millionth of a metre) or less, while $PM_{2.5}$ (a sub-portion of PM_{10}) contains particles with a diameter of 2.5 microns or less. The significance of these microscopic particles is they can be inhaled and are associated with health effects, including aggravation of existing pulmonary and cardiovascular disease. Generally, the smaller the particle, the greater the penetration into the lung and the greater the associated health risk.

Sources of particulates that can be inhaled include road dust and wind-blown soil, making up the majority of the PM_{10} particles. Particles in the $PM_{2.5}$ size range primarily result from combustion of fossil fuels for industrial activities, commercial and residential heating as well as vehicle emissions, forest fire smoke and chemical reactions between other gases emitted to the air.

The national Canadian Ambient Air Quality Standards (CAAQS) has set a limit for $PM_{2.5}$, but has not yet established a limit for PM_{10}. The CAAQS 24-hour average limit for $PM_{2.5}$ is 28µg/m^3 and this concentration has been adopted under the NWT *Environmental Protection Act* as the NWT AAQS for $PM_{2.5}$. Several Canadian jurisdictions (e.g. BC, Ontario, Newfoundland and Labrador) have adopted a PM_{10} concentration of 50µg/m^3 (24-hour average) as an acceptable limit.

Sulphur Dioxide (SO_2)

SO_2 is a colourless gas, with a pungent odour at elevated concentrations, which can have negative effects on human and environmental health. Certain types of vegetation (especially lichens) are very sensitive to SO_2 impacts. SO_2 also plays a role in acid deposition and formation of secondary fine particulate through chemical reactions with other pollutants in the air.

There are some natural sources of SO_2 in ambient air (forest fires, volcanoes), but human activity is the major source. Emissions of SO_2 primarily result from burning fossil fuels containing sulphur. Sources include natural gas processing plants, gas plant flares and oil refineries, metal ore smelting, power generating plants and commercial or residential heating.

The NWT AAQS for SO_2 are 172ppb (1-hour average), 57ppb (24-hour average) and 11ppb (annual average).

Hydrogen Sulphide (H_2S)

Hydrogen sulphide (H_2S) is a colourless gas with a characteristic rotten egg odour. At high concentrations (parts per million range), it can be toxic, but typical ambient (outdoor) concentrations, even in areas impacted by industrial sources, tend to fall in the parts per billion (ppb) range. However, due to its low odour threshold, the presence of H_2S can be offensive and it has been associated with eye irritation and triggering feelings of nausea in sensitive individuals.

Industrial sources include oil and gas extraction, petroleum refining, sewage treatment facilities, and pulp and paper mills. Natural sources include sulphur hot springs, swamps and sloughs, which release H_2S as a by-product of organic decomposition.

There are no NWT standards for H_2S. The Alberta Ambient Air Quality Objectives provide an hourly limit of 10ppb and a 24-hour limit of 3ppb, based on avoidance of odour.

Nitrogen Oxides (NO_x)

Nitrogen oxides (NO_x) is a mixture of nitrogen-based gases, primarily nitric oxide (NO) and nitrogen dioxide (NO_2). Emissions of NO and NO_2 results from the high temperature combustion of fossil fuels. The predominant emission is NO, which rapidly converts to NO_2 through chemical reaction in the atmosphere. NO is a colourless and odourless gas, whereas NO_2 is a reddish-brown colour with a pungent, irritating odour. NO_2 is considered the more toxic and irritating of the two gases and, at elevated concentrations, is associated with both acute and chronic respiratory effects. Both gases play a role in the atmospheric reactions resulting in acid deposition and secondary pollutant formation (i.e. O_3 and fine particulate).

Due to the greater health effects of NO_2, development of air quality standards has focused on this gas, rather than NO or total NO_x. The NWT AAQS are reflective of national maximum desirable levels of 213ppb (1-hour average), 106ppb (24-hour average) and 32ppb (annual average).

Ground Level Ozone (O_3)

Ground level ozone (O_3) should not be confused with stratospheric O_3, which occurs at much higher elevations and forms a shield protecting life on the planet from the sun's harmful ultraviolet radiation. The gas is the same, but at ground level, O_3 is seen as undesirable due to its association with a variety of human health concerns, environmental impacts and property damage. O_3 is a highly reactive gas and is defined as a secondary pollutant. It is not emitted in large quantities from any source, but is formed through a series of complex chemical reactions involving other pollutants called precursors (e.g. NO_x and volatile organic compounds or VOCs) in the presence of sunlight.

The national standards provide a maximum acceptable level of 82ppb for O_3 based on a 1-hour average, and an annual maximum acceptable level of 15ppb. The Canada-wide Standards (CWS) process has also set an acceptable limit of 65ppb based on an 8-hour average. The CWS 8-hour limit has been adopted under the NWT *Environmental Protection Act* as the NWT AAQS for O_3.

Carbon Monoxide (CO)

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of fuels containing carbon. The primary source is vehicle exhaust, especially in cities with heavy traffic congestion. Other sources include industrial processes and fuel combustion for building heating. One natural source is wildfires.

CO affects humans and animals by interfering with the ability of the blood to transport oxygen around the body.

The NWT standards for CO reflect the national maximum desirable levels of 13ppm (1-hour average) and 5ppm (8-hour average). CO values are reported in ppm as opposed to other gaseous pollutants, which are reported in ppb.

Acid Deposition

Acidity in precipitation is measured in pH units on a scale of 0 to 14. A value of seven indicates neutral, values less than seven indicate acidic conditions and values greater than seven indicate alkaline conditions. Even clean precipitation is slightly acidic – around pH5.6 – due to the presence of naturally occurring concentrations of carbon dioxide, and minor amounts of sulphate and nitrate ions. The introduction of sulphur dioxide and nitrogen oxide emissions from combustion of fossil fuels for industrial, commercial and individual activities can result in an increase in acidic compounds in the atmosphere – often in areas far removed from the original emission sources. The removal of these sulphur and nitrogen compounds through atmospheric washout is reflected in the increased acidity (lower pH values) of precipitation. Calcium and magnesium ions – mostly from natural sources – act to neutralize acidity in precipitation.

Generally, precipitation with a pH value of 5.0 or less is termed 'acidic'. However, assessment of acid precipitation is usually based on deposition to an area over a specified time period (e.g. kilograms per hectare per year, kg/ha/yr) rather than review of specific precipitation event parameters. The degree of impact to a particular environment is influenced by its 'buffering' capacity or ability to tolerate the acidic inputs. Therefore, determination of acceptable limits usually requires a range of values to reflect the differing tolerances of various areas.

Environment Division
Department of Environment and Natural Resources
Government of the Northwest Territories
P.O. Box 1320
Yellowknife, NT X1A 2L9

Telephone: (867) 767-9236 ext. 53177
Facsimile: (867) 873-0221

This report is also available online at
www.enr.gov.nt.ca/programs/air-quality