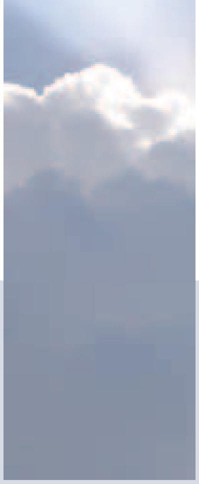
Northwest Territories
Air Quality Report 2011

Northwest Territories Environment and Natural Resources



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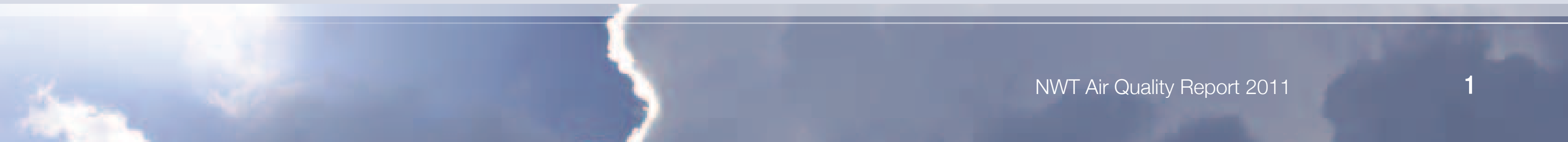

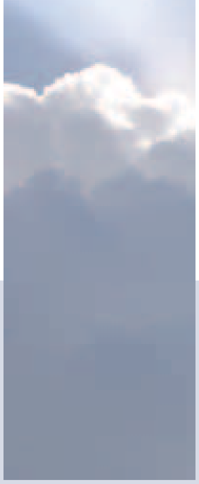

INTRODUCTION

The Environment Division (ED) of 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 Liard and Norman Wells. Each station is capable of continuously sampling and analyzing 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 urban air quality trends throughout Canada. A secondary overall objective of the stations is to establish baseline levels of SO_2, H_2S, NO_x, O_3 and PM ahead of development as well as track the trends and cumulative impacts from source emissions should they occur.

ENR also monitors acid precipitation at Snare Rapids, in cooperation with the Canadian Air and Precipitation Monitoring Network (CAPMoN) and the Northwest Territories Power Corporation (NTPC).

The 2011 Annual Air Quality Report summarizes the air quality information collected in 2011, along with some discussion of trends. The report also provides information on network operations, the air pollutants monitored and the air quality standards used in assessing the monitoring results. Further information, including 'almost real-time' air pollutant readings, can be found by visiting the NWT Air Quality Monitoring Network web site at http://www.air.enr.gov.nt.ca/NWTAQ/NetworkSummary.aspx.

After reading this report, if you have questions or require further information, you can contact:

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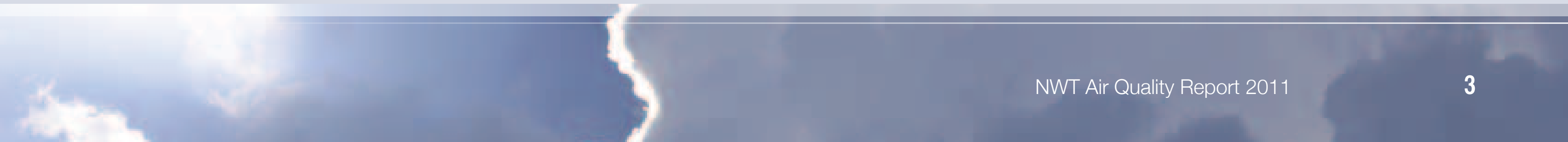
This report is also available on the Internet at
http://www.enr.gov.nt.ca/_live/pages/wpPages/Air_Quality.aspx



OPERATIONS (NETWORK)

The NWT Air Quality Monitoring Network consists of four permanent monitoring stations located in Yellowknife, Inuvik, Fort Liard and Norman Wells. The stations are climate-controlled trailers and include state-of-the-art monitoring equipment capable of continuously sampling and analyzing a variety of air pollutants and meteorological conditions. Pollutants monitored vary by station, but include sulphur dioxide (SO_2), hydrogen sulphide (H_2S), 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 B.

Figure 1: Map of the Air Quality Monitoring Network

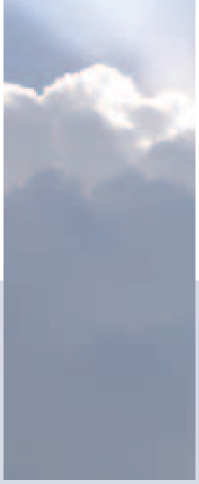
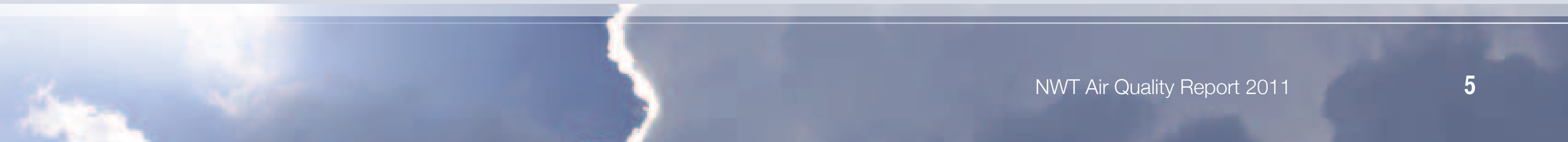


Table 1 shows the breakdown of the NWT Air Quality Monitoring Network by substances and meteorological parameters monitored at each station.

Table 1 – Substances Monitored by Station

Stations	Particulate Matter		Gaseous					Precipitation	Meteorological Monitoring	
	$PM_{2.5}$ – Fine Particulate	PM_{10} – Coarse Particulate	SO_2 Sulphur Dioxide	H_2S Hydrogen Sulphide	NO_x Nitrogen Oxides	O_3 Ground Level Ozone	CO Carbon Monoxide	Acidic Deposition	Wind Speed and Direction	Air Temperature
Yellowknife	√	√	√		√	√	√		√	√
Inuvik	√	√	√	√	√	√			√	√
Norman Wells	√	√	√	√	√	√			√	√
Fort Liard	√	√	√	√	√	√			√	√
Snare Rapids						√		√		

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



The Yellowknife and Inuvik stations are part of a larger national network that monitors the common or criteria air pollutants in urban centres across Canada. The National Air Pollution Surveillance (NAPS) Network is a joint federal/provincial/territorial program, incorporating approximately 286 stations located in 203 communities, which monitor similar particulate and gaseous substances as those sampled in Yellowknife and Inuvik. Data from both these NWT stations, along with data from other cities, is summarized and assessed, with results published in the NAPS annual data reports available at http://www.etc-cte.ec.gc.ca/publications/napsreports_e.html.

The NAPS Network has a stringent quality assurance/quality control (QA/QC) program that ensures 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, in turn, applies these procedures at the other stations.

The Fort Liard and Norman Wells stations are territorial stations that were set up in response to increasing resource development activity in the NWT and the potential for the associated emissions to affect air quality. The NAPS Inuvik station still fulfills its original territorial goals, along with its national urban monitoring objective. The primary territorial objective of these stations is to establish baseline levels of SO_2, H_2S, NO_x, O_3 and PM ahead of development as well as track the trends and cumulative impacts from source emissions should they occur.

ENR is involved in a second federal monitoring system; the Canadian Air and Precipitation Monitoring Network (CAPMoN). CAPMoN is a non-urban monitoring network with, as of 2010, 33 measurement sites in Canada and one in the United States that are 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. ENR, with assistance from the Northwest Territories Power Corporation staff, operates NWT's sole CAPMoN station at the Snare Rapids hydro-electric site, consisting of an acid precipitation collector and ozone analyzer. Daily rain and snow samples are collected and forwarded to the CAPMoN laboratory for analysis, and the data is used by both Environment Canada and ENR.

Table 2 presents the various government affiliations involved with the air quality monitoring stations in the NWT.

Table 2 – NWT Air Quality Network

	Partnership/ Contract	Stations	Network
Environment and Natural Resources – Environment Division		Yellowknife and Inuvik	National Air Pollution Surveillance
		Fort Liard and Norman Wells	Northwest Territories stations
	NWT Power Corporation	Snare Rapids	Canadian Air and Precipitation Monitoring

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

Appendix A traces the history of air quality monitoring in the NWT, while previous ENR Annual Air Quality Reports can be found at http://www.enr.gov.nt.ca/_live/pages/wpPages/Air_Quality.aspx

DEVELOPMENTS IN 2011

Many upgrades were conducted throughout the network in 2011 to remain current with monitoring technology advancements and to conform with the NAPS operating standards:

- A non-continuous particulate sampler was installed at the Yellowknife station in 2011. This instrument is a manual partisol dichotomous sampler and is operated on a 24-hour run-time, every six days. This filter-based instrument is the Federal Reference Method (FRM) and allows for speciation of the particulate.
- The $PM_{2.5}$ BAM at the Inuvik station was replaced with a BAM FEM, similar to Yellowknife's upgrade in 2010, which conforms with the 'federal equivalency method'. The NAPS network has moved toward upgrading all $PM_{2.5}$ monitors to this FEM standard.
- The data acquisition and management system was upgraded in 2011 for three of the four stations. This included upgrading DRDAS software and installing PC-based industrial loggers at the Yellowknife, Norman Wells and Inuvik stations. The new loggers replaced the analog Campbell Scientific data-loggers, which had operated since the stations' inceptions in 2003. This system allows ENR remote access to the stations for select features, including access to diagnostic information, re-booting options and the ability to activate certain calibration features.

FUTURE PLANS

ENR plans to conduct the following updates to the Air Quality Monitoring Network in 2012:

- Finalize the upgrade of the air quality data acquisition and management system for Fort Liard.
- Launch an improved Air Quality Monitoring Network website, which provides more user-friendly features in accessing current and historic data and associated statistics.
- Replace the SO_2 and CO analyzers in Yellowknife with analyzers capable of trace-level detection.

NWT AIR QUALITY STANDARDS

The Government of the NWT has adopted a number of concentration limits for protection of ambient (outdoor) air quality in the NWT. These limits apply to select pollutants and are contained 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 standards are used in the assessment of air quality monitoring data as well as determining 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

Parameter and Standard	Concentration (µg/m^3)*	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	130	65
Total Suspended Particulate (TSP)		
24-hour average	120	
Annual geometric mean	60	
Fine Particulate Matter (PM$_{2.5}$)		
24-hour average	30	
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/m^3)	13,000
8-hour average	6,000 (6mg/m^3)	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 additional information on air pollutants, see Appendix B.

YELLOWKNIFE AIR QUALITY

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) and continuously monitors criteria air contaminants (CACs) fine particulate ($PM_{2.5}$), coarse particulate (PM_{10}), SO_2, O_3, NO_x and CO. The station also monitors wind speed, wind direction and temperature, which assist in identifying possible sources of unusual or elevated readings.

Figure 2: Sir John Franklin Station

Additional non-continuous monitoring at the station consists of an automated partisol dichotomous particulate sampler (dichot), which is used for establishing the speciation of particles. As mentioned previously, this unit was commissioned in 2011 and, as such, results were not available at the time of this report.

The air quality monitoring results from the Sir John Franklin station are discussed in the following sections, and historical data is used to demonstrate trends where applicable.

Particulate Matter

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

ENR uses two methods of sampling the particulate size fractions of PM in Yellowknife – Beta Attenuation Mass Monitors (BAM) and a filter-based partisol dichotomous sampler (dichot). The BAM methodology provides continuous, almost real-time (hourly) analysis of particulate concentrations, while the dichot samples on a 24-hour basis every six days. The dichot sampler simultaneously collects both the 2.5µm and less and the 2.5 to 10µm particulate size fractions on a filter media. The filters require laboratory analysis to determine particulate concentrations and, unlike the BAM, do not provide timely information for real-time air quality assessment. However, the filters can also be analyzed for a whole suite of additional parameters, including metals. The dichot compliments the BAM in that particle identification can be determined, which provides more in-depth information about fine and coarse particulate. *Note that the laboratory results for the 2011 dichot filters were not available at the time of the release of this report*.

Fine Particulate ($PM_{2.5}$)

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

There were four $PM_{2.5}$ BAM readings at the Sir John Franklin station in 2011 that exceeded the NWT 24-hour standard (30µg/m^3), all as a result of forest fire smoke. Impacts to $PM_{2.5}$ levels from forest fires were observed in periods from May into July. Specifically, forest fires burning in the Slave Lake region of Alberta affected $PM_{2.5}$ readings in Yellowknife in mid-May. Forest fire smoke from fires burning in the North Slave (Behchokǫ̀), the South Slave, Alberta and Saskatchewan affected the June readings. Fires in Lutsel Ke, the Yellowknife area and a fire in Fort Resolution affected the $PM_{2.5}$ levels in July.

Figure 3: 2011 Yellowknife BAM $PM_{2.5}$

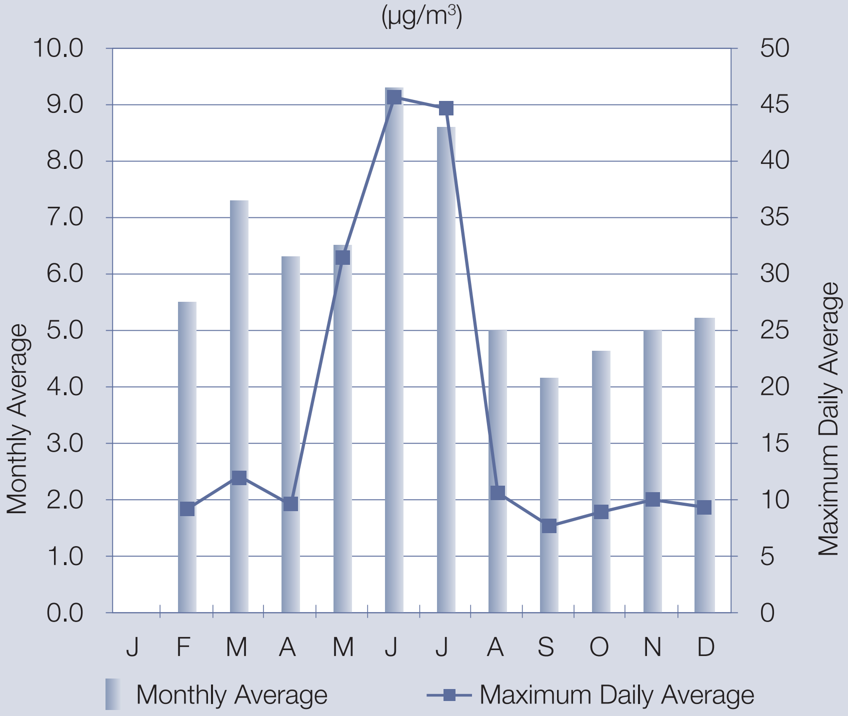


Figure 3 shows the monthly averages and maximum daily average per month, measured at the Sir John Franklin station in 2011 on the FEM BAM $PM_{2.5}$. The highest daily average concentration was 45.8µg/m^3, measured in July.

Figure 4: 2007 - 2010 Summary Yellowknife Hourly $PM_{2.5}$

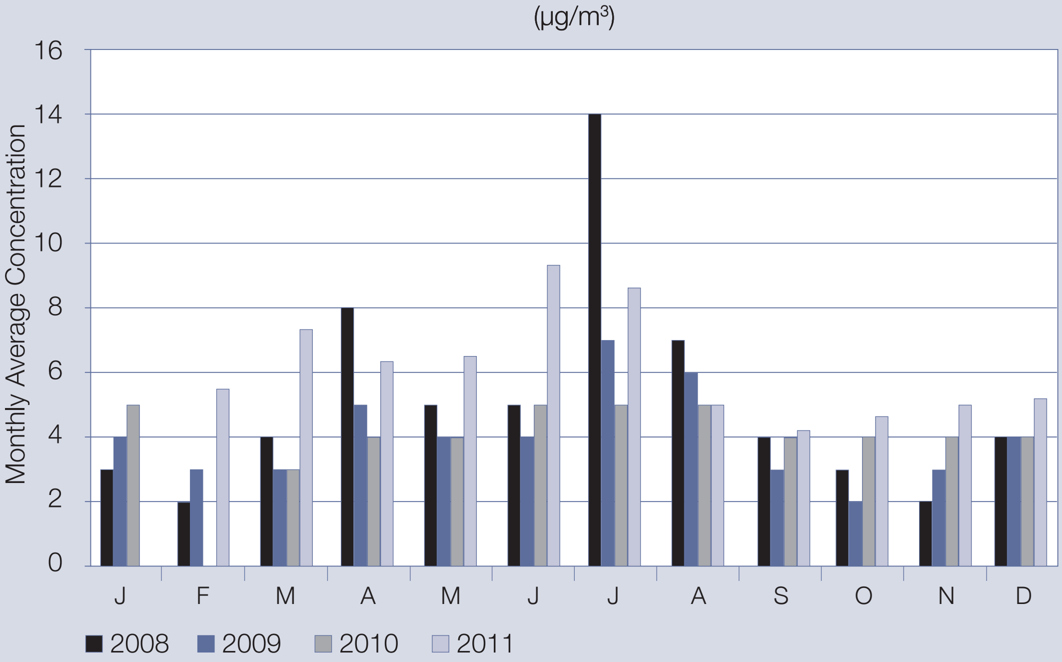


Figure 4 summarizes the monthly average BAM $PM_{2.5}$ data over the last four years. The overall trends indicate that $PM_{2.5}$ levels increase during the summer months, which is typically attributed to forest fires that occur during this time of year. As the graph indicates, the 2011 fire season was similar to those of previous years, with the exception of 2008, which had a more severe season.

Coarse Particulate (PM_{10})

The NWT does not have a standard for PM_{10}, but instead adopts a 24-hour average criterion of 50µg/m^3. This level is used in several Canadian jurisdictions, including BC, Ontario and Newfoundland and Labrador.

The graph in Figure 5 presents the PM_{10} data for 2011 and clearly shows the annual 'dust' event, which is typical mainly for the month of April. This is due to residual gravel on the roads following the spring snow thaw. There were thirteen exceedances of the adopted standard of 50µg/m^3 in 2011. The majority of these occurred in April and correlate well with the springtime "dust event". The other exceedances occurred during the months of June and July and were attributed to the previously mentioned smoke from forest fires.

Figure 5: 2011 Yellowknife BAM PM_{10}

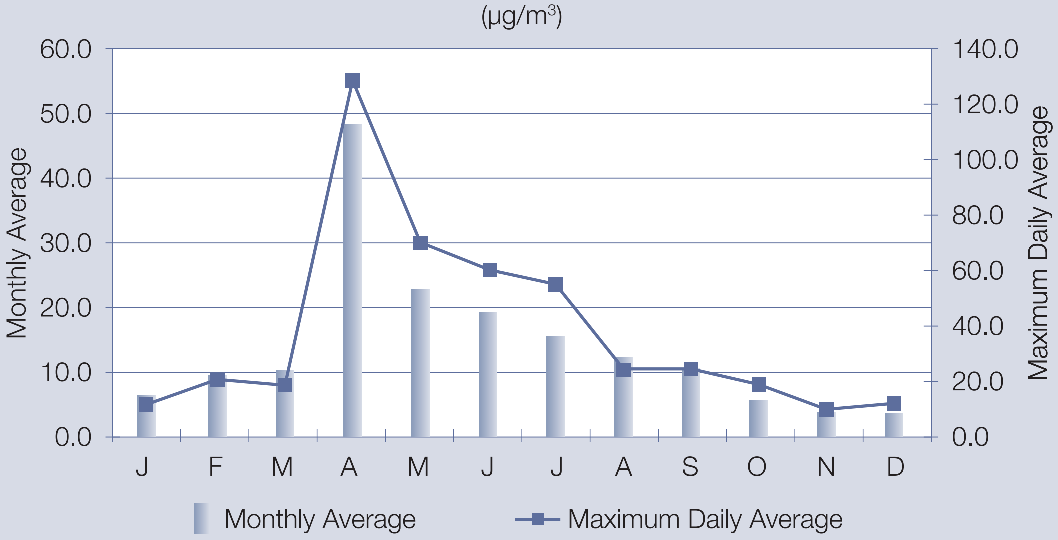


Figure 5 shows the BAM PM_{10} monthly averages and maximum daily averages per month measured at the Yellowknife station in 2011. The highest maximum daily concentration was 127.9µg/m^3, occurring in April.

Sulphur Dioxide (SO_2)

Continuous monitoring for SO_2 has been conducted in Yellowknife at several locations since 1992, 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.

There were no exceedances of the NWT hourly (450µg/m^3) or 24-hour (150µg/m^3) standards in 2011 in Yellowknife. The annual average was less than 2µg/m^3, a level that is well below the NWT (30µg/m^3) standard.

The majority of the hourly concentrations recorded in 2011 were only background or slightly greater, usually in the range of 3 to 4µg/m^3, with a single maximum hourly concentration of 21µg/m^3 that coincided with vehicle emissions next to the station. The concentrations are similar to the years since 1999 when the last gold mine closed, and reflect naturally occurring SO_2 and/or small amounts from the burning of fossil fuels.

Figure 6: 1996 - 2011 Summary Yellowknife Sulphur Dioxide

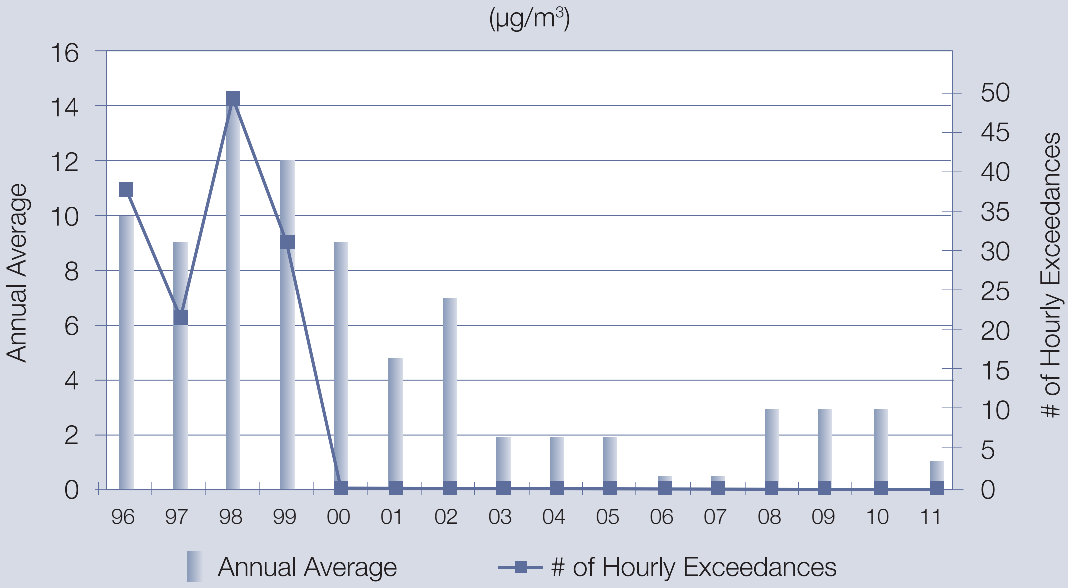


Figure 6 shows the general trends in SO_2 levels measured in Yellowknife air from 1995 to 2011. As illustrated, the number of exceedances has fallen to zero since the closure of Giant Mine in 1999. The 2011 data continued the trend of recent years.

Ground Level Ozone (O_3)

Continuous ozone monitoring has been conducted in Yellowknife since 1998, while the current analyzer has been operating at the Sir John Franklin station since February of 2003.

The maximum 8-hour average in 2011 was 102µg/m^3, which occurred in March and met the 8-hour NWT standard (130µg/m^3). The maximum 1-hour average was 106µg/m^3, which met the national maximum acceptable standard (160µg/m^3). The 2011 annual hourly average was 50µg/m^3.

Detectable concentrations of O_3 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 40 to 80µg/m^3. In large urban areas (and areas downwind), ozone concentrations can be much higher than typical background levels due to the additional emissions of precursor gases from anthropogenic sources (see Appendix B).

Figure 7: 2010 Yellowknife Ozone

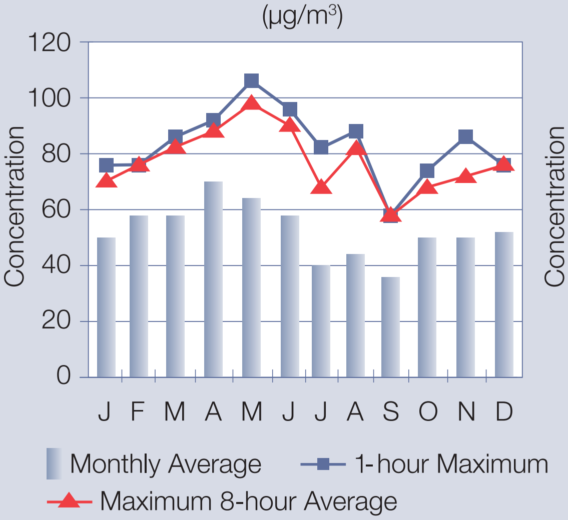
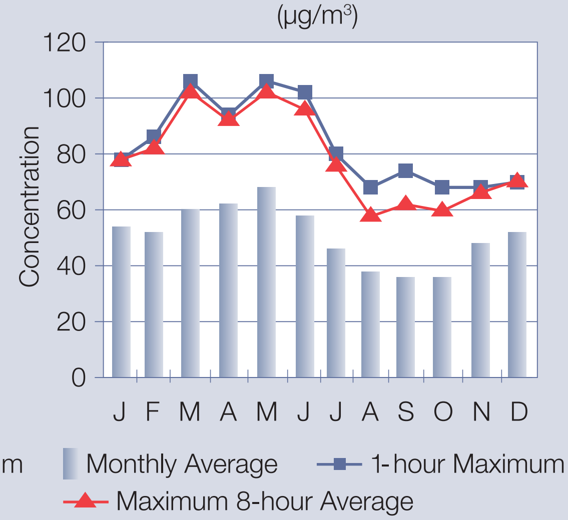


Figure 8: 2011 Yellowknife Ozone



Figures 7 and 8 show the maximum hourly reading and maximum 8-hour average per month as well as the monthly averages recorded for 2010 and 2011.

The Figures illustrate the typical spring maximum, which commonly occurs at remote monitoring stations located in mid to high latitudes in the northern hemisphere. The source of this spring maximum continues to be the subject of scientific debate as to how much is attributable to natural vs. anthropogenic sources. Typical monthly ozone concentrations at remote sites in Canada range between 40 and 90µg/m^3[1] and Yellowknife concentrations for both years fell within or below this range.

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[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 B).

The 2011 results indicated that there were no exceedances of the 1-hour, 24-hour or annual NWT standards for NO_2 (400, 200, 60 µg/m^3, respectively). The maximum 1-hour average was 84µg/m^3, the maximum 24-hour average was 38µg/m^3, while the annual average was 7µg/m^3.

Figure 9: 2010 Yellowknife Nitrogen Dioxide

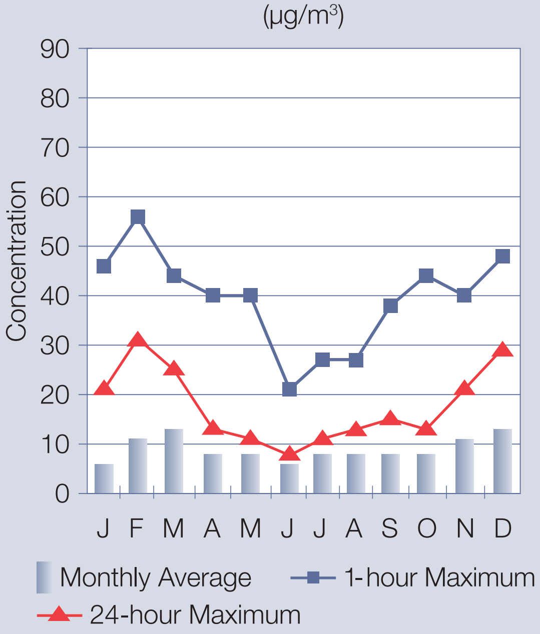
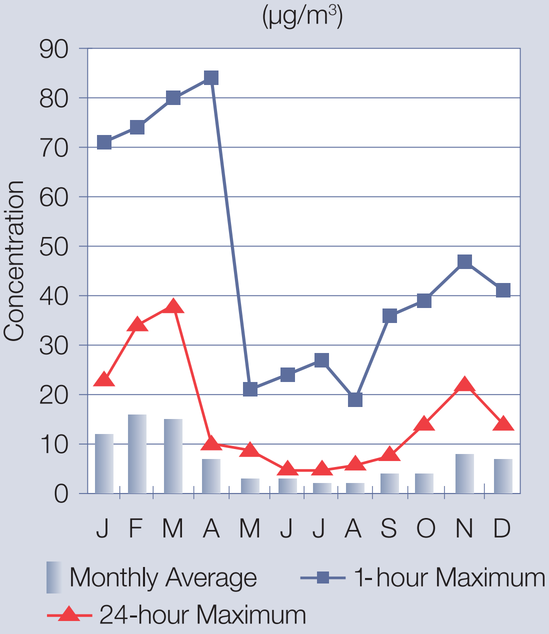


Figure 10: 2011 Yellowknife Nitrogen Dioxide



Figures 9 and 10 show the 2010 and 2011 maximum hourly, maximum daily and monthly averages of NO_2 in Yellowknife. Generally, both the highest monthly averages and the highest hourly concentrations occurred during the winter months. This is likely caused by increased emissions from fuel combustion for residential and commercial heating and idling vehicles as well as short-term ‘rush hour’ traffic influences. The effects of these 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)

The 2011 data continued the extremely low CO readings measured in 2010 and were well below the NWT 1-hour and 8-hour average standards (15mg/m^3 and 6mg/m^3 respectively). In 2011, the maximum 1-hour average was 2.4 mg/m^3 and the annual average was 0.3 mg/m^3. Given the absence of heavy traffic volumes in Yellowknife, low levels of CO are expected.

Figure 11: 2011 Yellowknife Carbon Monoxide

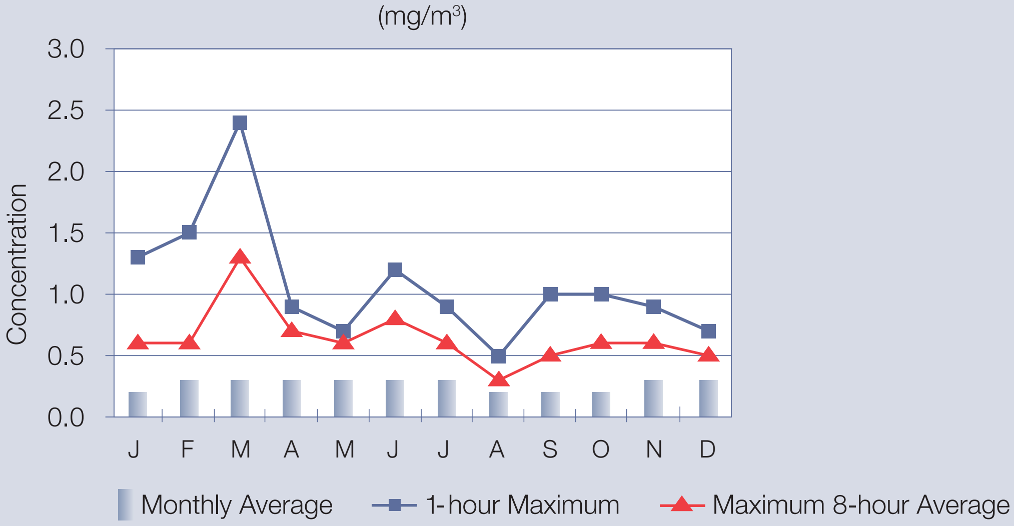


Figure 11 shows the 2011 monthly averages and highest hourly concentrations for CO in Yellowknife.

INUVIK AIR QUALITY

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.

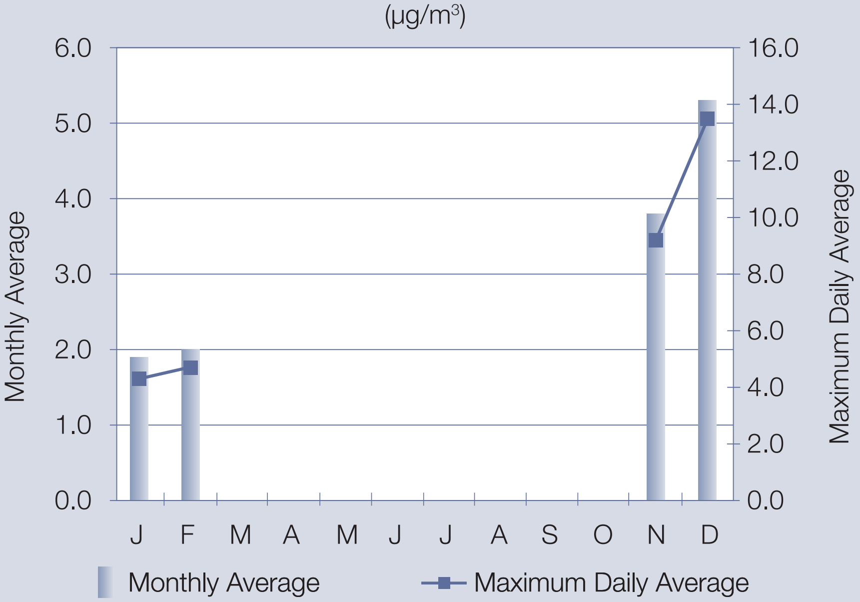
This station has been in operation since 2003, but was moved from its original location at Samuel Hearne School to its present site on Bompas Street in 2009. The following parameters are measured at the Inuvik station: $PM_{2.5}$, PM_{10}, SO_2, O_3, NO_2 and H_2S.

Figure 12: Inuvik Station

Fine Particulate ($PM_{2.5)}$

Due to logger issues following installation of the BAM FEM $PM_{2.5}$, erroneous readings were recorded throughout the year as a result of a programming code malfunction. As a result, the data over this time period was invalidated, leaving only a data set of January, November and December of 2011. This monitoring period does not cover the summer forest fire season, where $PM_{2.5}$ readings typically experience elevations.

Figure 13: 2011 Inuvik BAM $PM_{2.5}$



Coarse Particulate (PM_{10})

The maximum daily average measured from the PM_{10} BAM in Inuvik in 2011 was 96.3µg/m^3, recorded in May. The highest hourly maximum was 308.4µg/m^3 and occurred in July. There were 15 exceedances of the adopted 24-hour standard (50µg/m^3), which generally occurred in the snow-free months. Similar to previous years, the spring-time levels were elevated and were representative of the typical 'spring-time dust event' associated with residual winter gravel. Given the dirt roads in the Inuvik area in proximity to the monitoring station, the dust events can persist into the summer months as well.

Figure 14: 2011 Inuvik BAM PM_{10}

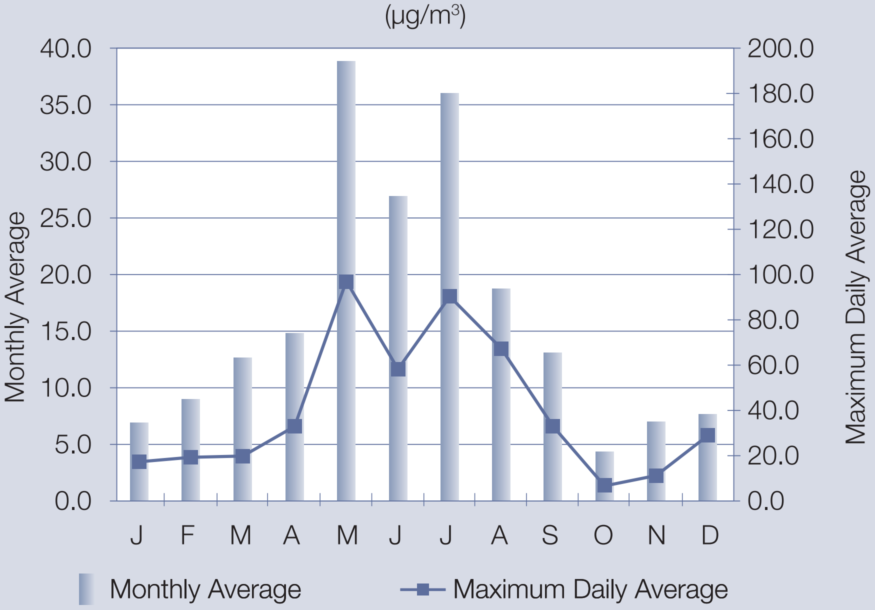


Figure 14 shows the monthly averages and the maximum daily average concentrations of PM_{10} from the BAM in Inuvik. The spring spike is attributed to the residual winter gravel on the roads following the thaw, while the summer elevations are likely attributed to a combination of the forest fires burning in the Inuvik area in June, July and August, and the presence of dirt roads in proximity to the station.

Sulphur Dioxide (SO_2)

The annual average of SO_2 was less than 3µg/m^3 and the maximum 1-hour average was 5µg/m^3. The SO_2 concentrations measured in 2011 were very low and similar to previous years' results, with no exceedances of the NWT hourly (450µg/m^3), 24-hour (150µg/m^3) or annual average (30µg/m^3) standards.

Ground Level zone (O_3)

Ozone data was available for 10 months during 2011. It was not available for the months of October and December due to analyzer component failures. The maximum 1-hour average was 96µg/m^3, while the maximum 8-hour average was 92µg/m^3. Neither the 1-hour national maximum acceptable level (160µg/m^3) nor the 8-hour NWT standard (130µg/m^3) for ground level ozone was exceeded in 2011. The annual average was 46µg/m^3, which is typical of background levels.

Figure 15: 2011 Inuvik Ozone

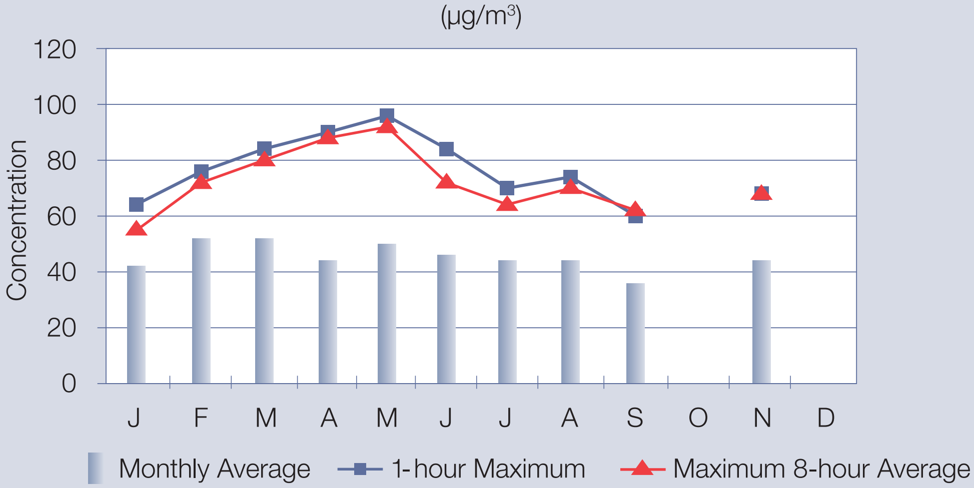


Figure 15 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in 2011. The typical elevated readings in the spring-time were observed, which is consistent with historical data.

Nitrogen Dioxide (NO_2)

The NO_2 results for Inuvik in 2011 show that the maximum 1-hour average was 88µg/m^3, the maximum 24-hour average was 38µg/m^3 and the overall annual average was 5µg/m^3, all of which were within the NWT standards (400, 200, 60 µg/m^3, respectively).

Figure 16: 2011 Inuvik Nitrogen Dioxide

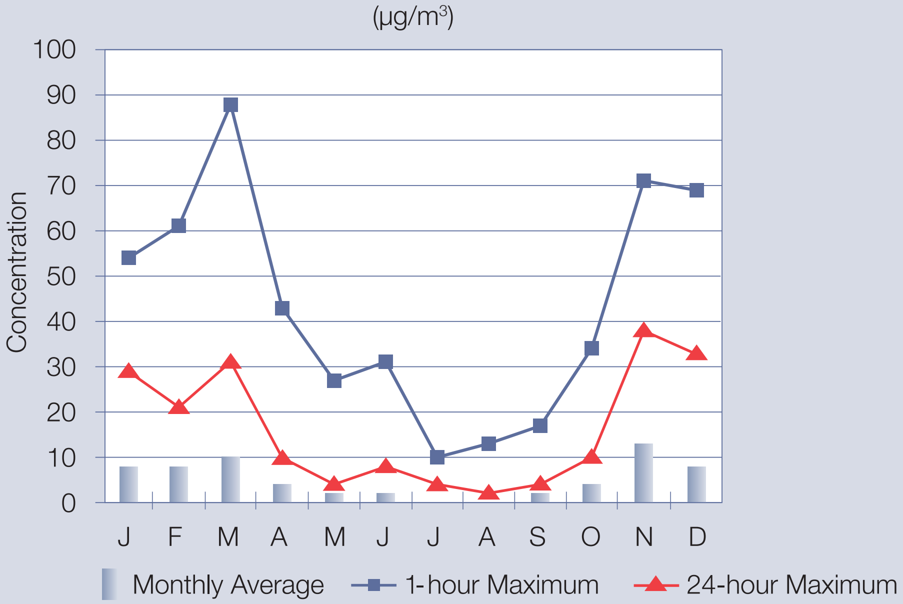


Figure 16 shows the maximum hourly, maximum daily and monthly averages of NO_2 in Inuvik in 2011. Average concentrations are observed to be higher in the colder months, similar to previous years, likely as a result of idling and other combustion sources during inversions (stagnant air masses).

Hydrogen Sulphide (H_2S)

The data collected in 2011 continues to indicate very low H_2S concentrations in Inuvik – essentially non-detectable. Most of the readings are less than 1µg/m^3, which is below the detectable limits of the instrumentation and within the ‘noise’ range.

The maximum recorded 1-hour average was 5µg/m^3, while the maximum 24-hour average was 2µg/m^3. There were no exceedances of the adopted Alberta guidelines (1-hour average 14µg/m^3 and a 24-hour average of 4µg/m^3). These results are consistent with the readings collected in previous years.

FORT LIARD AIR QUALITY

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

The station is located near the Fort Liard Airport and measures $PM_{2.5}$, PM_{10}, SO_2, O_3, NO_2 and H_2S. Monitoring has been conducted for select parameters since 2000; however, this station was established in 2004. Note that the O_3 analyzer was installed in 2007.

Fine Particulate ($PM_{2.5}$)

The 2011 annual $PM_{2.5}$ average concentration was 4.6µg/m^3, while the maximum daily average was 25.8µg/m^3. There were no exceedances of the NWT 24-hour standard for $PM_{2.5}$ (30µg/m^3).

Figure 17: 2011 Fort Liard BAM $PM_{2.5}$

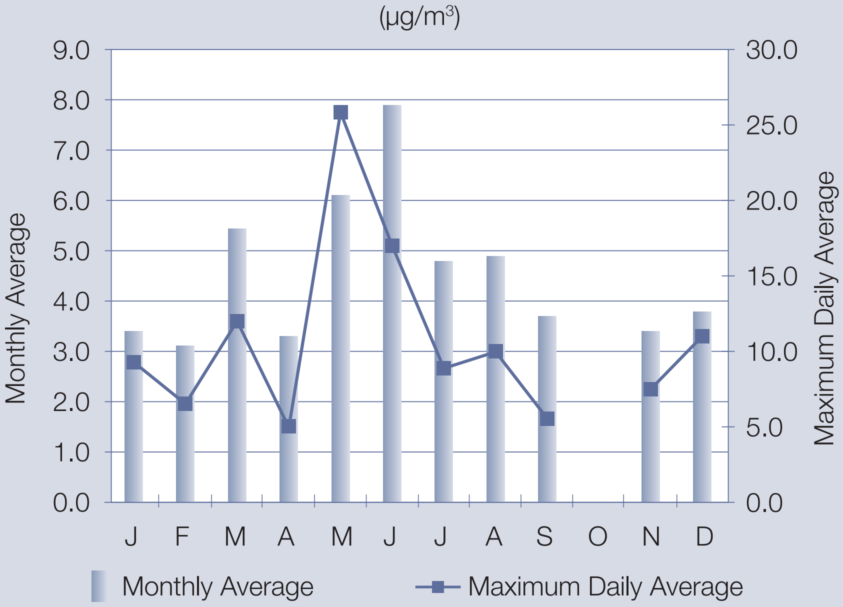


Figure 17 shows the monthly averages and maximum daily averages for $PM_{2.5}$ measured from the BAM at the Fort Liard station in 2011. The slightly elevated readings in the summer months are typical and reflect the dusty roads and forest fire events in the region.

Coarse Particulate (PM_{10})

The highest daily maximum for PM_{10} was 66.4µg/m^3, recorded in May, and it was also the only exceedance of the adopted 24-hour standard (50µg/m^3). Results were not available for the months of April and October due to issues with tape changes. Elevated PM_{10} readings were measured from May until September, which represent the snow-free months of the year and are attributed to the presence of gravel roads throughout Fort Liard. These results are expected and are consistent with previous years.

Figure 18: 2011 Fort Liard BAM PM_{10}

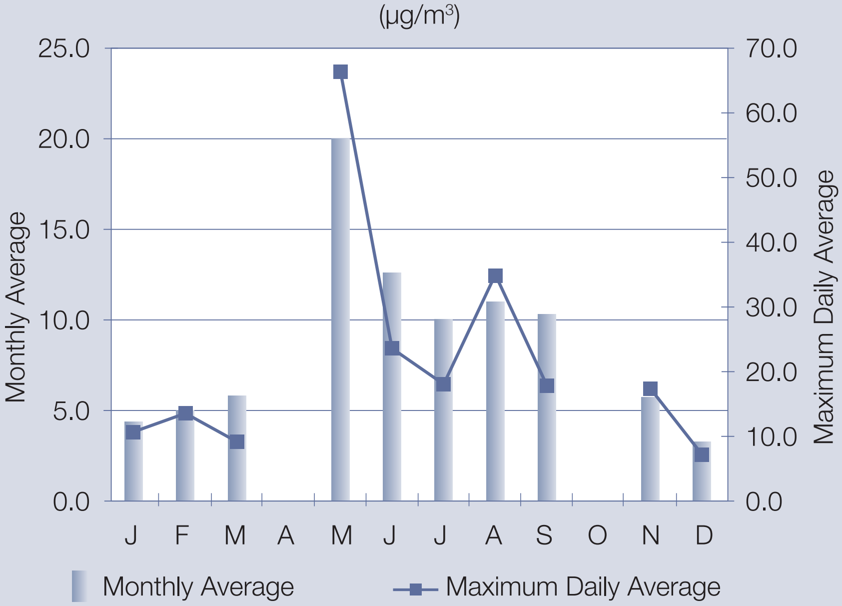


Figure 18 shows the monthly averages and the maximum daily average concentrations of PM_{10} measured from the BAM in Fort Liard in 2011.

Sulphur Dioxide (SO_2)

As in previous years, there were no exceedances of the NWT hourly (450µg/m^3), 24-hour (150µg/m^3) or annual average (30µg/m^3) standards for SO_2 in Fort Liard, with a maximum 1-hour average value of only 5µg/m^3. The monthly averages were very low, with values less than 2µg/m^3. These readings are consistent with those measured in previous years.

Ground Level Ozone (O_3)

Ozone data in Fort Liard was invalidated in 2011 due to an instrument and data acquisition malfunction.

Nitrogen Dioxide (NO_2)

NO_2 data was not available for the months of May, June and July due to an analyzer component failure. The results for Fort Liard, based on seven months of 2011 NO_2 data, show that the maximum 1-hour average was 50µg/m^3, the maximum 24-hour average was 17µg/m^3 and the overall annual average was 2µg/m^3, which were within the NWT standards (400, 200, 60 µg/m^3, respectively).

Figure 19: 2011 Fort Liard Nitrogen Dioxide

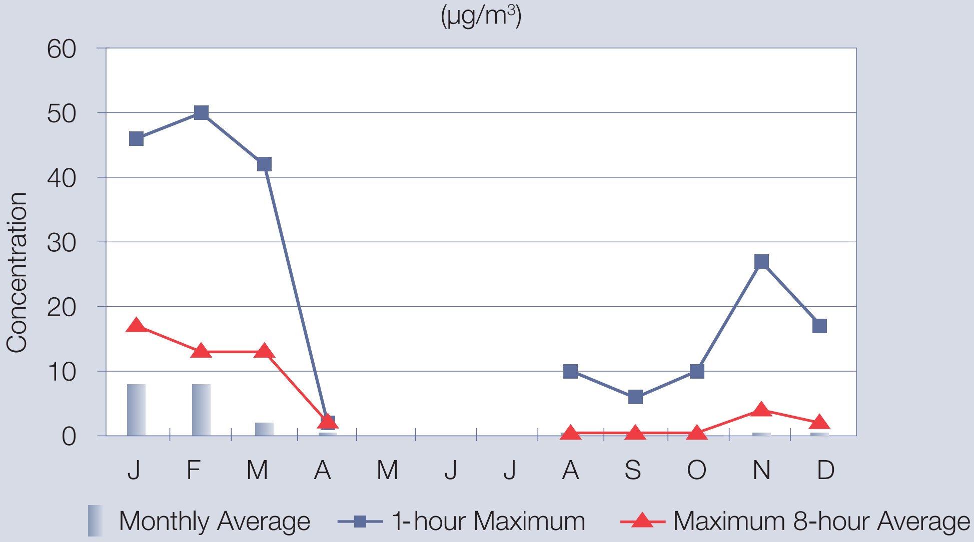


Figure 19 shows the maximum hourly, maximum daily and monthly averages of NO_2 in Fort Liard in 2011. Average concentrations are observed to be higher in the colder months, similar to previous years, likely as a result of idling and other combustion sources during inversions (stagnant air masses).

Hydrogen Sulphide (H_2S)

The maximum hourly H_2S concentration in 2011 was 3µg/m^3 and the vast majority of readings were less than 1µg/m^3, essentially within the detection limits or ‘noise’ range of the analyzer. H_2S in Fort Liard was within the limits of the adopted Alberta guidelines (1-hour average of 14µg/m^3 and a 24-hour average of 4µg/m^3).

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, NO_2 and H_2S. It has been in operation since 2003.

Fine Particulate ($PM_{2.5}$)

The maximum daily average concentration of $PM_{2.5}$ in Norman Wells in 2011 was 22.1µg/m^3 and the annual average was 4.7µg/m^3. There were no exceedances of the NWT 24-hour standard for $PM_{2.5}$ (30µg/m^3). The elevated readings measured in June and July are attributed to dusty conditions in June and smoke from forest fires burning near Fort Good Hope, Délı̨ne and at 25 Mile Lake in the month of July.

Figure 20: 2011 Norman Wells BAM $PM_{2.5}$

(µg/m^3)

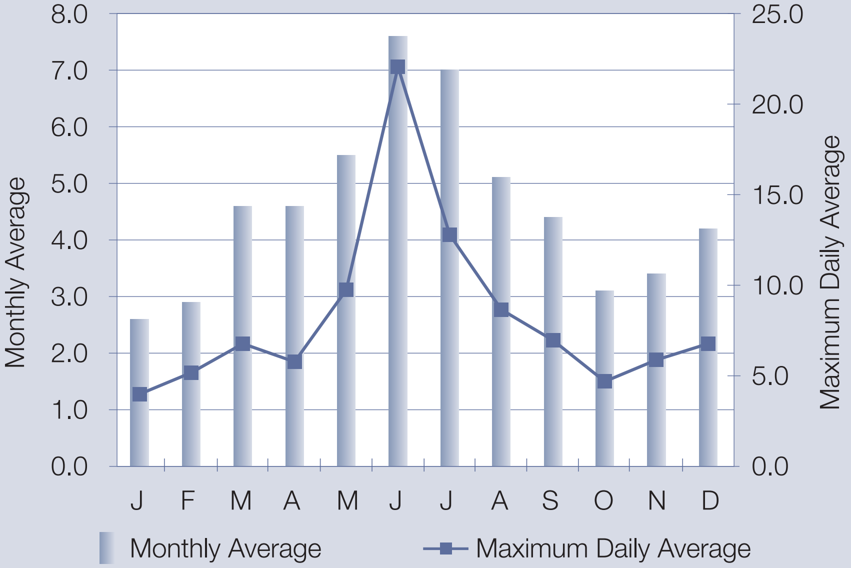


Figure 20 shows the monthly averages and maximum daily averages of $PM_{2.5}$ measured from the BAM at the Norman Wells station in 2011. The elevated readings in the summer are typical and are associated with the forest fire season.

Coarse Particulate (PM_{10})

The 2011 year represents the first full year in which PM_{10} data was collected in Norman Wells. The 1-hour maximum concentration was 327.6µg/m^3, which occurred in May during the spring-time 'dust' event. The 24-hour maximum concentration was 80.4µg/m^3 and the annual average concentration was 18.1µg/m^3. There were 11 exceedances of the adopted 24-hour average standard of 50µg/m^3.

Figure 21: 2011 Norman Wells BAM PM_{10}

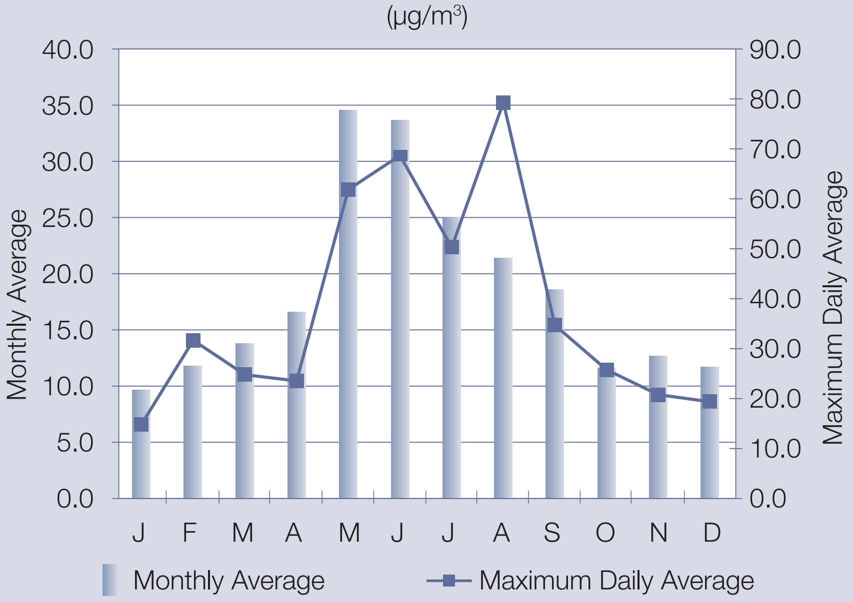


Figure 21 shows the monthly averages and the maximum daily average concentrations of PM_{10} measured from the BAM in Norman Wells in 2011. The snow-free months were affected by dusty conditions throughout the summer from the gravel roads and construction activities.

Sulphur Dioxide (SO_2)

Overall, SO_2 concentrations in Norman Wells were generally very low. The 1-hour maximum SO_2 reading was 5µg/m^3, the maximum 24-hour average was 3µg/m^3 and the annual average was less than 2µg/m^3. No exceedances of the NWT standards occurred (1-hour average of 450µg/m^3, 24-hour average of 150µg/m^3 and annual average of 30µg/m^3). This is consistent with previous years.

Ground Level Ozone (O_3)

The maximum 1-hour average was 110µg/m^3, while the maximum 8-hour average was 106µg/m^3, both occurring in May. Neither the 1-hour national maximum acceptable level (160µg/m^3) nor the 8-hour NWT standard (130µg/m^3) for ground level ozone was exceeded in 2011. The annual average was 46µg/m^3, which is within the range of what is considered background levels. The typical elevated readings in the spring-time were observed, which is consistent with historical data.

Figure 22: 2011 Norman Wells Ozone

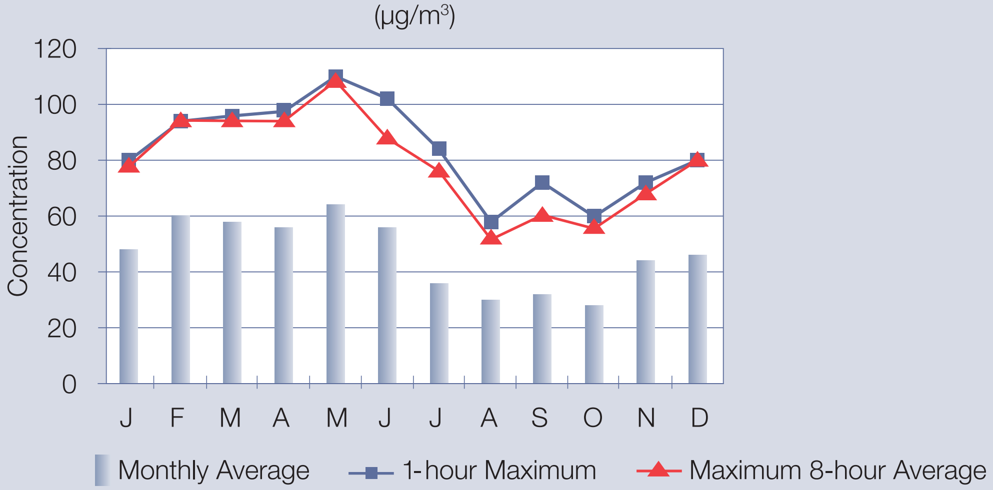


Figure 22 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in Norman Wells in 2011.

Nitrogen Dioxide (NO_2)

The 2011 NO_2 results for Norman Wells show that the maximum 1-hour average was 42µg/m^3, the maximum 24-hour average was 13µg/m^3 and the overall annual average was 2µg/m^3, which were within the NWT standards (400, 200, 60 µg/m^3, respectively).

Figure 23: 2011 Norman Wells Nitrogen Dioxide

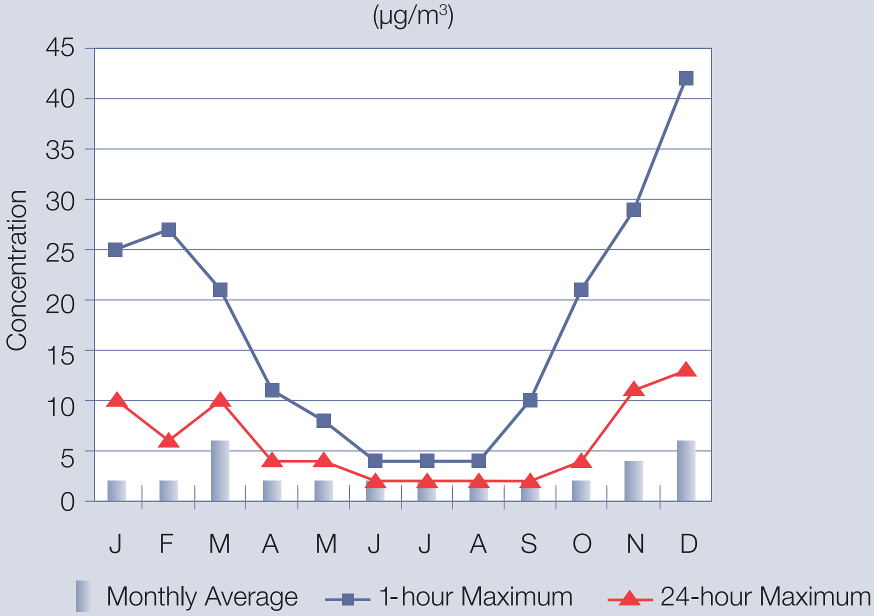


Figure 23 shows the 2011 monthly averages, maximum 24-hour averages and maximum 1-hour concentrations of NO_2 in Norman Wells. As with previous years, NO_2 levels were observed to increase in the winter months as a function of idling and other combustion sources during inversions (stagnant air masses).

Hydrogen Sulphide (H_2S)

The maximum hourly H_2S concentration in 2011 was 2µg/m^3 and the vast majority of readings were less than 1µg/m^3, essentially within the detection limits or 'noise' range of the analyzer. The maximum 24-hour average was 2µg/m^3. H_2S in Norman Wells was within the limits of the adopted Alberta guidelines (1-hour average of 14µg/m^3 and a 24-hour average of 4µg/m^3). The 2011 results are consistent with previous years.

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 site. This site is located 150 kilometres northwest of Yellowknife. Rain and snow samples are collected on a daily basis and sent to Environment Canada's CAPMoN laboratory in Toronto for analysis of precipitation chemistry. Select results are presented below.

Figure 24: Snare Rapids Acid Deposition (1993 - 2011)

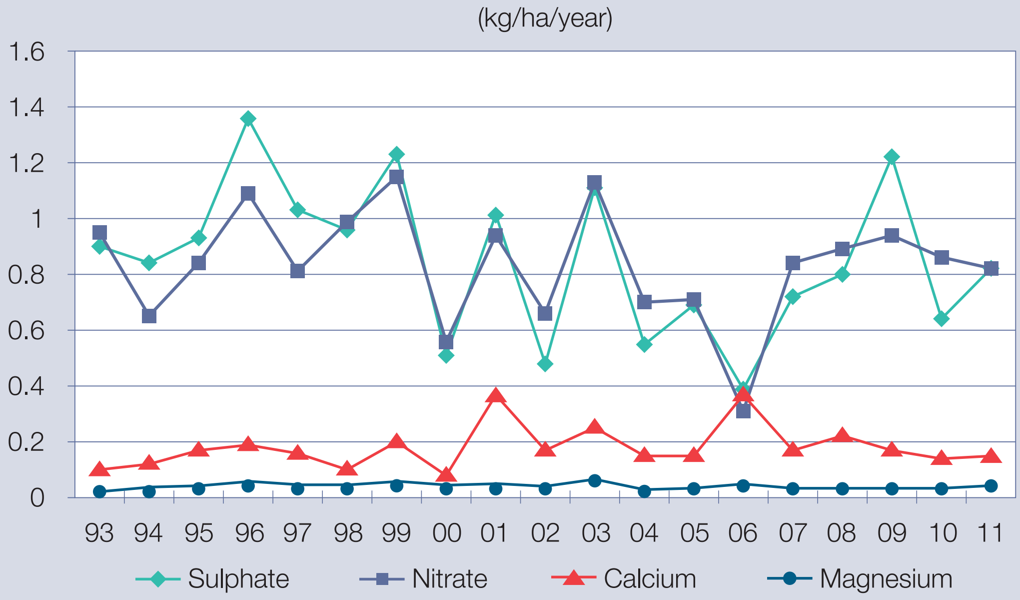


Figure 24 shows the deposition rates for sulphate, calcium, nitrate and magnesium from 1993 to 2011.

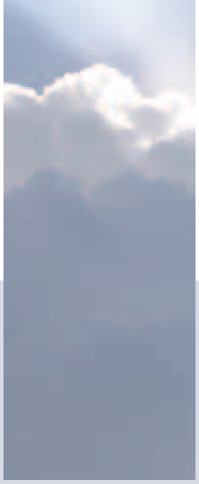
The geology of the NWT is mostly characterized by non-carbonate bedrock resistant to weathering and/or shallow, coarse-textured soils with low cation exchange capacity, low sulphate adsorption capacity and low pH. The sulphate level of deposition that is considered to be protective of sensitive ecosystems 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 that would be expected to cause a significant environmental effect in sensitive ecosystems.

APPENDIX A: 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 H_2S 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 Ècole 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.

History of Air Quality Monitoring in the Northwest Territories (cont.)	
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 from all NAPS stations. • 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.



APPENDIX B: 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 as Criteria Air Contaminants (CACs). They represent the gases and compounds most often affecting community air quality and targeted by monitoring programs.

H_2S is monitored at the air quality stations in Inuvik, Norman Wells and Fort Liard due to its association with oil and gas development activities.

Total Suspended Particulate (TSP)

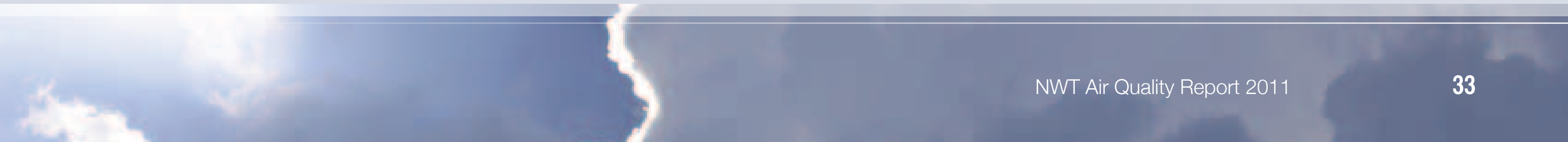
Total Suspended Particulate (TSP) is a general term for dust. TSP includes a wide variety of solid and liquid particles found floating in the air, with a size range of approximately 50 micrometers (µm) in diameter and smaller (a human hair is approximately 100 µm in diameter). While TSP can have environmental 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 Ambient Air Quality Standard for TSP is 120µg/m^3 over a 24-hour period. The standard for the annual average is 60µg/m^3 (geometric mean).

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 within 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 that 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, which make 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 Canada-wide Standards (CWS) process has set an acceptable limit for $PM_{2.5}$, but has not yet established a limit for PM_{10}. The CWS 24-hour average acceptable limit for $PM_{2.5}$ is 30µg/m^3 and this concentration has been adopted under the NWT *Environmental Protection Act* as the NWT Ambient Air Quality Standard 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 the burning of 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.

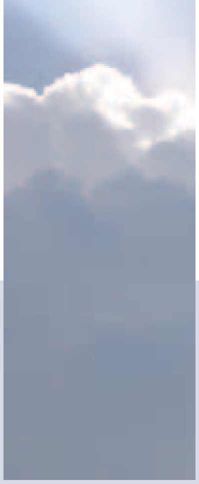
The NWT Ambient Air Quality Standards for SO_2 are 450 µg/m^3 (1-hour average), 150 µg/m^3 (24-hour average) and 30 µg/m^3 (annual average).

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 14µg/m^3 (or 10ppb) and a 24-hour limit of 4µg/m^3 (or 3ppb), based on avoidance of odour.



Nitrogen Oxides (NO_X)

Nitrogen oxides (NO_x) consist of a mixture of nitrogen-based gases, primarily nitric oxide (NO) and nitrogen dioxide (NO_2). Emissions of both NO and NO_2 results from the high temperature combustion of fossil fuels. The predominant emission is NO, which then 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).

Because of 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 standards are reflective of national maximum desirable levels of 400µg/m^3 (1-hour average), 200µg/m^3 (24-hour average) and 60µg/m^3 (annual average).

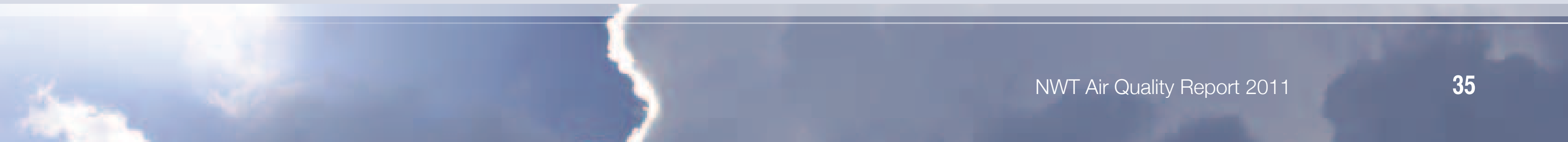
Ground Level Ozone (O_3)

Ground level ozone (O_3) should not be confused with stratospheric O_3, which occurs at much higher elevations and forms a shield that protects life on the planet from the sun's harmful ultraviolet radiation. The gas is the same, but at ground level O_3 is regarded 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 160µg/m^3 for O_3 based on a 1-hour average. The Canada-wide Standards (CWS) process has also set an acceptable limit of 65ppb or 130µg/m^3 based on an 8-hour average. The CWS 8-hour limit has been adopted under the NWT *Environmental Protection Act* as the NWT Ambient Air Quality Standard 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 15mg/m^3 (1-hour average) and 6mg/m^3 (8-hour average). CO values are reported in mg/m^3 as opposed to other gaseous pollutants, which are reported in µg/m^3.

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. Also, 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.