Ambient Air Monitoring Program
Wabamun–Genesee Area

2006 Annual Report

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Executive Summary

TransAlta Utilities and EPCOR Utilities Inc. operate four coal-fired thermal generating plants – Sundance, Keephills, Wabamun, and Genesee - located in the Wabamun-Genesee area of west-central Alberta. These generating plants operate under Alberta Environmental Protection and Enhancement Act (EPEA) approvals. As part of their EPEA approvals, the generating plants conduct special environmental monitoring programs, including ambient air monitoring. This 2006 annual report summarizes results of the ambient air monitoring program that are important for understanding the state of air quality in the Wabamun-Genesee area. Components conducted during 2006 included a continuous monitoring program, an intermittent monitoring program, and a passive monitoring program.

Continuous Monitoring Program

A continuous program was conducted at the Genesee, Meadows, Wagner, and Powers air monitoring stations in the Wabamun-Genesee area during 2006. Data capture rates for measured parameters at all air monitoring stations were above the 90 percent criterion required in the Alberta Environment Air Monitoring Directive. High uptimes were indicative that equipment in the continuous air monitoring network was generally well-maintained. The $NO/NO_2/NO_x$ sensor at the Wagner air monitoring station was removed from service near the end of July due to damage caused by static on the telephone line. The sensor was returned to service August 29, resulting in 8.3 percent uptime during August. The sensor has been functioning properly since then.

Overall, air quality was interpreted as good at the monitoring stations during 2006:

- Average nitrogen dioxide (NO_2) concentrations at all of the stations represented less than three percent of the hourly Ambient Air Quality Objective and less than five percent of the daily Ambient Air Quality Objective. Hourly NO_2 concentrations were very low at all four air monitoring stations (<55 $\mu g/m^3$ for 98 percent of the time) during 2006.
- Average sulphur dioxide (SO_2) concentrations at all of the stations represented approximately one percent of the hourly Ambient Air Quality Objective and two percent of the 24-hour Ambient Air Quality Objective. Hourly SO_2 concentrations were very low at all four air monitoring stations (<34 $\mu g/m^3$ for 98 percent of the time) during 2006.
- The annual average ozone (O_3) concentration at the Genesee air monitoring station was 53 $\mu g/m^3$. This is similar to the annual hourly average O_3 concentration observed in 2005 (54 $\mu g/m^3$). Hourly O_3 concentrations at the Genesee air monitoring station were comparable to that observed at a rural air monitoring station in west central Alberta (Carrot Creek). Hourly O_3 concentrations at the Genesee air monitoring station were <119 $\mu g/m^3$ for 98 percent of the time during 2006.
- Twenty-four hour $PM_{2.5}$ concentrations at the Genesee air monitoring station ranged from <1 to 46 $\mu g/m^3$ in 2006. Twenty-four hour $PM_{2.5}$ concentrations at the Powers air monitoring station ranged from <1 to 58 $\mu g/m^3$ in 2006. Median (50th percentile) 24-hour $PM_{2.5}$ concentrations at both stations were very low ($\leq$4 $\mu g/m^3$). The 98th percentile 24-hour $PM_{2.5}$ concentrations at both air monitoring stations were low (<19 $\mu g/m^3$) in 2006.

Intermittent Monitoring Program

During 2006, 24-hour average particulate matter (PM_{10} and $PM_{2.5}$) samples were collected at the Powers and Genesee air monitoring stations according to a National Air Pollution Surveillance six-day cycle sampling frequency during 2006:

- Twenty-four hour average $PM_{2.5}$ concentrations were <17 $\mu g/m^3$ at both the Genesee and Powers air monitoring station for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations.
- The maximum 24-hour average PM_{10} concentration at the Powers air monitoring station (62 $\mu g/m^3$) was higher than at the Genesee air monitoring stations (43 $\mu g/m^3$). Greater variation in 24-hour average PM_{10} concentrations was observed at Powers air monitoring station compared with the Genesee air monitoring station.

Passive Monitoring Program

Passive air monitors were deployed at 21 sites in the Wabamun-Genesee area during 2006:

- Annual average NO_2 concentrations ranged from 4.9 to 7.5 $\mu g/m^3$ at passive sites located within 30 km of the generating plants. In contrast, the annual average NO_2 concentration observed at the Edmonton East air monitoring station was 29 $\mu g/m^3$ in 2006. Annual NO_2 concentrations determined by passive monitors increased from sites near Lake Wabamun to sites adjacent to the City of Edmonton.

  This spatial trend is consistent with previous studies in the same area and is due to the influence of increasing urban NO_x emissions adjacent to and within the City of Edmonton. These findings indicate that urban source emissions are more important contributors to ambient NO_2 concentrations, observed in the City of Edmonton and surrounding area, compared to generating plant emissions in the Wabamun-Genesee area.
- Annual average SO_2 concentrations were very low – in the 1.6 to 5.5 $\mu g/m^3$ range – at all passive sites in the Wabamun-Genesee area. The lack of spatial trend observed is consistent with that reported in previous studies for the same area.
- A higher annual average O_3 concentration was observed at a rural background air monitoring station 55 km west of the generating plants (32.4 $\mu g/m^3$ at the Violet Grove air monitoring station) compared with passive monitoring sites directly east of the Wabamun-Genesee area (range 22.1 to 28.3 $\mu g/m^3$) in 2006. A partial explanation for this difference is O_3 scavenging, believed to be a result of increased NO_x emissions, approaching the City of Edmonton from the west.
- Two new passive monitoring sites were started in February 2006 downwind of the generating plants along an imaginary northwest line in which the generating plants are located. These sites are located greater than two to four-hours travel time downwind based on annual average wind speeds in the area. Previous work by others has indicated that generating plant plume chemistry maturity and peak production capacities of anthropogenic O_3 and inorganic nitrogen species occurs between 30 and 100 km downwind of generating plants.

Annual average O_3 concentrations based on 11 months sampling at these two sites – February through December 2006 – were within five percent of the annual average O_3 concentration at the Violet Grove air monitoring station. This difference is within the expected accuracy and precision of the O_3 passive monitoring device used (±15%). These findings initially indicate that observation of anthropogenic O_3 production downwind of generating plant emissions is not readily apparent using passive monitors.

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Abbreviations

AAQO	ambient air quality objective
AENV	Alberta Environment
AMS	air monitoring station
CASA	Clean Air Strategic Alliance
COPCs	Chemicals of Potential Concern
CWS	Canada-Wide Standard
EPEA	Environmental Protection and Enhancement Act
IQR	interquartile range
NAPS	National Ambient Pollutant Surveillance
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
ppb	parts per billion
$PM_{2.5}$	particulate matter ≤ 2.5 μm
PM_{10}	particulate matter ≤ 10 μm
R^2	coefficient of determination
SO_2	sulphur dioxide
TSP	total suspended particulate
MW	megawatts
U.S. EPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WCAS	West Central Airshed Society

1 Introduction

TransAlta Utilities (TransAlta) [www.transalta.com] and EPCOR Generation Inc. (EPCOR) [www.epcor.ca] operate four coal-fired thermal generating plants (generating stations) – Wabamun, Sundance, Keephills, and Genesee – located in the Wabamun-Genesee area of west-central Alberta. The location of these plants is shown in Figure 1-1. Collectively, the four generating plants have a net generating capacity of 4277 MW.

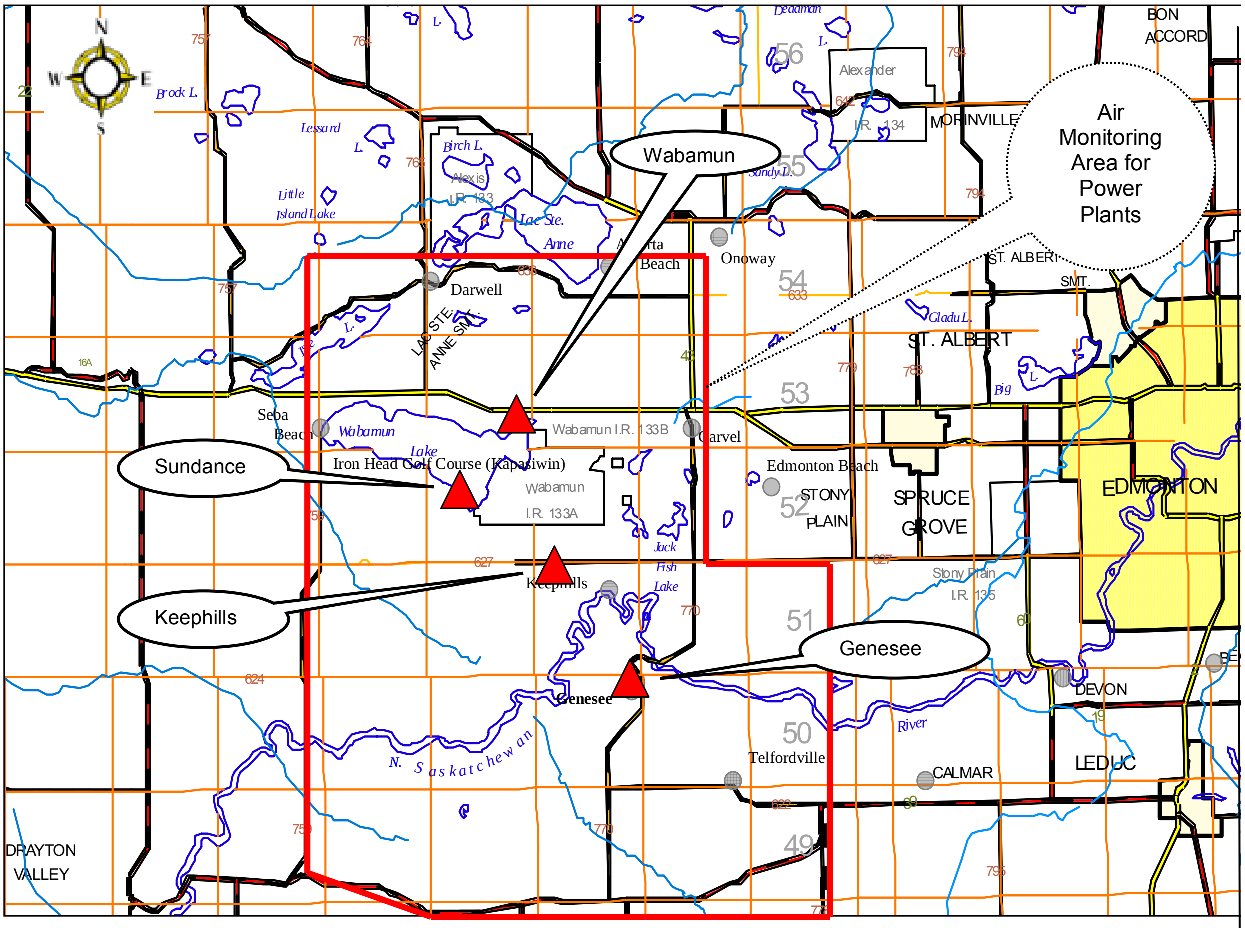


Figure 1-1 Locations of Coal-fired Generating Plants and Air Monitoring Area for Generating Plants in the Wabamun-Genesee Area

Wabamun generating plant is the oldest of TransAlta's three generating plants in the Lake Wabamun area. It is near the Village of Wabamun and has a net generating capacity of 279 MW. Only one generating unit was in operation at the Wabamun plant in 2006. The remaining three units were retired in 2002 (Unit 3) and 2004 (Units 1 and 2).

The TransAlta Sundance generating plant consists of six generating units, and is the largest, coal-fired generating plant in western Canada. Sundance is situated on the south shore of Lake Wabamun, approximately 70 km west of Edmonton, Alberta (Figure 1-1). The plant has been in operation since 1970, with steady expansion from a single original generating unit to six generating units throughout the 1970s. Sundance currently has a net generating capacity of 2020 megawatts (MW).

The Keephills generating plant is located 5 km southeast of Wabamun Lake (Figure 1-1). It has a net generating capacity of 766 MW, and consists of two generating units. Keephills has been in operation since 1983.

The Genesee generating plant, located 50 km southwest of Edmonton, consists of three generating (Figure 1-1). EPCOR fully owns and operates Units 1 and 2, which have a combined net generating capacity of 762 MW. These units have been in operation since 1994 and 1989, respectively. Genesee 3 (Unit 3), commissioned in 2005, is a 50/50 joint venture between TransAlta and EPCOR. Genesee 3 has a net generating capacity of 450 MW.

1.1 Environmental Monitoring Programs for Generating Plants

The generating plants operate under Alberta Environmental Protection and Enhancement Act (EPEA) approvals listed in Table 1-1. Under their EPEA approvals, the generating plants are committed to conducting special environmental monitoring programs. These programs are designed to:

- Identify and quantify ambient levels and deposition patterns of chemical species of potential concern that are associated with generating plant emissions.
- Generate an inventory of representative baseline data for the chemicals of potential concern.
- Provide data for assessing long-term impacts and for evaluating and implementing air quality management plans.

Table 1-1 Alberta Environmental Protection and Enhancement Act (EPEA) Operating Approvals for Four Generating Plants in the Wabamun-Genesee Area

Facility	Capacity (MW, net)	Location	Approval No. (as amended)	Applicable Approval Terms
Wabamun	279	2,3,10,11-53-04 W5M	10323-02-00	6.1.18 to 6.1.24; 6.1.32 to 6.1.34
Sundance	2020	3,4,8,9,10,16,17,20, and 31-52-04 W5M	9830-01-00	13.1.18 to 13.1.24; 13.1.32 to 13.1.34
Keephills	766	36-51-04 W5M	10324-01-00	6.1.18 to 6.1.24; 6.1.32 to 6.1.37
Genesee	1212	25-50-03 W5M	773-02-00	7.1.1 to 7.1.9

A component of the special environmental monitoring program is the development and implementation of an ambient air quality monitoring program. The ambient air quality monitoring program consists of the following elements (Figure 1-2):

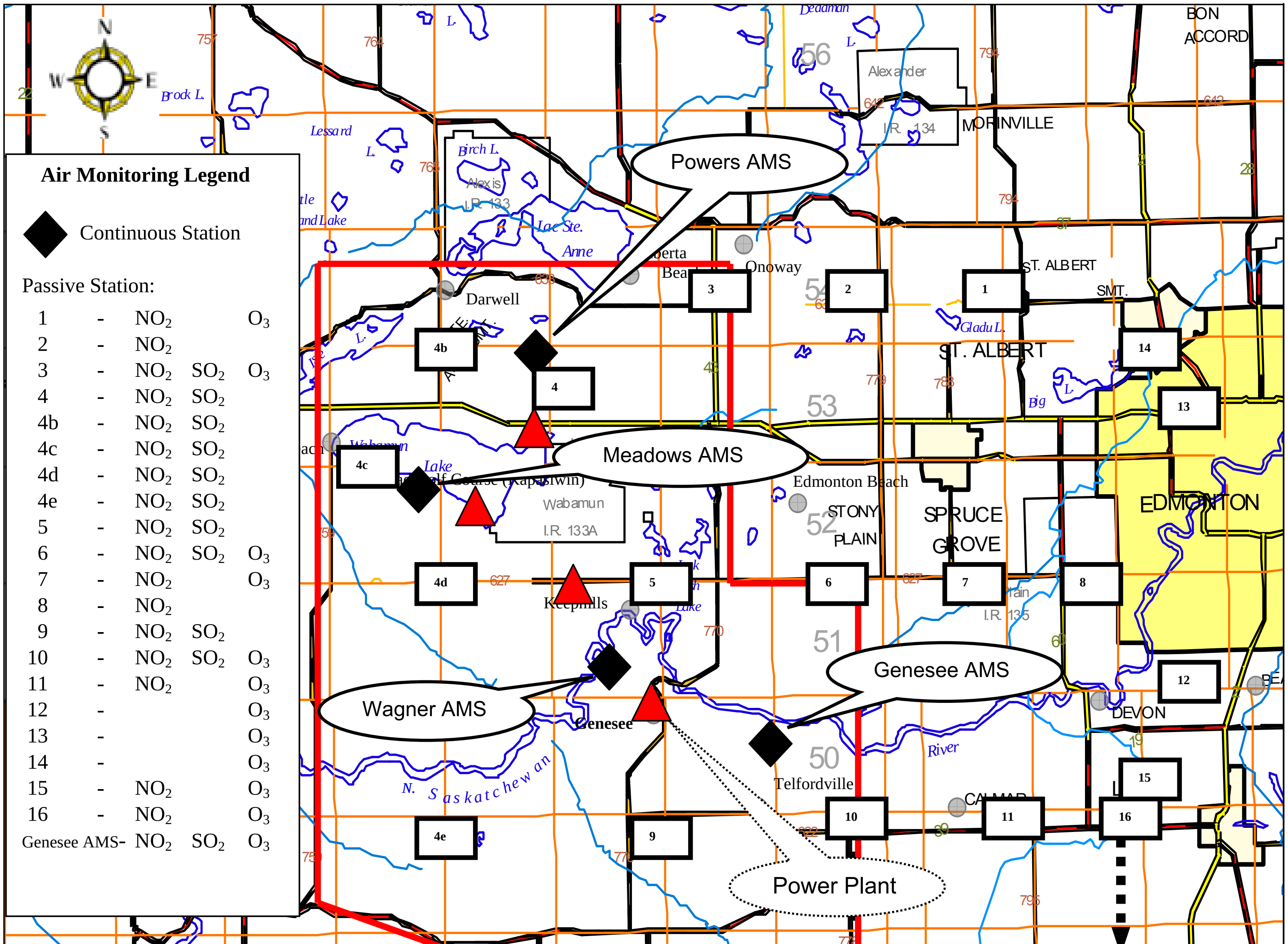


Figure 1-2 Continuous and Passive Monitoring Locations in the Wabamun-Genesee Area during 2006

- A continuous monitoring program for: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and a number of meteorological parameters at four air monitoring stations (AMS) (Genesee AMS, Powers AMS, Meadows AMS, and Wagner AMS); particulate matter with aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$) at two stations (Genesee AMS and Powers AMS); and ozone (O_3) at one station (Genesee AMS).
- An intermittent monitoring program (24 hour sampling every 6 days) for particulate matter with aerodynamic diameter less than or equal to 10 microns (PM_{10}), and $PM_{2.5}$, and metals speciation of the $PM_{2.5}$ at two stations (Genesee AMS and Powers AMS).
- A passive monitoring program consisting of monthly passive monitoring at 21 locations in the Wabamun-Genesee area for NO_2, SO_2, and O_3.

Specific clauses within the EPEA approvals that refer to the ambient air quality monitoring program are provided in Table 1-1.

1.2 Purpose of Report

This annual report presents and analyzes information collected as part of the 2006 ambient air monitoring program. These data provide a basis for developing an understanding of the state of air quality in relation to emissions from the four coal-fired generating plants in the Wabamun-Genesee area. Monitoring components associated with an acid deposition assessment program and a mercury assessment program in the Wabamun-Genesee area are reported separately in stand-alone reports (TransAlta and EPCOR 2007a, b).

2 Background on Air Quality Parameters Monitored

A number of chemicals of potential concern are emitted from the coal-fired generating plants in the Wabamun-Genesee area. With respect to the ambient air monitoring program, these chemicals of potential concern (COPCs) include: oxides of nitrogen, sulphur oxides, ground level ozone, and airborne particulate matter. The importance of these COPCs is discussed below.

2.1 Oxides of Nitrogen

Oxides of nitrogen (NO_x) are made up of nitrogen dioxide (NO_2) and nitric oxide (NO). They are formed during high temperature combustion processes when nitrogen present in hydrocarbon fuel and combustion air reacts with oxygen in combustion air to form NO. NO quickly reacts with ozone in ambient air to form NO_2 (Environment Canada 2006a). The major emission sources of NO_x are transportation, electrical utilities, and industrial, commercial and residential fuel-burning sources (U.S. EPA 1998a). NO_x contributes to formation of ozone, acid aerosols, nitrate particulates, acid rain, and nutrient overload that result in lower water quality (U.S. EPA 1998a).

The Alberta ambient air quality objective (AAQO) for NO_x is expressed as NO_2. NO_x concentrations are typically expressed as NO_2, for comparison to an AAQO. CASA (2006) reports that a 10-year average concentration of NO_2 measured at a rural background location in Alberta (Hightower Ridge) is 8 ppb (15 $\mu g/m^3$).

2.2 Sulphur Dioxide

Sulphur dioxide (SO_2) is formed from sulphur present in raw materials such as coal, fuel oils, and metallic ores (Environment Canada 2006b). SO_2 reacts with water vapour in air to form acidic sulphur compounds and particulates (U.S. EPA 2000). Major sources of SO_2 are metal smelters, fossil fuel-fired generating plants, transportation, upstream oil and gas, and other industrial facilities. CASA (2006) reports that a 10-year average concentration of SO_2 measured at a rural background location in Alberta (Hightower Ridge) is 2 ppb (5 $\mu g/m^3$).

2.3 Ground-Level Ozone

Ground-level ozone (O_3) is a secondary pollutant, which means that it is not directly emitted into the atmosphere. It is formed through a series of photochemical reactions between NO_x and volatile organic compounds (VOCs). Major sources of NO_x were described above. Major emission sources of VOCs are natural (vegetation) and anthropogenic (motor vehicles, petroleum and chemical industries, and other combustion processes). Ground-level ozone may also occur through intrusion of upper stratospheric ozone into the troposphere (ground-level layer of the atmosphere).

The Clean Air Strategic Alliance (CASA 2006) reports that a 10-year average concentration of O_3 measured at a rural background location in Alberta (Hightower Ridge) is 42 ppb (81 $\mu g/m^3$).

He et al. (2005) and Kindzierski et al. (2005) reported that meteorological conditions appear to be the most important factors related to the behaviour of O_3 concentrations (e.g., hourly average O_3 concentration maximums and minimums) observed at three air monitoring stations in west-central Alberta.

It was found by these authors that variation in hourly O_3 concentrations was closely related to changes in hourly temperature, relative humidity, and pressure. This strongly points to the importance of natural phenomena as the predominant factor contributing to the presence of ground-level O_3 at these monitoring sites. Anthropogenic factors (i.e., precursor air pollutants originating from the activity of humans) were less important in relating to the behaviour of hourly O_3 concentrations at these monitoring sites.

2.4 Particulate Matter

Airborne particulate matter (PM) is a complex mix of various pollutants in solid and liquid forms in ambient air. These pollutants include acids (sulphates and nitrates), metals, organic chemicals, and soil or dust particles (U.S. EPA 2006). Airborne particulate matter is commonly distinguished by three different size fractions:

- Total suspended particulate (TSP) – particles with aerodynamic diameters 100 µm or less
- PM_{10} – particles with aerodynamic diameters 10 µm or less
- $PM_{2.5}$ – particles with aerodynamic diameters 2.5 µm or less

CASA (2006) reports that a 10-year average concentration of $PM_{2.5}$ measured at a rural background location (Hightower Ridge) is 2.3 $\mu g/m^3$. Air quality criteria are used to protect human health, safeguard the environment, and for aesthetic purposes. In this case, specific Alberta Ambient Air Quality Objectives (AAQO) and Canada-wide Standards (CWS) exist for these COPCs to aid in the interpretation of measured ambient levels of these pollutants. These objectives and standards are listed in Table 2-1.

Table 2-1 Air Quality Objectives and Standards for Specific COPCs Related to Generating Plant Emissions in the Wabamun-Genesee Area

Parameter	Averaging Time	Alberta Ambient Air Quality Objective	Canada-Wide Standard
NO_x (as NO_2)	1 hour 24 hour annual	400 $\mu g/m^3$ (212 ppb) 200 $\mu g/m^3$ (106 ppb) 60 $\mu g/m^3$ (32 ppb)	- - -
SO_2	1 hour 24 hour annual	450 $\mu g/m^3$ (172 ppb) 150 $\mu g/m^3$ (57 ppb) 30 $\mu g/m^3$ (11 ppb)	- - -
$PM_{2.5}$	24-hour average based on 98th percentile value over 3 consecutive years	-	30 $\mu g/m^3$
O_3	1 hour 8 hour average based on 4th highest value over 3 consecutive years	160 $\mu g/m^3$ (82 ppb) -	- 126 $\mu g/m^3$ (65 ppb)
NOTE: - not applicable			

3 Methods

3.1 Continuous Monitoring Program

Analytical methods used to determine ambient pollutant concentrations for the continuous program conducted at the Genesee, Meadows, Wagner, and Powers air monitoring stations are described in the following sections. Refer to Figure 1-2 for the monitoring locations. Procedures and guidelines for measurement and analysis of air quality parameters listed below are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007).

NO_2

NO_2 is analyzed at Genesee, Meadows, Wagner, and Powers air monitoring stations. NO_2 is measured by chemiluminescence using TECO 42C (Thermo Electron Corporation, Waltham, MA) or equivalent analyzers. NO_x in air is converted to nitric oxide (NO) as it flows over a heated catalyst. The NO is then oxidized by O_3, resulting in light emission during the reaction. The light emission, which is proportional to each molecule of NO that is oxidized, is measured and presented on an NO_2 basis.

SO_2

SO_2 is analyzed at Genesee, Meadows, Wagner, and Powers air monitoring stations. SO_2 is measured with pulsed fluorescence using TECO 43 (Thermo Electron Corporation, Waltham, MA) or equivalent analyzers. Air samples are bombarded with pulses of ultraviolet (UV) light that excite SO_2 molecules to higher energy levels. When the SO_2 molecules return to their original energy state, light is released; this light is measured in the analyzer and is proportional to the amount of SO_2 in air.

O_3

O_3 is measured at Genesee with a TECO 49 UV-absorption ozone analyzer (Thermo Electron Corporation, Waltham, MA) analyzer. This measurement is based on ozone’s ability to absorb UV light. A sample of air is exposed to UV light and the amount absorbed is measured. The UV light absorbed is proportional to the amount of O_3 in air.

$PM_{2.5}$

$PM_{2.5}$ is measured at Powers AMS and Genesee AMS using a tapered element oscillating microbalance (TEOM) (Thermo Electron Corporation, Waltham, MA). Particulates in air are separated by diameter and passed through a filter attached to a tapered element vibrating at its natural frequency. As particles deposit on the filter, the vibration frequency of the element changes in proportion to the mass of particles deposited.

Wind speed, wind direction, air temperature, and relative humidity are monitored at Genesee, Meadows, Wagner, and Powers air monitoring stations using standard meteorological monitoring equipment.

In 2006, West Central Airshed Society (WCAS) technicians maintained and calibrated the analyzers in the continuous stations. The data are reviewed for errors and omissions by WCAS personnel and WBK and Associates Inc. (St Albert, AB) the information is reported on a monthly, quarterly, and annual basis. The raw data are also available to the public on the WCAS website (www.wcas.ca) on a real-time basis.

3.2 Intermittent Monitoring Program

Twenty-four hour average PM_{10} and $PM_{2.5}$ samples are collected at Powers and Genesee air monitoring stations. These samples are collected according to a National Air Pollution Surveillance (NAPS) six-day cycle sampling frequency using Partisols (Thermo Electron Corporation, Waltham, MA). Procedures and guidelines for measurement and analysis of PM_{10} and $PM_{2.5}$ samples are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007).

The Partisols separate particulates in sampled air according to size to allow for size-selective collection on a filter. Technicians from Seacor Environmental Inc. (Edmonton, AB) collected Partisol filters according to a NAPS schedule (see http://www.etcentre.org/NAPS/index_e.html) and shipped the filters to the Alberta Research Council (Vegreville, AB) for gravimetric and metals analyses. Seacor Environmental Inc. personnel reviewed the analytical results on an as-received basis.

Results from metals analyses of 24-hour average $PM_{2.5}$ samples are currently archived and will eventually be used to undertake source apportionment. Source apportionment is the quantitative identification of the relative contributions of different source types to airborne particle concentrations. Source apportionment for $PM_{2.5}$ will define the total contribution that different sources in the Wabamun-Genesee area make to airborne particle concentrations at the Powers and Genesee air monitoring stations. Generally, greater than 100 $PM_{2.5}$ samples are required to undertake source apportionment ($\geq$2 years of monitoring data).

3.3 Passive Monitoring Program

Passive air monitors are deployed at a total of 21 stations in the Wabamun-Genesee area (Figure 1-2). Maxxam Analytics (Edmonton, AB) PASS samplers are deployed for durations of approximately one month to measure SO_2, NO_2, and O_3. Procedures and guidelines for collection and analysis of SO_2, NO_2, and O_3 passive samplers are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007).

The passive approach collects gas from the atmosphere at a rate controlled by the gas' natural diffusion across a membrane. Passive collection of a given air pollutant is achieved by chemical absorption or by physical adsorption onto a medium in the sampler.

Seacor Environmental Inc. technicians collected the passive samplers and deployed fresh passive samplers within two days of the end of each month. The samplers were delivered to Maxxam Analytics (Edmonton, AB) for laboratory analysis.

A schedule for the sampling programs described above is presented in Table 3-1.

Table 3-1 Sampling Schedule for Parameters in the Ambient Air Quality Monitoring Program in the Wabamun-Genesee Area

Parameter	**Continuous**	**Intermittent** (every 6th day (NAPS) schedule)	**Monthly** (passives)
SO_2	•		•
NO_2	•		•
O_3	•		•
PM_{10}		•	
$PM_{2.5}$	•	•	
Wind speed and direction, temperature, relative humidity)	•		

4 Results and Discussion

4.1 Continuous Monitoring Program

4.1.1 Percent Completeness

An important component for ensuring quality for continuous monitoring data is completeness. Completeness indicates the percentage of time that a continuous monitor is capturing valid data. In general, the Air Monitoring Directive (1989) requires greater than 90 percent completeness. Tables 4-1 to 4-4 show data capture rates (percent completeness) for the four continuous air monitoring stations in the Wabamun-Genesee area during 2006.

Table 4-1 Monthly and Annual Data Capture Rates (% completeness) for Genesee Air Monitoring Station during 2006

Parameter	Up-time (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NO_2	100.0	100.0	100.0	100.0	100.0	94.8	100.0	100.0	100.0	99.7	99.9	100.0	99.5
SO_2	100.0	100.0	100.0	100.0	100.0	94.0	100.0	100.0	100.0	99.7	99.9	100.0	99.5
O_3	100.0	100.0	100.0	100.0	100.0	93.9	100.0	100.0	100.0	99.7	99.9	100.0	99.5
$PM_{2.5}$	100.0	96.6	98.8	99.0	99.5	93.6	99.5	99.5	99.6	99.6	99.6	98.5	98.6
WSP	100.0	100.0	100.0	100.0	100.0	93.5	100.0	100.0	100.0	99.7	100.0	100.0	99.4
WDR	100.0	100.0	84.1	100.0	100.0	94.3	100.0	100.0	100.0	99.7	100.0	100.0	98.2
T_2	100.0	100.0	100.0	100.0	100.0	94.3	100.0	100.0	99.2	99.6	99.9	99.9	99.4
T_{10}	100.0	100.0	100.0	100.0	100.0	94.3	100.0	100.0	99.2	99.6	99.9	99.9	99.4
RH	100.0	100.0	100.0	100.0	100.0	94.3	100.0	100.0	99.2	99.7	99.9	100.0	99.4

NOTES:
Key: WSP = wind speed; WDR = wind direction; T_2 = temperature at 2-metre height above ground; T_{10} = temperature at 10-metres height above ground; RH = relative humidity.

Table 4-2 Monthly and Annual Data Capture Rates (% completeness) for Meadows Air Monitoring Station during 2006

Parameter	Up-time (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NO_2	99.6	99.2	100.0	97.8	97.8	100.0	98.9	100.0	99.9	99.2	100.0	94.5	98.9
SO_2	99.6	99.1	100.0	99.9	97.7	100.0	98.9	100.0	99.9	99.2	100.0	94.1	99.0
WSP	99.6	99.3	99.5	99.9	98.0	100.0	99.2	100.0	100.0	99.3	100.0	94.3	99.1
WDR	99.6	99.3	100.0	99.9	98.0	100.0	99.2	100.0	100.0	99.3	100.0	94.3	99.1
T_2	99.6	99.1	100.0	99.9	97.8	100.0	98.8	100.0	99.9	99.2	100.0	94.3	99.1
RH	99.6	99.1	100.0	99.9	97.8	100.0	98.8	100.0	99.9	99.2	100.0	94.3	99.1

NOTES:
Key: WSP = wind speed; WDR = wind direction; T_2 = temperature at 2-metre height above ground; RH = relative humidity.

Table 4-3 Monthly and Annual Data Capture Rates (% completeness) for Wagner Air Monitoring Station during 2006

Parameter	Up-time (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NO_2	100.0	98.2	100.0	99.3	100.0	100.0	91.1	8.3	98.9	99.2	100.0	99.9	91.2
SO_2	100.0	97.8	100.0	99.3	100.0	100.0	97.2	100.0	99.0	100.0	100.0	99.9	99.4
WSP	100.0	97.9	100.0	99.3	100.0	100.0	99.9	100.0	99.2	100.0	98.3	100.0	99.5
WDR	100.0	97.9	100.0	99.3	100.0	100.0	99.9	100.0	99.2	100.0	98.3	100.0	99.5
T_2	100.0	97.9	100.0	99.3	100.0	100.0	99.9	99.9	99.0	99.9	100.0	99.9	99.6
RH	100.0	97.9	100.0	99.3	100.0	100.0	99.9	100.0	99.0	100.0	100.0	99.9	99.7

NOTES:
Key: WSP = wind speed; WDR = wind direction; T_2 = temperature at 2-metre height above ground; RH = relative humidity.

Table 4-4 Monthly and Annual Data Capture Rates (% completeness) for Powers Air Monitoring Station during 2006

Parameter	Up-time (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NO_2	100.0	100.0	100.0	99.6	100.0	100.0	99.9	99.9	99.9	100.0	100.0	100.0	99.9
SO_2	100.0	100.0	100.0	99.6	100.0	100.0	99.9	99.9	99.9	100.0	100.0	100.0	99.9
$PM_{2.5}$	99.5	99.3	98.9	98.3	98.8	97.8	97.8	99.2	98.5	99.1	100.0	99.2	98.9
WSP	100.0	100.0	100.0	99.9	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	100.0
WDR	100.0	100.0	100.0	99.9	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	100.0
T_2	100.0	100.0	100.0	99.6	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	99.9
RH	100.0	100.0	100.0	99.6	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	99.9

NOTES:
Key: WSP = wind speed; WDR = wind direction; T_2 = temperature at 2-metre height above ground; RH = relative humidity.

Data capture rates for all stations were well above the 90 percent criterion on a monthly basis as stipulated in the Air Monitoring Directive (1989), except as noted. High up-times indicate that equipment in the continuous air monitoring network was generally well-maintained. The $NO/NO_2/NO_x$ sensor at the Wagner AMS was removed from service near the end of July due to damage caused by static on the telephone line. This was reported to Alberta Environment on August 17, 2006 under reference #175470. The sensor was not returned to service until August 29, resulting in only 8.3 percent up-time during August. The sensor has been functioning properly since.

4.1.2 Air Pollutant Concentration Statistics

One method of displaying a set of air quality data is with box-and-whisker plots. Box-and-whisker plots are helpful in interpreting the distribution of data because they only illustrate certain statistics rather than all the data. The plots presented here show five values for individual pollutants collected at each station during 2006 – 25th percentile (bottom of box), 50th percentile (line inside box), 75th percentile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). In some cases, the 98th percentile (diamond symbol) rather than the annual arithmetic mean concentration is shown. The bottom whisker is not shown in plots presented here because the values represented by bottom whiskers are unessential for data interpretation.

Figures 4-1 and 4-2 are box-and-whisker plots that compare key statistical values for 1-hour and 24-hour NO_2 concentrations observed at: the four ambient air monitoring stations, a background station relative to the air monitoring area for generating plants (Carrot Creek), and an urban station (Edmonton East station) relative to Alberta's Ambient Air Quality Objectives (AAQOs). In Figures 4-1 and 4-2, the bottom of the yellow zone, boundary of the yellow and blue zones, top of the blue zone, and top tee represent the 25th, 50th, 75th, and maximum values, respectively. The star symbol in each plot represents the annual arithmetic mean concentration.

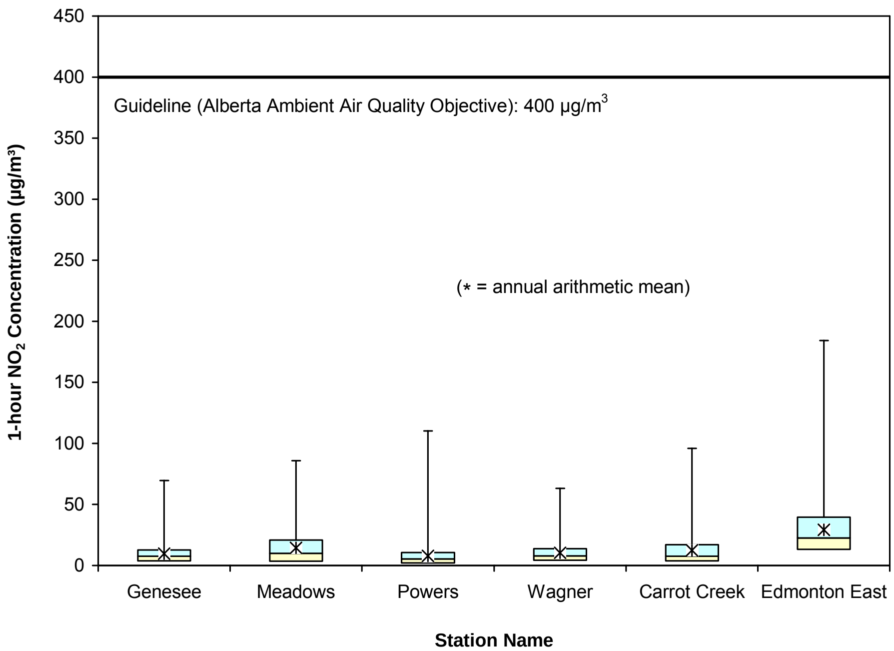


Figure 4-1 Box-and-Whisker Plot of 1-hour Average NO_2 Concentrations at Selected Air Monitoring Stations in Central Alberta during 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol).

Figures 4-1 (1-hour) and 4-2 (24-hour) show that NO_2 concentrations at all stations were well below the respective AAQO for both 1-hour and 24-hour averaged concentrations. Average NO_2 concentrations represented less than three percent of the 1-hour AAQO and less than five percent of the 24-hour AAQO. NO_2 concentrations were highest at the urban (Edmonton East) air monitoring station for both averaging periods, reflecting the influence of motor vehicles on ambient concentrations at this urban location. Of the four generating plant air monitoring stations, 1-hour NO_2 concentrations ranged from a minimum of < 0.1 $\mu g/m^3$ at all stations to a maximum of 110 $\mu g/m^3$ at the Powers AMS. Annual average NO_2 concentrations at all stations except Edmonton East were comparable to the 10-year average concentration reported by CASA (2006) for Hightower Ridge (5 $\mu g/m^3$). There were no exceedances of the AAQO in 2006.

The interquartile range (IQR) is the distance between the 75th percentile and the 25th percentile for a set of data (i.e., height of each box in Figures 4-1 and 4-2). The IQR provides a good quantitative indication of the variation or degree to which values in a set of data are spread out or clustered together because it is not affected by outliers or extreme values. Of the generating plant air monitoring stations, the largest IQR (i.e., largest box) occurred for the Meadows AMS for hourly data (Figure 4-1) and for 24-hour data (Figure 4-2). However, IQRs for NO_2 at the Meadows AMS are narrow (e.g., only 8.8 $\mu g/m^3$ for hourly concentrations), indicating little variation in hourly concentrations throughout 2006.

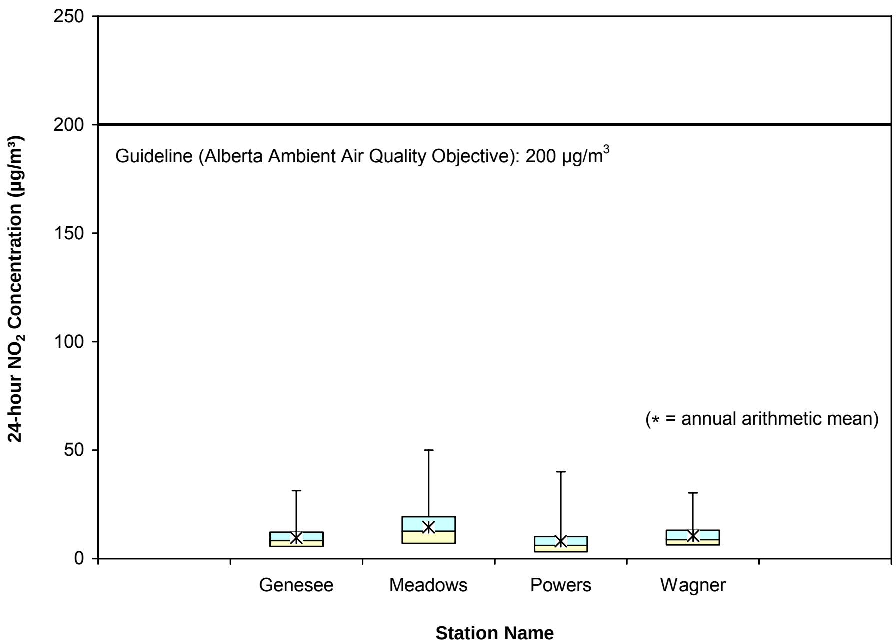


Figure 4-2 Box-and-Whisker Plot of 24-hour Average NO_2 Concentrations at Selected Air Monitoring Stations in Central Alberta during 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol).

Another method of displaying a set of air quality data is with a cumulative distribution plot. A cumulative distribution plot shows the fraction (or percentage) of concentration values for a pollutant that is less than or equal to a particular value. Figure 4-3 shows a cumulative distribution plot for hourly NO_2 concentrations at each of the stations in the Wabamun-Genesee area. Key percentile values (50^{th}, 65^{th}, 80^{th}, 95^{th}, and 98^{th}) are shown in this plot to assist in comparison with future data to allow examination of trends in ambient air pollutant concentrations using simple methods described by Faisal et al. (2006), Haque et al. (2006) and Xu et al. (2006).

These key percentile values can be calculated from year to year to examine changes to air quality over time. Statistically significant changes from year to year in these key percentile values are indicative of trends (changes) in the concentration data. Cumulative distribution data from the Genesee, Powers, and Wagner air monitoring stations (Figure 4-3) followed the same general distribution. The Meadows AMS data exhibited a greater concentration variation between the 50^{th} and 98^{th} percentile values compared with the other stations. Overall, hourly NO_2 concentrations were low at all four air monitoring stations (<55 $\mu g/m^3$ for 98 percent of time during 2006).

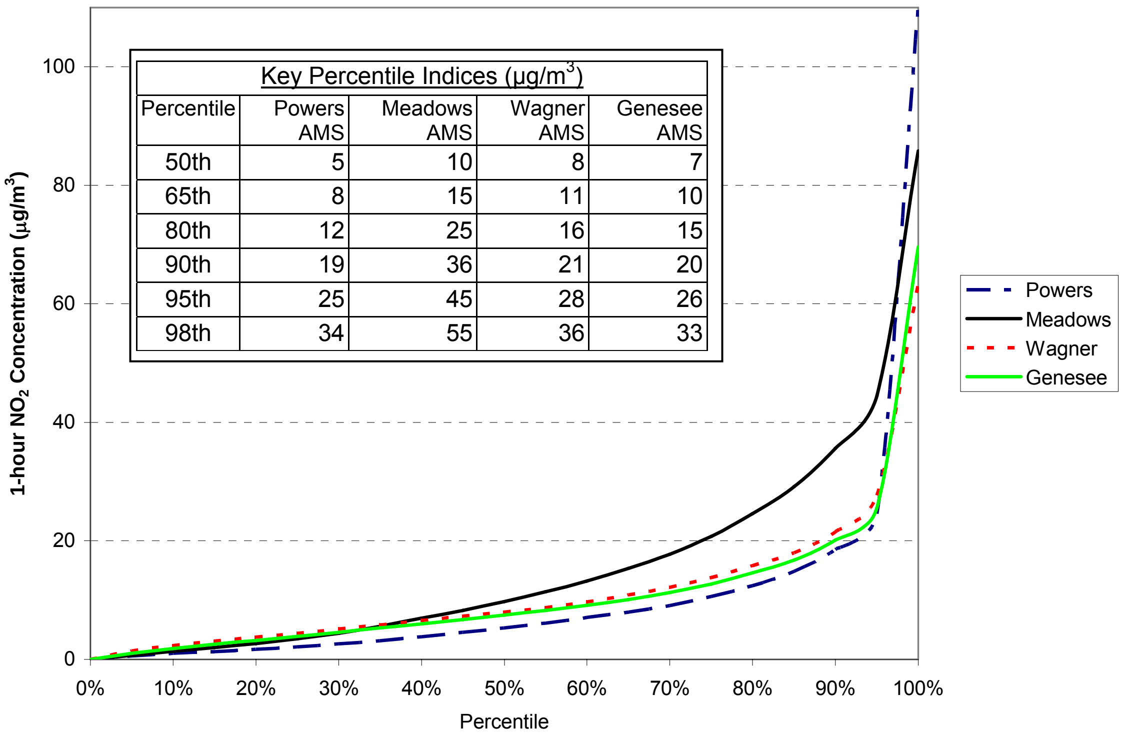


Figure 4-3 Cumulative Distribution Plot of 1-hour Average NO_2 Concentrations at Air Monitoring Stations in the Wabamun-Genesee Area during 2006

Figures 4-4 and 4-5 are box-and-whisker plots for 1-hour and 24-hour SO_2 concentrations, respectively. As shown in Figure 4-4, median (50^{th} percentile) hourly SO_2 concentrations at all four generating plant air monitoring stations were low (1 µg/m^3). All 1-hour and 24-hour concentrations were well below AAQOs.

One-hour SO_2 concentrations ranged from <0.1 µg/m^3 at all stations to 105 µg/m^3 at the Powers AMS. Annual average SO_2 concentrations at the air monitoring stations represented approximately one percent of the hourly AAQO and two percent of the 24-hour AAQO for SO_2. Annual mean 1-hour and 24-hour concentrations were less than the 10-year average measured at Hightower Ridge (5 µg/m^3). There were no exceedances of any AAQO in 2006.

Of the generating plant air monitoring stations, the Wagner AMS had the largest IQR (i.e., largest box) for hourly data (Figure 4-4) and for 24-hour data (Figure 4-57). However, IQRs for SO_2 at the Wagner AMS are very narrow (e.g., only 2 µg/m^3 for hourly concentrations), indicating very little variation in hourly concentrations throughout 2006.

Figure 4-6 shows the cumulative distribution and key percentile values for hourly SO_2 concentrations at the Genesee, Wabamun, Meadows and Powers air monitoring stations. SO_2 cumulative distribution curves were similar at all four air monitoring stations. Overall, hourly

SO_2 concentrations were very low at all four stations (<34 μg/m^3 for 98 percent of time during 2006).

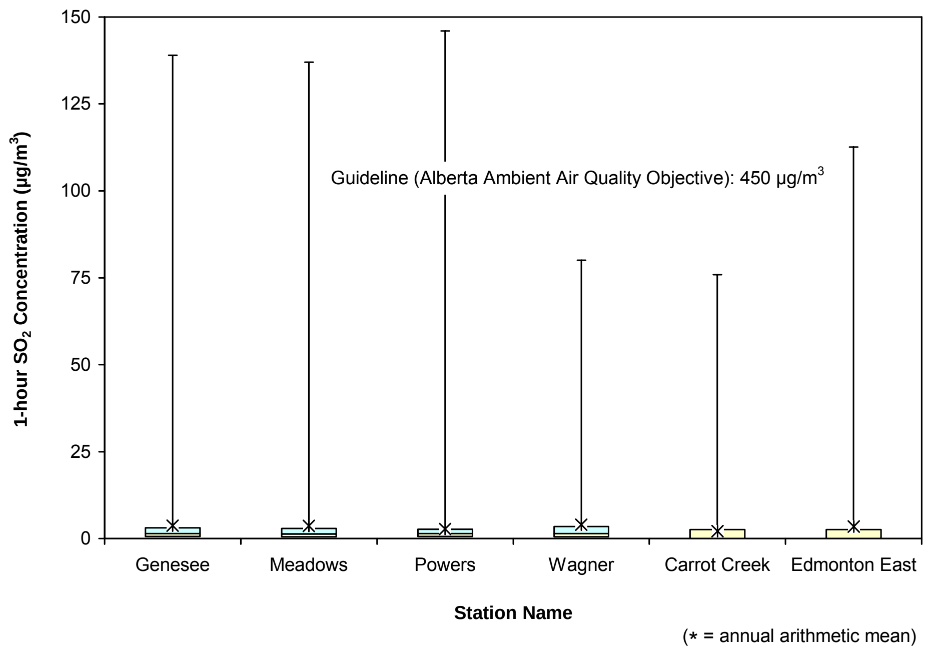


Figure 4-4 Box-and-Whisker Plot of 1-hour Average SO_2 Concentrations at Selected Air Monitoring Stations in Central Alberta during 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol).

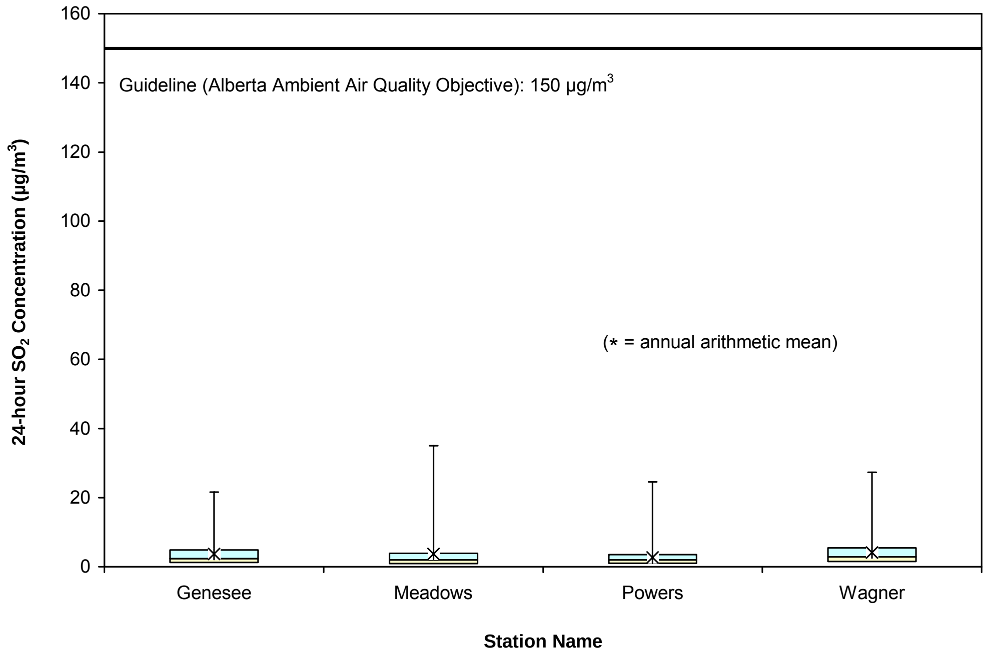
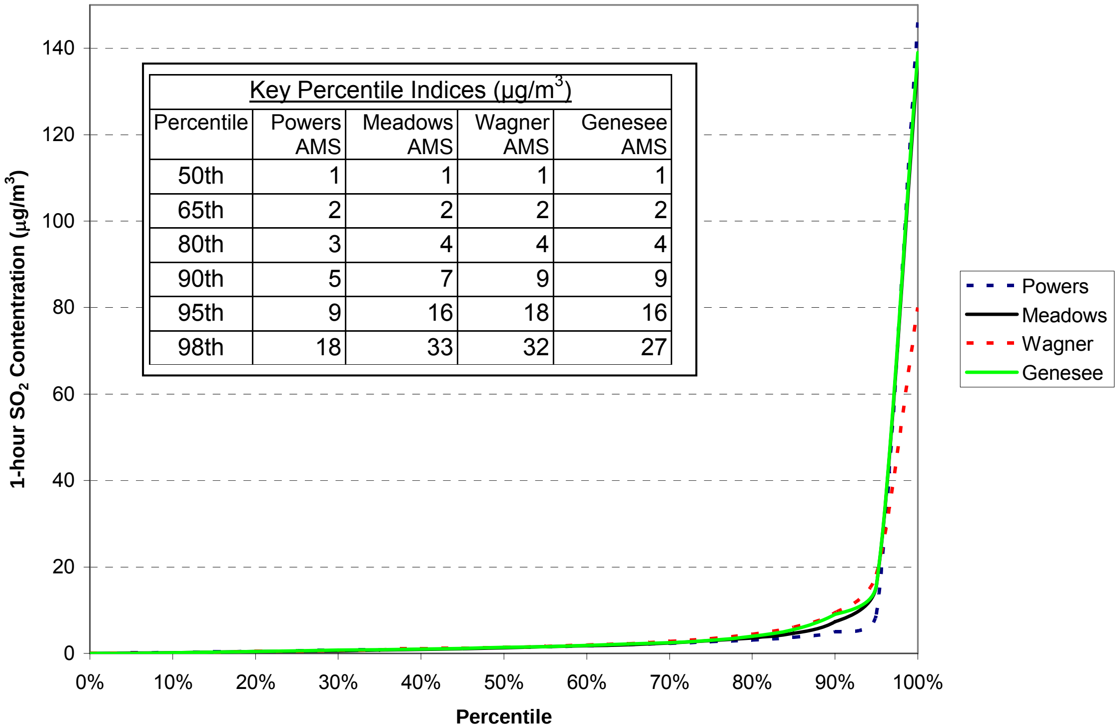


Figure 4-5 Box-and-Whisker Plot of 24-hour Average SO_2 Concentrations at Selected Air Monitoring Stations in Central Alberta during 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol).



Percentile	Powers AMS	Meadows AMS	Wagner AMS	Genesee AMS
50th	1	1	1	1
65th	2	2	2	2
80th	3	4	4	4
90th	5	7	9	9
95th	9	16	18	16
98th	18	33	32	27

Figure 4-6 Cumulative Distribution Plot of 1-hour Average SO_2 Concentrations at Air Monitoring Stations in the Wabamun-Genesee Area during 2006

Figure 4-7 is a box-and-whisker plot of 1-hour O_3 concentrations measured at the Genesee, Carrot Creek, and Edmonton East air monitoring stations. The annual hourly average O_3 concentration at the Genesee AMS was 53 $\mu g/m^3$, which is similar to the annual hourly average O_3 concentration observed in 2005 (54 $\mu g/m^3$). Hourly O_3 concentrations at Genesee ranged up to 175 $\mu g/m^3$. The smallest IQR for O_3 (35 $\mu g/m^3$) occurred at the Genesee AMS for hourly data, indicating that hourly O_3 concentrations showed the least amount of variation at this location compared with the Carrot Creek AMS and Edmonton East AMS.

The 25th, 50th, 75th, and maximum concentration values at the Edmonton East AMS were generally lower than that observed at the Genesee AMS and Carrot Creek AMS, consistent with O_3 trend data reported by Kindzierski et al. (2006) and Kindzierski (2006) over the last seven years in central Alberta. The main reason for these lower concentrations observed at the Edmonton East AMS is due to scavenging with NO_x from urban motor vehicle emissions.

Figure 4-8 shows the cumulative distribution and key percentile values for hourly O_3 concentrations at the Genesee AMS during 2006. Hourly O_3 concentrations were <119 $\mu g/m^3$ for 98 percent of time during 2006.

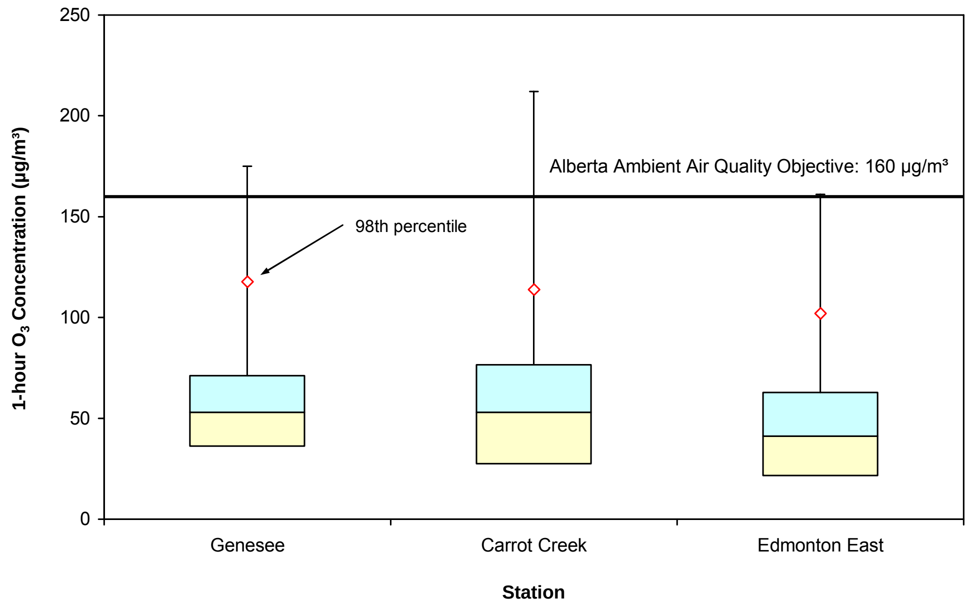


Figure 4-7 Box-and-Whisker Plot of 1-hour Average O_3 Concentrations at Selected Air Monitoring Stations in Central Alberta during 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile (diamond symbol).

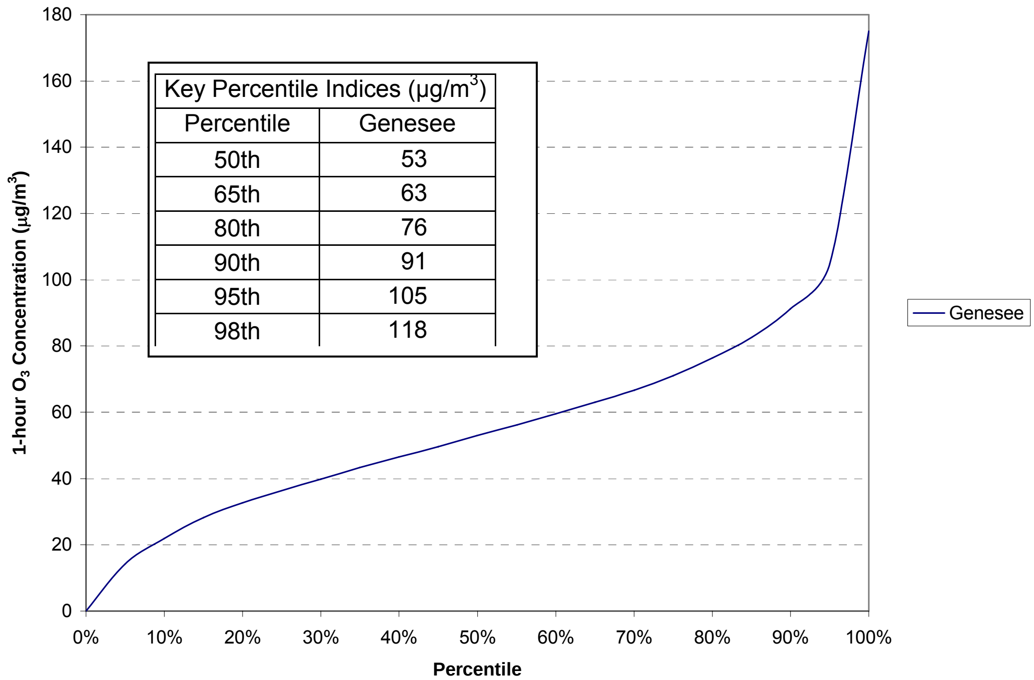


Figure 4-8 Cumulative Distribution Plot of 1-hour Average O_3 Concentrations at the Genesee Air Monitoring Station during 2006

Figure 4-9 is a box-and-whisker plot of 24-hour $PM_{2.5}$ concentrations measured at the Genesee AMS and Powers AMS in 2004, 2005, and 2006. Median (50th percentile) 24-hour $PM_{2.5}$ concentrations at both stations were low, ≤4 μg/m^3 for all years. The 98th percentile 24-hour $PM_{2.5}$ concentrations at both air monitoring stations were low (≤14 μg/m^3) for all years. These values are well below the 98th percentile, three-year average Canada-wide Standard (CWS) of 30 μg/m^3 also shown in Figure 4-9. Interquartile ranges for 24-hour $PM_{2.5}$ concentrations at both air monitoring stations were very narrow (≤4.5 μg/m^3), indicating very little variation in 24-hour average concentrations throughout 2004, 2005, and 2006.

Both the Genesee AMS and Powers AMS had 24-hour average concentrations exceeding the three-year average Canada-wide Standard (CWS) of 30 μg/m^3 in 2006. Upon closer inspection of the corresponding exceedence-days at these stations it was revealed that they occurred in July. One exceedence-day (July 6th) occurred at the Genesee AMS (46 μg/m^3) and two exceedence-days (July 5th and 6th) occurred at the Powers AMS (34 μg/m^3 and 58 μg/m^3, respectively). This time period was a high point in the Alberta forest fire season and the region was noted to be smoky at the time. For example, The West Central Airshed Society Tomahawk AMS 24-hour $PM_{2.5}$ concentration recorded on July 6th was 50 μg/m^3. However, Figure 4-9 shows that the 98th percentile $PM_{2.5}$ concentrations for the year 2006 well below the Canada Wide Standard (24-hour average) of 30 μg/m^3 at both the Genesee and Powers air monitoring stations.

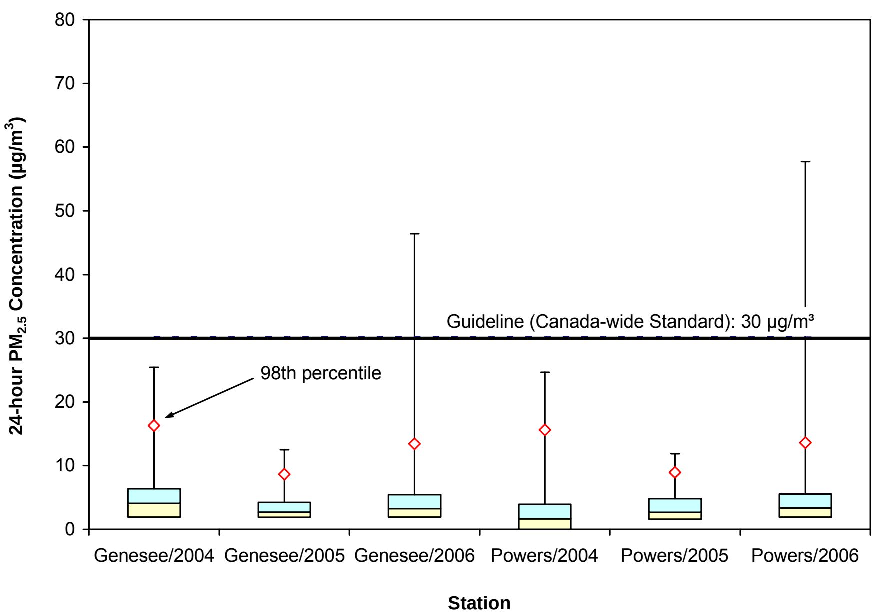


Figure 4-9 Box-and-Whisker Plot of 24-hour Average $PM_{2.5}$ Concentrations at the Genesee and Powers Air Monitoring Stations (2004, 2005, and 2006)

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile (diamond symbol).

Figure 4-10 shows the cumulative distribution plot for hourly $PM_{2.5}$ concentrations measured at the Powers and Genesee air monitoring stations. Overall, hourly $PM_{2.5}$ concentrations were low at these two stations, <19 µg/m³ for 98 percent of the time during 2006.

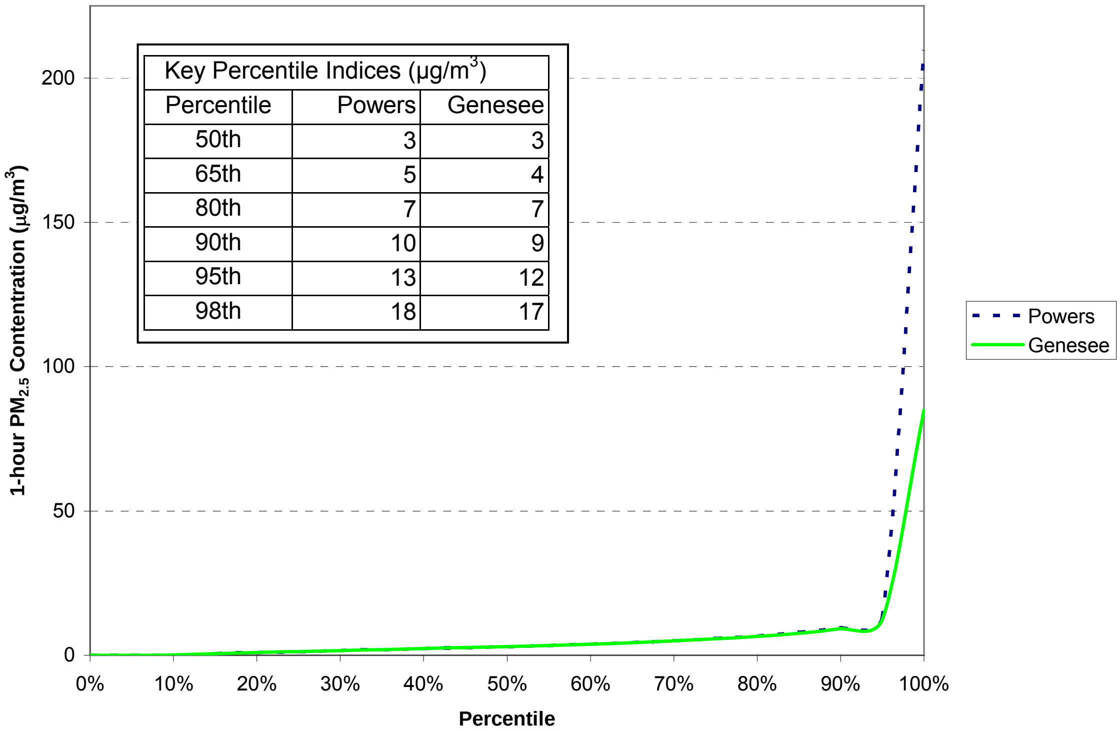


Figure 4-10 Cumulative Distribution Plot of 1-hour Average $PM_{2.5}$ Concentrations at the Powers and Genesee Air Monitoring Stations during 2006

4.1.3 Wind Speed and Direction Statistics

A wind rose plot is used to show information about the distributions of wind speeds, and frequency of the varying wind directions at the air monitoring stations. These plots are derived from hourly meteorological observations of wind speeds and directions. The wind rose plots shown here were divided into 16 sectors, one sector for each 22.5 degrees of the horizon.

The radius of the 16 outermost, wide wedges in a wind rose plot gives the relative frequency of each of the 16 wind directions (i.e., the percent of the time that the wind is blowing from that direction). The colours indicate the wind speed range (in m/s) for a particular direction.

Figures 4-11 to 4-14 show annual wind rose plots for the four air monitoring stations in the Wabamun-Genesee area during 2006. Figure 4-11 shows that winds blew from northwest to southwest directions at the Genesee AMS (about 46 percent of the time). In the case of the Powers AMS (Figure 4-12), winds blew from northwest to southwest directions about 35 percent of the time.

Figure 4-13 shows that winds blew from northwest to southwest directions at the Meadows AMS about 45 percent of the time. In the case of the Wagner AMS (Figure 4-14), winds blew from northwest to southwest directions about 42 percent of the time.

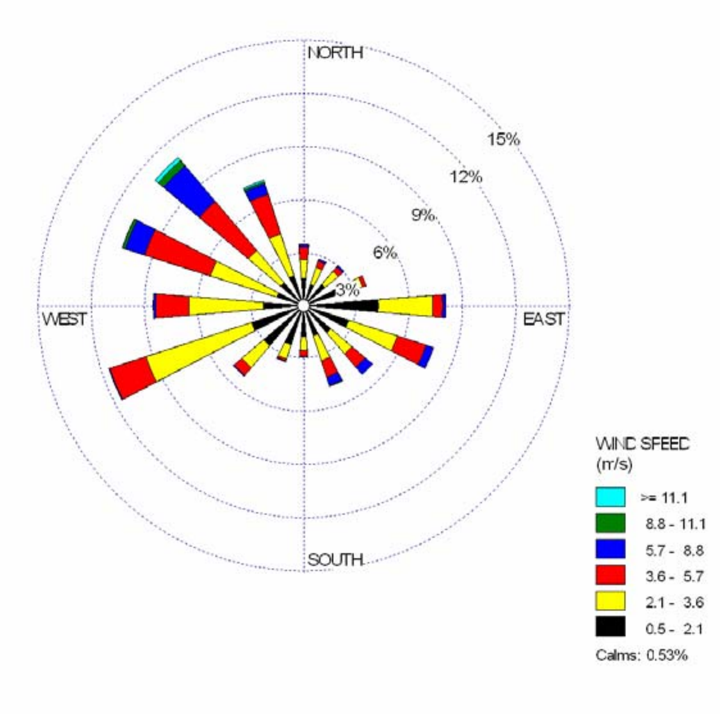


Figure 4-11 Annual Wind Rose Plot for the Genesee Air Monitoring Station during 2006

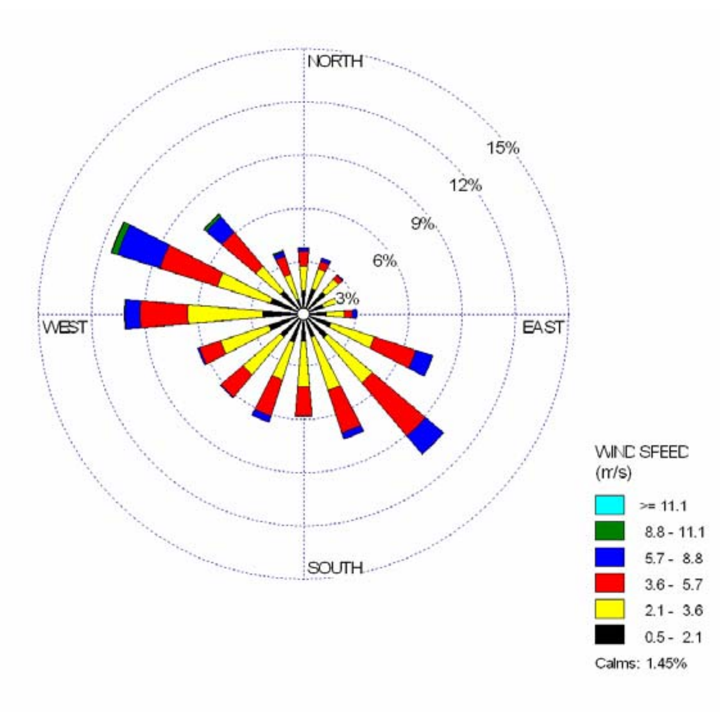


Figure 4-12 Annual Wind Rose Plot for the Powers Air Monitoring Station during 2006

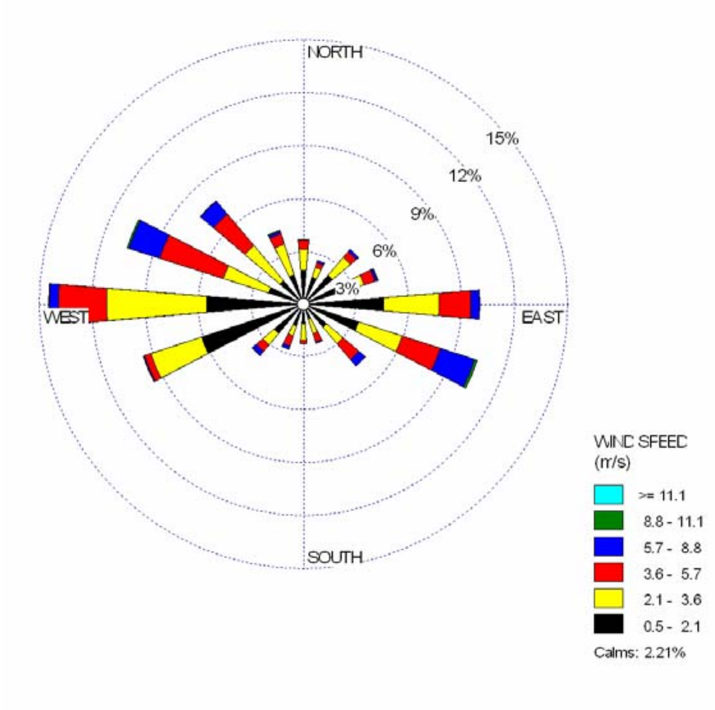


Figure 4-13 Annual Wind Rose Plot for the Meadows Air Monitoring Station during 2006

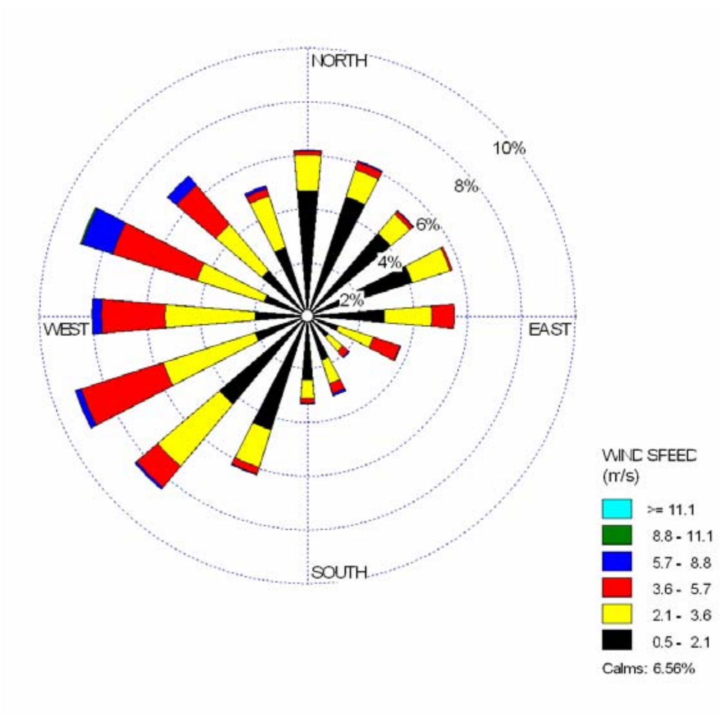


Figure 4-14 Annual Wind Rose Plot for the Wagner Air Monitoring Station during 2006

4.2 Intermittent Monitoring Program

Results of the intermittent PM monitoring program are shown in Figure 4-15 ($PM_{2.5}$) and Figure 4-16 (PM_{10}). Figure 4-15 is a box-and-whisker plot of 24-hour average $PM_{2.5}$ data collected on a 1-in-6 day schedule. Twenty-four hour average $PM_{2.5}$ concentrations were <17 μg/m³ at both the Genesee AMS and Powers AMS for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations during 2006 (Figure 4-9).

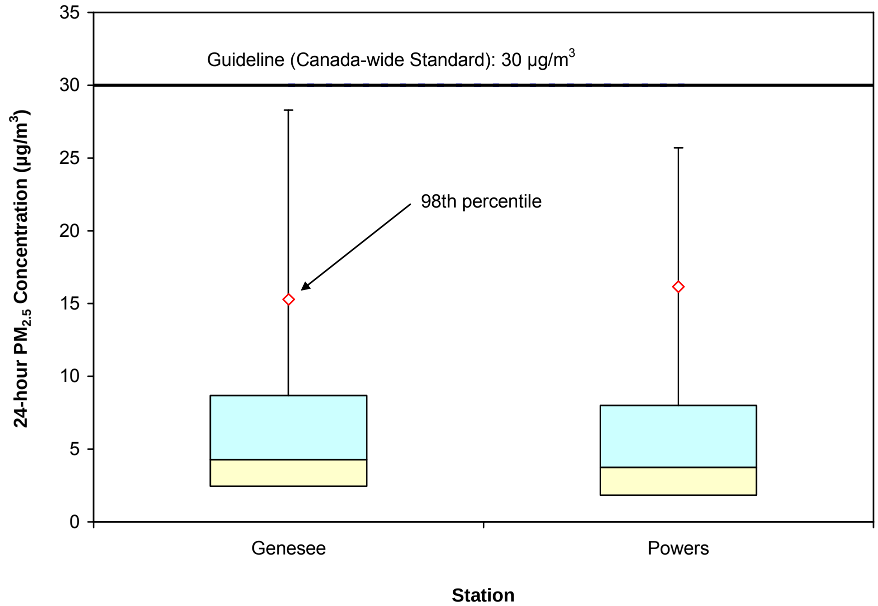


Figure 4-15 Box-and-Whisker Plot of Intermittent 24-hour Average $PM_{2.5}$ Concentrations at Genesee and Powers Air Monitoring Stations in 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile (diamond symbol).

Figure 4-16 is a box-and-whisker plot of PM_{10} concentrations at the Genesee AMS and Powers AMS during 2006. Twenty-four hour average PM_{10} concentrations were <11 μg/m³ at both the Genesee and Powers air monitoring stations for 50 percent of the time. The maximum 24-hour average PM_{10} concentration at the Powers AMS (62 μg/m³) was higher than that at the Genesee AMS (43 μg/m³). Greater variation in 24-hour average PM_{10} concentrations was observed at Powers AMS compared with the Genesee AMS. The IQR at the Powers AMS was 16 μg/m³; whereas the IQR at the Genesee AMS was 10 μg/m³.

Figures 4-17 and 4-18 show 24-hour average $PM_{2.5}$ concentrations versus PM_{10} concentrations at the Genesee and Powers air monitoring stations during 2006. Regression analysis was undertaken to examine the degree of comparison between individual 24-hour average $PM_{2.5}$ concentrations and PM_{10} concentrations. Specific interest was in how well the 24-hour average $PM_{2.5}$ concentration predicts 24-hour average PM_{10} concentrations.

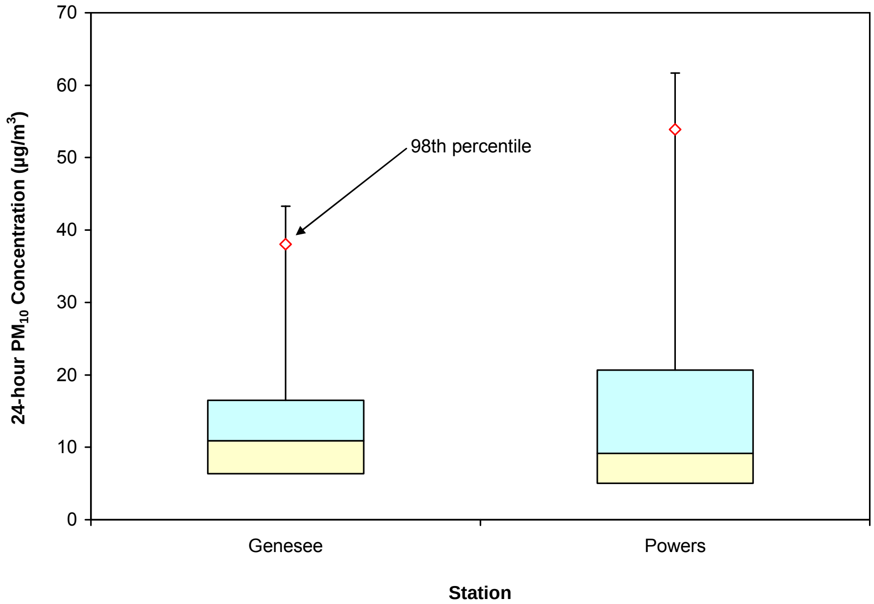


Figure 4-16 Box-and-Whisker Plot of 24-hour Average PM_{10} Concentrations at Genesee and Powers Air Monitoring Stations in 2006

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile (diamond symbol).

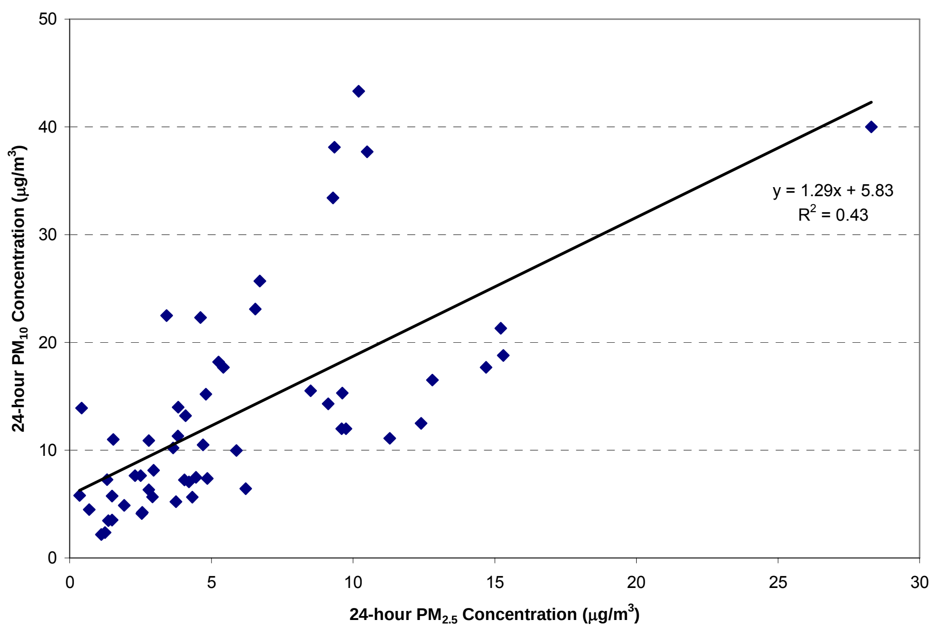


Figure 4-17 Twenty-four Hour Average $PM_{2.5}$ Concentration versus PM_{10} Concentration at the Genesee Air Monitoring Station during 2006

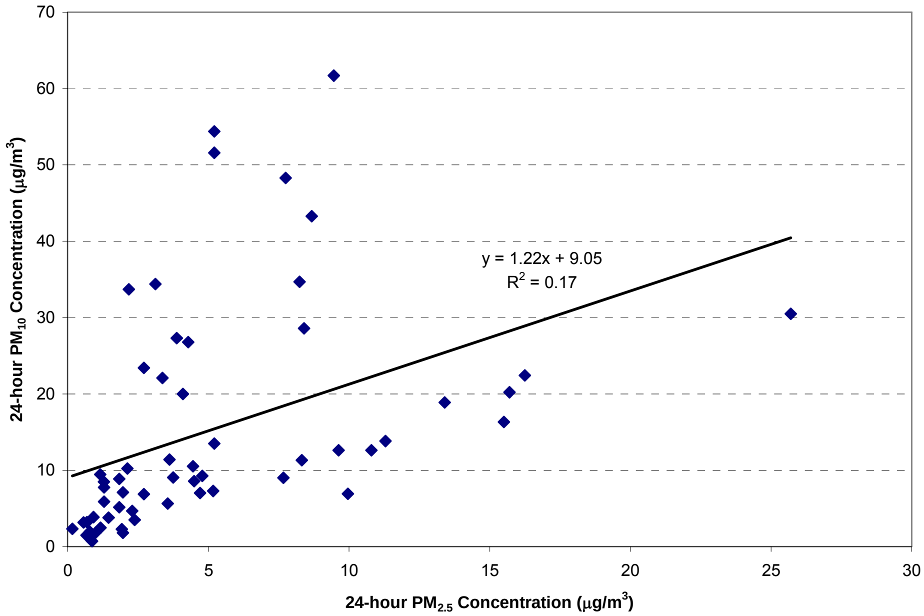


Figure 4-18 Twenty-four Hour Average $PM_{2.5}$ Concentration versus PM_{10} Concentration at the Powers Air Monitoring Station during 2006

Coefficient of determination (R^2) values were calculated from $PM_{2.5}$/PM_{10} matched pair data for each air monitoring station (Genesee and Powers) and are shown in Figures 4-17 and 4-18. A coefficient of determination (R^2) is the proportion of sample variance of a response variable (PM_{10} concentration) that is "explained" by predictor variables ($PM_{2.5}$ concentrations) when a linear regression is done.

Results for the Genesee AMS (R^2 = 0.43, n=55) indicated that only 43 percent of variance in 24-hour average PM_{10} concentrations was explained by variance in 24-hour average $PM_{2.5}$ concentrations. These findings indicate that 24-hour average $PM_{2.5}$ measurements at the Genesee AMS would be poor predictors of expected 24-hour average PM_{10} concentrations.

Results for the Powers AMS (R^2 = 0.17, n=56) indicated that only 17 percent of variance in 24-hour average PM_{10} concentration was explained by variance in 24-hour average $PM_{2.5}$ concentrations. Again these findings indicate that 24-hour average $PM_{2.5}$ measurements at Powers AMS would be poor predictors of expected 24-hour average PM_{10} concentrations.

4.3 Passive Monitoring Program

Bubble plots are used to show spatially the size of measured values. In this case, bubble plots were used to show annual average concentrations of NO_2, SO_2, and O_3 at the 21 passive monitoring sites in the Wabamun-Genesee area during 2006 (Figure 1-2). Annual average concentrations were determined by averaging 12 monthly monitoring results at each passive site. In addition, annual average concentrations of NO_2, SO_2, and O_3 at selected continuous monitoring stations in the area during 2006 were plotted for comparison purposes (Violet Grove

AMS and Edmonton East AMS). This information was obtained from the CASA Data Warehouse for 2006 (http://www.casadata.org/).

4.3.1 Nitrogen Dioxide

Figure 4-19 is a bubble plot of annual average NO_2 concentrations measured at 18 NO_2 passive monitoring sites during 2006. Figure 4-19 indicates that annual NO_2 concentrations determined by passive monitors increase from sites near Lake Wabamun to sites adjacent to the City of Edmonton. This spatial trend is consistent with that reported by Kindzierski (2002) for the same area. This trend is due to the influence of increasing urban source NO_2 emissions adjacent to and within the City of Edmonton.

The highest annual average NO_2 concentration shown in Figure 4-19 was observed at the Edmonton East station (15.6 ppb or 29 $\mu g/m^3$) compared to a range of 2.6 to 4 ppb (4.9 to 7.5 $\mu g/m^3$) observed at passive sites located within 30 km of the generating plants. These data clearly show that urban source emissions are more important contributors to ambient NO_2 concentrations observed in the City of Edmonton and surrounding area relative to generating plant emissions from the Wabamun-Genesee area.

4.3.2 Sulphur Dioxide

Figure 4-20 is a bubble plot of annual average SO_2 concentrations measured at 11 SO_2 passive monitoring sites during 2006. Annual average SO_2 concentrations were very low – in the 0.6 to 2.1 ppb (1.6 to 5.5 $\mu g/m^3$) range across all sites. This lack of spatial trend is consistent with that reported by Kindzierski (2002) for the same area based on a passive monitoring study conducted by Alberta Environment between July 2000 and September 2001 (Myrick 2002). This lack of trend is also consistent with predictions of future cumulative SO_2 emissions in the area associated with the Genesee generating plant expansion (EPCOR 2001), as well as with concentrations measured in the continuous program discussed previously in Section 4.1.2.

4.3.3 Ozone

Figure 4-21 is a bubble plot of annual average O_3 concentrations measured at 12 O_3 passive monitoring sites during 2006. In general, higher annual average O_3 concentrations were observed at a location in the west (Violet Grove AMS) compared with passive monitoring sites directly east of the Wabamun-Genesee area in Figure 4-21.

A partial explanation for this spatial trend is due to O_3 scavenging is believed to be due to increased NO_x emissions approaching the City of Edmonton (Kindzierski et al. 2006; Kindzierski 2006). This spatial trend is consistent with increasing NO_2 concentrations observed towards the City of Edmonton, as observed in Figure 4-19.

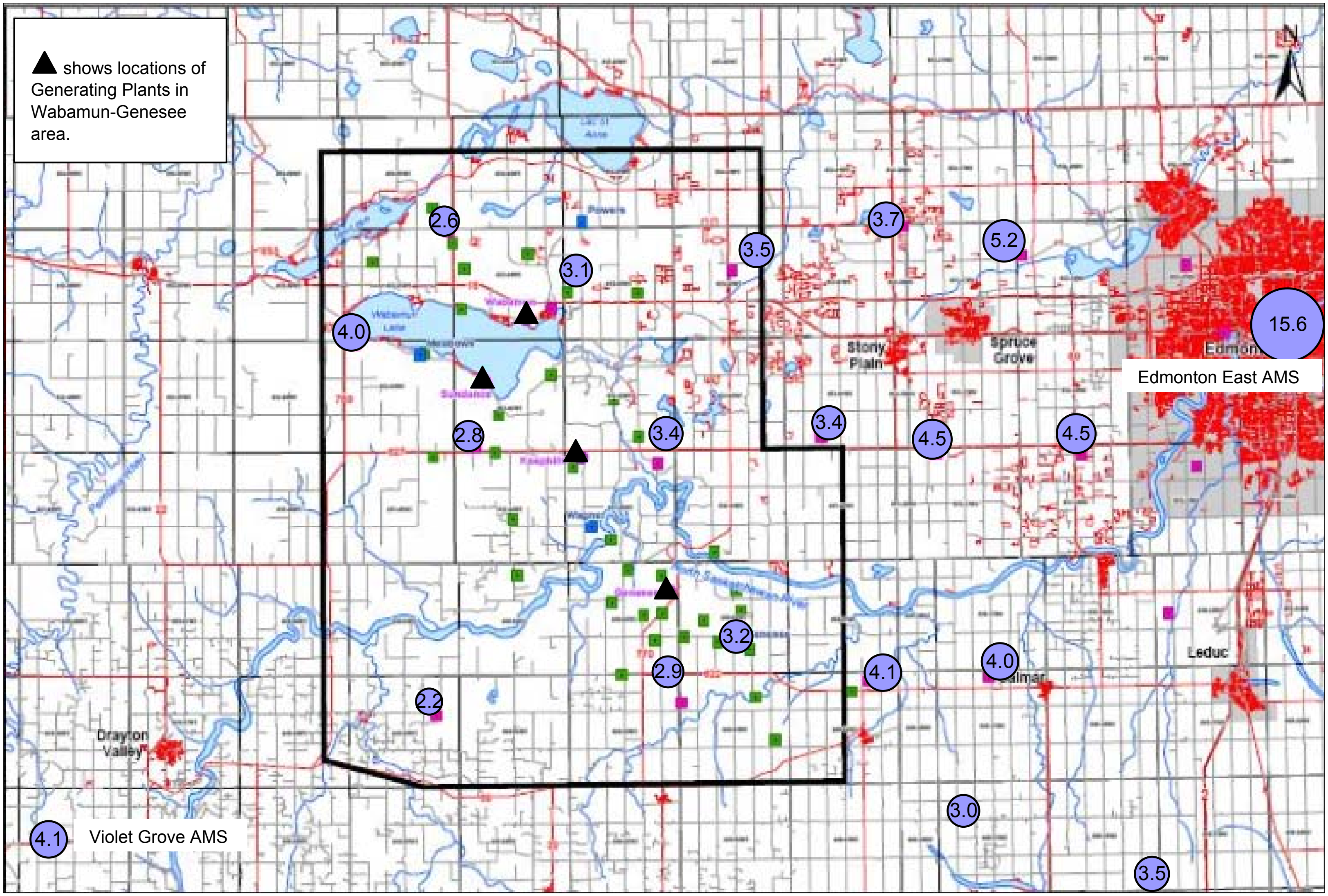


Figure 4-19 Bubble Plot of Annual Average NO_2 Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2006

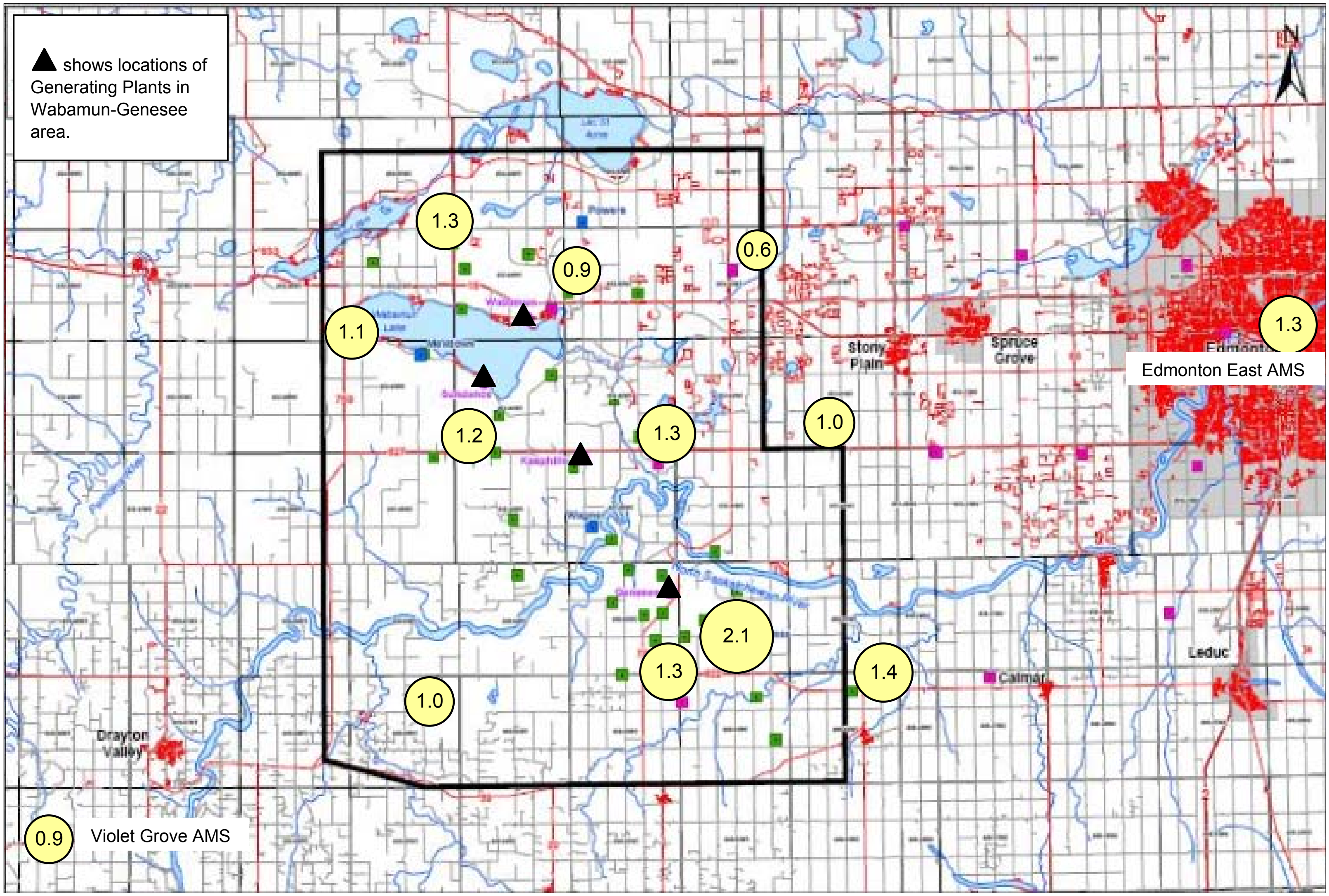


Figure 4-20 Bubble Plot of Annual Average SO_2 Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2006

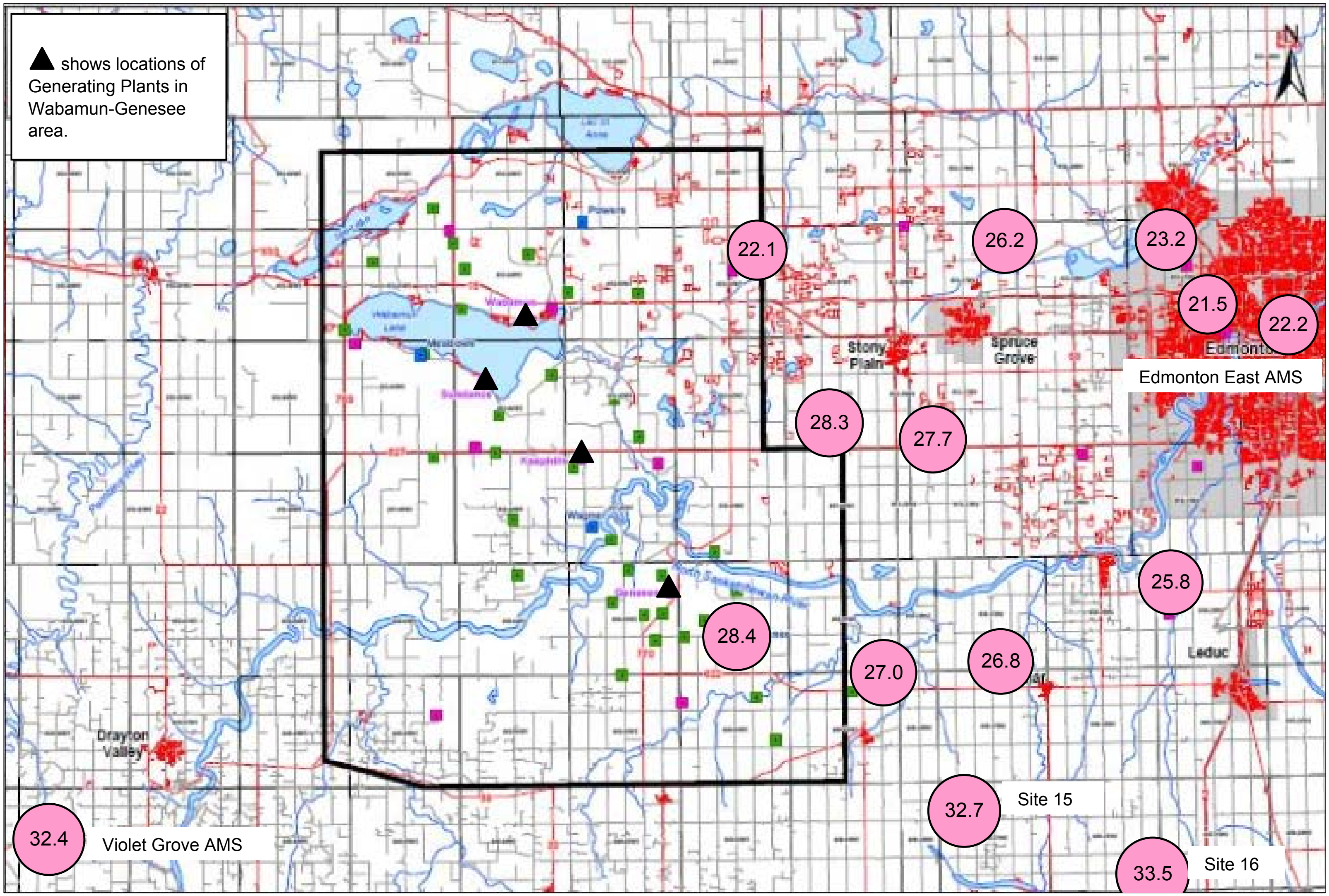


Figure 4-21 Bubble Plot of Annual Average O_3 Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2006

Ozone and NO_2 were analyzed at passive monitoring sites 15 and 16 (Figure 4-21), which were commissioned in February 2006. These sites are situated downwind of a principal wind-flow direction (winds from the northwest) along an imaginary northwest line in which the generating plants are located. Based on annual average wind speeds in the area, these sites are located greater than two- to four-hours travel time downwind of the generating plants. Previous investigations by others (Gillani et al. 1998; U.S. EPA 1998b) have indicated that generating plant plume chemistry maturity and peak production capacities of anthropogenic O_3 and inorganic nitrogen species occurs between 30 to 100 km downwind of generating plants.

Passive monitoring sites 15 and 16 were established to examine whether O_3 levels are higher, lower, or similar compared to O_3 sampling sites closer to the generating plants to help understand whether anthropogenic O_3 production may be occurring further away. It was important to avoid siting these sampling locations near urban areas because the influence of NO_x scavenging becomes more dominant resulting in lower O_3 levels.

Annual average O_3 concentrations at passive monitoring sites 15 and 16 were within five percent of the annual average O_3 concentration at Violet Grove AMS based on 11 months – February through December 2006 (Figure 4-21). This difference is within the expected variation due to accuracy and precision of the O_3 passive monitoring device used (±15 percent). These findings initially indicate that observation of anthropogenic O_3 production downwind of power plant emissions is not readily apparent using passive monitors.

Figure 4-22 shows monthly average concentrations measured at O_3 passive monitoring sites during 2006. Highest monthly average O_3 concentrations observed in the network occurred in spring, peaking in March. This temporal trend is consistent with historical data reported by Kindzierski et al. (2006) and He et al. (2005) for other O_3 monitoring sites in west central Alberta. This seasonal variation is influenced by stratospheric intrusion of O_3 that has been frequently observed in previous studies in Alberta (He et al., 2005; Chaikowsky, 2001; Sandhu, 1999).

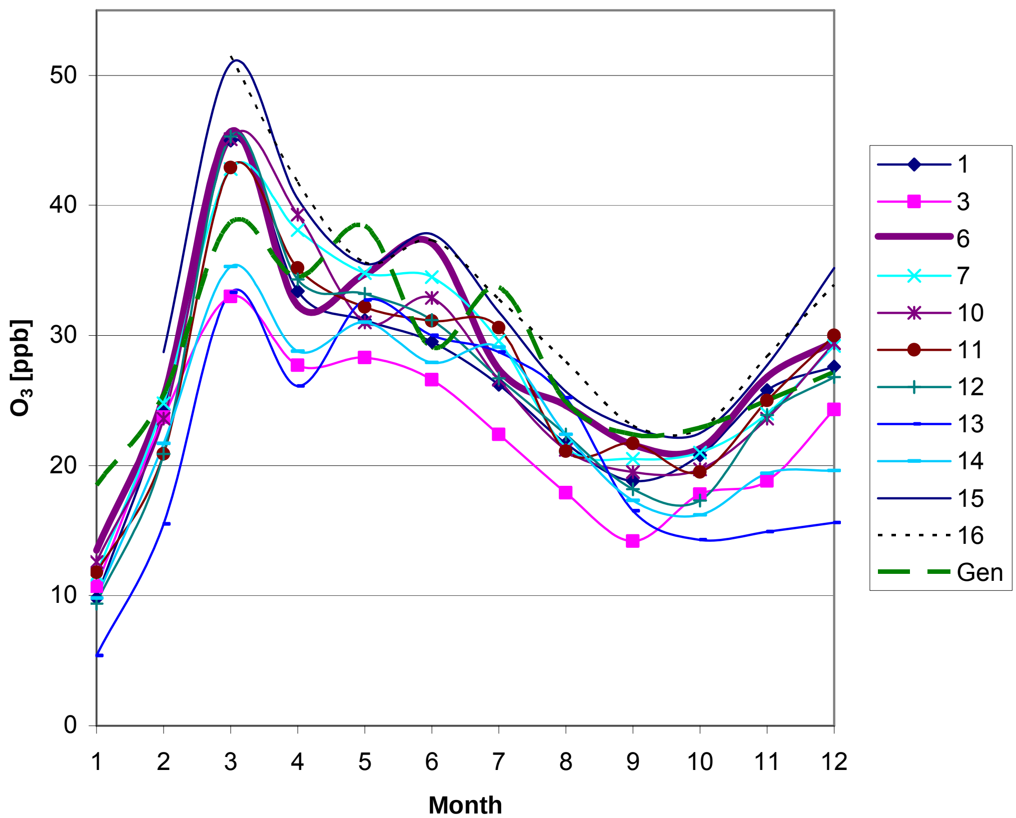


Figure 4-22 Monthly Average O_3 Concentration at Passive Monitoring Sites in Central Alberta during 2006

Note – refer to Figure 1-2 for location of passive stations.

5 Findings

A continuous program was conducted at the Genesee, Meadows, Wagner, and Powers air monitoring stations in the Wabamun-Genesee area during 2006. Data capture rates for measured parameters at all air monitoring stations were above the 90 percent criterion required in the Alberta Environment Air Monitoring Directive. High up-times were indicative that equipment in the continuous air monitoring network was generally well-maintained. The $NO/NO_2/NO_x$ sensor at the Wagner air monitoring station was removed from service near the end of July due to damage caused by static on the telephone line. The sensor was not returned to service until August 29, resulting in 8.3 percent up-time during August. The sensor has been functioning properly since then.

Overall, air quality was interpreted to be good at the monitoring stations during 2006:

- Average nitrogen dioxide (NO_2) concentrations at all of the stations represented less than three percent of the hourly AAQO and less than five percent of the daily AAQO. Hourly NO_2 concentrations were very low at all four air monitoring stations (<55 $\mu g/m^3$ for 98 percent of the time) during 2006.
- Average sulphur dioxide (SO_2) concentrations at all of the stations represented approximately one percent of the hourly AAQO and two percent of the 24-hour AAQO. Hourly SO_2 concentrations were very low at all four air monitoring stations (<34 $\mu g/m^3$ for 98 percent of the time) during 2006.
- The annual average ozone (O_3) concentration at the Genesee AMS was 53 $\mu g/m^3$. This is similar to the annual hourly average O_3 concentration observed in 2005 (54 $\mu g/m^3$). Hourly O_3 concentrations at the Genesee AMS were comparable to that observed at a rural air monitoring station in west central Alberta (Carrot Creek). Hourly O_3 concentrations at the Genesee AMS were <119 $\mu g/m^3$ for 98 percent of the time during 2006.
- Twenty-four hour $PM_{2.5}$ concentrations at the Genesee AMS ranged from <1 to 46 $\mu g/m^3$ in 2006. Twenty-four hour $PM_{2.5}$ concentrations at the Powers AMS ranged from <1 to 58 $\mu g/m^3$ in 2006. Median (50th percentile) 24-hour $PM_{2.5}$ concentrations at both stations were very low ($\leq$4 $\mu g/m^3$). The 98th percentile 24-hour $PM_{2.5}$ concentrations at both air monitoring stations were low (<19 $\mu g/m^3$) in 2006.

Twenty-four hour average PM_{10} and $PM_{2.5}$ samples were collected at the Powers AMS and Genesee AMS according to a National Air Pollution Surveillance (NAPS) six-day cycle sampling frequency during 2006:

- Twenty-four hour average $PM_{2.5}$ concentrations were <17 $\mu g/m^3$ at both the Genesee AMS and Powers AMS for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations during 2006.
- The maximum 24-hour average PM_{10} concentration at the Powers AMS (62 $\mu g/m^3$) was higher than at the Genesee AMS (43 $\mu g/m^3$). Greater variation in 24-hour average PM_{10} concentrations was observed at Powers AMS compared with the Genesee AMS.

Passive air monitors were deployed at 21 stations in the Wabamun-Genesee area during 2006:

- Annual average NO_2 concentrations ranged from 4.9 to 7.5 $\mu g/m^3$ at passive sites located within 30 km of the generating plants, whereas the annual average NO_2 concentration observed at the Edmonton East AMS was 29 $\mu g/m^3$ in 2006. Annual NO_2 concentrations determined by passive monitors increased from sites near Lake Wabamun to sites adjacent to the City of Edmonton.

  This spatial trend is consistent with previous studies in the same area and is due to the influence of increasing urban NO_x emissions adjacent to and within the City of Edmonton. These findings indicate that urban source emissions are more important contributors to ambient NO_2 concentrations, observed in the City of Edmonton and surrounding area, compared with generating plant emissions in the Wabamun-Genesee area.

- Annual average SO_2 concentrations were very low – in the 1.6 to 5.5 $\mu g/m^3$ range – at all passive sites in the Wabamun-Genesee area. This lack of spatial trend is consistent with that reported in previous studies for the same area.

- A higher annual average O_3 concentration was observed at a rural background air monitoring station 55 km west of the generating plants (32.4 $\mu g/m^3$ at Violet Grove air monitoring station) compared with passive monitoring sites directly east of the Wabamun-Genesee area (range 22.1 to 28.3 $\mu g/m^3$) in 2006. A partial explanation for this difference is O_3 scavenging, believed to be a result of increased NO_x emissions approaching the City of Edmonton from the west.

- Two new passive monitoring sites were started in February 2006 downwind of the generating plants along an imaginary northwest line in which the generating plants are located. Based on annual average wind speeds in the area, these sites are located greater than two- to four-hours travel time downwind. Previous work by others has indicated that generating plant plume chemistry maturity and peak production capacities of anthropogenic O_3 and inorganic nitrogen species occurs between 30 and 100 km downwind of generating plants.

  Annual average O_3 concentrations based on 11 months sampling at these two sites – February through December 2006 – were within five percent of the annual average O_3 concentration at the Violet Grove AMS. This difference is within the expected accuracy and precision of the O_3 passive monitoring device used (±15 percent). These findings initially indicate that observation of anthropogenic O_3 production downwind of generating plant emissions is not readily apparent using passive monitors.

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APPENDIX Summary of 2006 Passive Monitoring Data

Table A1. Summary of 2006 NO_2 passive monitoring data (monthly average concentration in ppb).

Station	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	9.6	4.5	6.2	5	4	2.6	2.2	3	3.8	3.8	7.6	9.7
2	7.7	3.3	2.1	1.8	3.7	1.8	2.3	2.9	3.2	5.3	6.2	4.7
3	6.5	3.2	4.6	2.1	1.3	1.7	-	2.7	2.1	2.5	5.2	6.6
4	7	2.7	3.6	2.8	1.5	1.6	1.5	1.8	1.8	-	3.7	5.7
04B	5.7	1.6	1.4	1.9	2.9	1.9	1.9	2.6	2.3	3	3.9	-
04C	8	3.9	3	3.9	2.2	2.6	3.1	3.3	3.5	4	4.4	5.9
04D	5.2	2.9	1.8	2.4	2.3	2.1	3	1.8	3.2	2.8	2.9	3.4
04E	4.8	-	1.4	1.7	1.2	1.6	1.8	1.2	2.2	2.6	2.5	2.7
5	5.7	2.9	3.9	2.8	2.5	2.3	2.2	3.4	2.6	3.3	3.8	5.7
6	5.8	3.2	3.6	2.9	3	2	2.2	2.6	3	3.4	4.2	5
7	7.7	4.5	5	4.2	2.9	3.1	3.2	2.9	4	3.9	5.7	6.9
8	7.7	5.2	5.1	3.6	3.6	2.4	2.5	2.7	3.5	4.3	5.7	8.1
9	4.9	2.7	2.9	1.9	2.6	2.7	2.3	2	2.7	2.7	3.9	3.8
10	7.1	4.4	3.3	3.3	2.7	2.5	3.3	2.9	3.1	3.4	4.9	8
11	7.9	4	3.3	3.3	2.6	2.4	2.5	2.5	2.9	3.1	4.6	8.3
15	-	3.5	2.8	3.5	1.7	1.9	1.9	2.5	2.3	3.2	4.5	5.3
16	-	-	3.5	3.4	2.3	2.3	2.4	2.9	3	3	4.6	7.7
Genesee AMS	5.4	4.9	2.5	3.3	3.1	3.2	3.8	3.1	0.05	3.1	2.5	3.4
- not available												

Table A2. Summary of 2006 SO_2 passive monitoring data (monthly average concentration in ppb).

Station	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
3	1	0.9	0.7	0.7	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5
4	1.1	1.8	1	1.1	0.7	0.9	0.7	0.9	0.6	0.8	0.5	0.6
04B	1.9	1.5	1.1	1	1.5	0.7	1.2	1.9	0.9	0.9	1.2	-
04C	0.9	1.4	2.1	0.9	1.2	0.9	0.7	1	1.1	0.9	1.5	0.5
04D	1.3	1.5	1.3	1.2	1.6	1	1.1	1	1	1.2	1.1	0.8
04E	1	-	1	0.8	1.1	0.8	0.6	0.6	1	1.4	1.3	0.9
5	1.1	1.7	0.9	1.4	1.5	1.1	1.5	2	1.1	1.4	1	1.2
6	1.1	1.8	1	0.8	1	0.7	1.2	1.3	0.8	0.8	0.8	0.8
9	0.9	1.4	0.9	1.2	1.8	1.6	1.4	1.3	2	1.1	1.1	0.6
10	1.3	2.5	1	1.4	1.1	1.5	-	1.5	0.9	1	1.5	1.3
Genesee AMS	1.4	3.9	2.2	1.7	2	2.6	2	2.1	1.5	1.4	2.1	2.1
- not available												

Table A3. Summary of 2006 O_3 passive monitoring data (monthly average concentration in ppb).

Station	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	9.8	24.3	45	33.4	31.2	29.5	26.2	21.7	18.8	20.8	25.8	27.6
3	10.7	23.7	33	27.7	28.3	26.6	22.4	17.9	14.2	17.8	18.8	24.3
6	13.5	25.3	45.7	32.3	34.7	37.1	27.4	24.6	21.6	21.3	26.8	29.5
7	11.6	24.8	42.8	38.1	34.8	34.5	29.6	21.4	20.5	21	24	29.2
10	12.6	23.6	45.1	39.3	31	32.9	26.6	21.2	19.5	19.7	23.6	29.4
11	11.8	20.9	42.9	35.2	32.2	31.1	30.6	21.1	21.7	19.5	25	30
12	9.4	20.9	45.3	34.3	33.2	31.2	26.7	22.4	18.2	17.3	23.9	26.8
13	5.4	15.5	33.3	26.1	32.7	30	28.7	25.2	16.5	14.3	14.9	15.6
14	9.8	21.7	35.3	28.8	31	27.9	29.1	22.4	17.3	16.2	19.4	19.6
15	-	28.7	50.9	40.5	35.5	37.8	31.8	25.7	22.9	22.5	27.7	35.2
16	-	-	51.5	41.8	35.6	37.3	32.8	28	23.1	22.8	28.4	33.9
Genesee	18.5	25.4	38.7	34.5	38.4	29.1	33.7	24.9	22.4	22.9	25	27.2
- not available												