TransAlta Generation Partnership and Capital Power Corporation Ambient Air Monitoring Program

2011 ANNUAL REPORT

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Executive Summary

TransAlta Generation Partnership and Capital Power Corporation operate three coal-fired thermal generating stations, including Sundance, Keephills and Genesee, which are located in the Wabamun–Genesee area of west-central Alberta. The three generating stations operate under the terms and conditions of their respective Alberta Environmental Protection and Enhancement Act (EPEA) approvals.

As part of their approvals, the generating stations conduct special environmental monitoring programs, including ambient air monitoring. This 2011 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 2011 included a continuous monitoring program, an intermittent monitoring program and a passive monitoring program.

Continuous Monitoring Program

Data capture rates for continuously measured parameters at all of the air monitoring stations were above the 90% criterion for the year as required by the Alberta Environment Air Monitoring Directive. High up-times were indicative that equipment in the continuous air monitoring network was well-maintained. Overall, air quality was judged to be good at the air monitoring stations (AMS) during 2011, similar to that observed in previous years. A summary of the 2011 continuous monitoring data is as follows:

- Hourly nitrogen dioxide ($NO_2$) concentrations were very low at all four air monitoring stations (below 61 microgram per cubic metre ($\mu g/m^3$) for 98% of the time). The 9th highest hourly concentration is representative of the upper end (i.e., 99th percentile) of the annual distribution of hourly concentrations. The 9th highest 1-hour NO$_2$ concentrations ranged from 48 $\mu g/m^3$ at the Genesee AMS to 128 $\mu g/m^3$ at the Powers AMS. For comparison purposes, the 9th highest 1 hour NO$_2$ concentrations at the Carrot Creek AMS and Edmonton East AMS during 2011 were 75 and 115 $\mu g/m^3$, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 400 $\mu g/m^3$.

- Hourly sulphur dioxide ($SO_2$) concentrations were very low at all four air monitoring stations (below 26 $\mu g/m^3$ for 98% of the time). The 9th highest 1-hour SO$_2$ concentrations ranged from 36 $\mu g/m^3$ at the Powers AMS to 63 $\mu g/m^3$ at the Wagner AMS. For comparison purposes, the 9th highest 1 hour SO$_2$ concentrations at the Carrot Creek AMS and Edmonton East AMS during 2011 were 18 and 58 $\mu g/m^3$, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 450 $\mu g/m^3$.

- The annual average ozone ($O_3$) concentration at the Genesee AMS was 54 $\mu g/m^3$. Hourly O$_3$ concentrations at the Genesee AMS were below 106 $\mu g/m^3$ for 98% of the time during 2011. The 9th highest 1 hour O$_3$ concentration at the Genesee AMS was 122 $\mu g/m^3$. For comparison purposes, the 9th highest 1-hour O$_3$ concentrations at the Carrot Creek AMS and Edmonton East AMS were 122 and 124 $\mu g/m^3$, respectively. O$_3$ concentrations at the Genesee AMS did not exceed the Alberta Ambient Air Quality objective of 160 $\mu g/m^3$ at any time during 2011.

- Median (50th percentile) 24-hour PM$_{2.5}$ concentrations at the Genesee and Powers air monitoring stations were very low (below 5 $\mu g/m^3$). The 98th percentile 24-hour PM$_{2.5}$ concentrations at both air monitoring stations were below 22 $\mu g/m^3$. This is well below the 24-hour Canada Wide Standard of 30 $\mu g/m^3$. 
Intermittent Monitoring Program

Twenty-four hour average PM$_{2.5}$ and PM$_{10}$ samples were collected at the Genesee air monitoring station (n=61) and the Powers air monitoring station (n=59) according to a National Ambient Pollutant Surveillance (NAPS) six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2011:

- Twenty-four hour average PM$_{2.5}$ concentrations were below 19 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98% of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations.

- Twenty-four hour average PM$_{10}$ concentrations were below 51 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98% of the time.

Passive Monitoring Program

Passive air monitors were deployed at 21 sites in the Wabamun–Genesee area during 2011. The 2011 passive data results are outlined as follows:

- At passive sites located within 30 km of the generating stations, annual average NO$_2$ concentrations ranged from 1.3 to 2.0 parts per billion (ppb) (2.0 to 4.0 µg/m$^3$), whereas at the Edmonton East AMS the annual average NO$_2$ concentration was 26 µg/m$^3$. Annual NO$_2$ concentrations determined by passive monitors show a small increase between sites near Lake Wabamun and 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 oxides of nitrogen (NO$_x$) emissions, within and adjacent to, the City of Edmonton. Urban source emissions are more important contributors to ambient NO$_2$ concentrations observed in and around the City of Edmonton than emissions from generating stations located in the Wabamun-Genesee area.

- Annual average SO$_2$ concentrations were very low, ranging from 0.6 to 1.3 ppb (1.6 to 3.4 µg/m$^3$) 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.

- Annual average O$_3$ concentrations at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24 to 32 ppb (48 to 64 µg/m$^3$). Two passive monitoring sites – sites 15 and 16 – are located greater than two to four-hours travel time downwind of the generating stations along an imaginary northwest line on which the generating stations are located. Previous work by others has indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occur between 30 and 100 km downwind of generating stations (within the range of where these two passive monitoring sites are located). Annual average O$_3$ concentrations at sites 15 and 16 were 8% and 5% less, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2011. The Violet Grove AMS is located 55 km to the southwest of the generating stations.
Table of Contents

1 Introduction ................................................................................................................................. 1-1
  1.1 Environmental Monitoring Programs for Generating Stations .............................................. 1-1
  1.2 Purpose of Report .................................................................................................................. 1-3
2 Background on Air Quality Parameters .................................................................................... 2-1
  2.1 Oxides of Nitrogen ................................................................................................................. 2-1
  2.2 Sulphur Dioxide .................................................................................................................... 2-1
  2.3 Ground-Level Ozone ............................................................................................................. 2-2
  2.4 Particulate Matter ............................................................................................................... 2-2
  2.5 Ambient Air Objectives, Guidelines and Standards .......................................................... 2-3
3 Methods ...................................................................................................................................... 3-1
  3.1 Continuous Monitoring Program ....................................................................................... 3-1
    3.1.1 Nitrogen Dioxide ........................................................................................................... 3-1
    3.1.2 Sulphur Dioxide ............................................................................................................ 3-1
    3.1.3 Ozone ............................................................................................................................ 3-1
    3.1.4 Fine Particulate Matter ................................................................................................. 3-2
    3.1.5 Meteorology ................................................................................................................. 3-2
  3.2 Intermittent Monitoring Program ........................................................................................ 3-2
  3.3 Passive Monitoring Program ............................................................................................... 3-2
4 Results and Discussion ............................................................................................................... 4-1
  4.1 Continuous Monitoring Program ....................................................................................... 4-1
    4.1.1 Percent Completeness .................................................................................................. 4-1
    4.1.2 Air Pollutant Concentration Statistics ....................................................................... 4-2
    4.1.3 Wind Speed and Direction Statistics ........................................................................... 4-10
  4.2 Intermittent Monitoring Program ....................................................................................... 4-15
  4.3 Passive Monitoring Program ............................................................................................... 4-17
    4.3.1 Nitrogen Dioxide ........................................................................................................... 4-17
    4.3.2 Sulphur Dioxide ........................................................................................................... 4-18
    4.3.3 Ozone ........................................................................................................................... 4-18
5 Summary .................................................................................................................................... 5-1
6 References ................................................................................................................................. 6-1
  6.1 Literature Cited .................................................................................................................... 6-1
  6.2 Personal Communications .................................................................................................. 6-2
  6.3 Internet Sites ....................................................................................................................... 6-2
Appendix A Passive Monitoring Data for 2011 .......................................................................... A-1

List of Tables

Table 1-1 Alberta EPEA Operating Approvals for Three Generating Stations in the Wabamun–Genesee Area ............................................................................................................. 1-3
Table 2-1 Ambient Air Quality Objectives, Guidelines and Standards for Specific Criteria Air Contaminants Defined as COPC Related to Generating Station Emissions in the Wabamun–Genesee Area ................................................................................................................. 2-3
Table 3-1 Sampling Schedule for Parameters in the Ambient Air Quality Monitoring Program in the Wabamun–Genesee Area ........................................................................................................... 3-1
Table 4-1 Monthly and Annual Data Capture Rates (% completeness) for Genesee Air Monitoring Station during 2011 .......................................................................................................................... 4-1
Table of Contents

Table 4-2  Monthly and Annual Data Capture Rates (% completeness) for Meadows Air Monitoring Station during 2011 ................................................................. 4-1
Table 4-3  Monthly and Annual Data Capture Rates (% completeness) for Powers Air Monitoring Station during 2011 ................................................................. 4-2
Table 4-4  Monthly and Annual Data Capture Rates (% completeness) for Wagner Air Monitoring Station during 2011 ................................................................. 4-2
Table A-1  2011 NO₂ Passive Monitoring Data (monthly average concentration in ppb) ................................................................. 1
Table A-2  2011 SO₂ Passive Monitoring Data (monthly average concentration in ppb) ................................................................. 1
Table A-3  2011 O₃ Passive Monitoring Data (monthly average concentration in ppb) ................................................................. 2

List of Figures

Figure 1-1  Location of TransAlta and Capital Power Coal-fired Generating Stations and Air Monitoring Area in the Wabamun–Genesee Area of Alberta ................................................. 1-2
Figure 1-2  Continuous and Passive Monitoring Locations in the Wabamun–Genesee Area During 2011 ......................................................................................... 1-4
Figure 4-1  Box-and-Whisker Plot of 1-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011 ................................. 1-4
Figure 4-2  Box-and-Whisker Plot of 24-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011 ................................. 4-3
Figure 4-3  Cumulative Distribution Plot of 1-hour Average NO₂ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2011 .................. 4-5
Figure 4-4  Box-and-Whisker Plot of 1-hour Average SO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011 ................................. 4-6
Figure 4-5  Box-and-Whisker Plot of 24-hour Average SO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011 ................................. 4-6
Figure 4-6  Cumulative Distribution Plot of 1-hour Average SO₂ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2011 .................. 4-6
Figure 4-7  Box-and-Whisker Plot of 1-hour Average O₃ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011 ................................. 4-7
Figure 4-8  Cumulative Distribution Plot of 1-hour Average O₃ Concentrations at the Genesee Air Monitoring Station during 2011 .................................................. 4-8
Figure 4-9  Box-and-Whisker Plot of 24-hour Average PM₂.₅ Concentrations at the Genesee and Powers Air Monitoring Stations (2009, 2010 and 2011) .............. 4-9
Figure 4-10 Cumulative Distribution Plot of 1-hour Average PM₂.₅ Concentrations at the Powers and Genesee Air Monitoring Stations during 2011 ............................... 4-10
Figure 4-11 Annual Wind Rose Plot for the Genesee Air Monitoring Station during 2011 ................................................................. 4-11
Figure 4-12 Annual Wind Class Frequency Distribution Plot for the Genesee Air Monitoring Station during 2011 ................................................................. 4-11
Figure 4-13 Annual Wind Rose Plot for the Meadows Air Monitoring Station during 2011 ................................................................. 4-12
Figure 4-14 Annual Wind Class Frequency Distribution Plot for the Meadows Air Monitoring Station during 2011 ................................................................. 4-12
Figure 4-15 Annual Wind Rose Plot for the Powers Air Monitoring Station during 2011 ................................................................. 4-13
Figure 4-16 Annual Wind Class Frequency Distribution Plot for the Powers Air Monitoring Station during 2011 ................................................................. 4-13
Figure 4-17 Annual Wind Rose Plot for the Wagner Air Monitoring Station during 2011 ................................................................. 4-14
Figure 4-18 Annual Wind Class Frequency Distribution Plot for the Wagner Air Monitoring Station during 2011 ................................................................. 4-14
Figure 4-19 Box-and-Whisker Plot of Intermittent 24-hour Average PM₂.₅ Concentrations at Genesee and Powers Air Monitoring Stations in 2011 ............................... 4-15
Figure 4–20  Box-and-Whisker Plot of Intermittent 24-hour Average PM$_{10}$ Concentrations at Genesee and Powers Air Monitoring Stations in 2011 .................................................... 4-16
Figure 4–21  Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Genesee Air Monitoring Station during 2011 .................................................... 4-16
Figure 4–22  Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Powers Air Monitoring Station during 2011 .................................................... 4-17
Figure 4–23  Bubble Plot of Annual Average NO$_2$ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011 .................................................... 4-19
Figure 4–24  Bubble Plot of Annual Average SO$_2$ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011 .................................................... 4-20
Figure 4–25  Bubble Plot of Annual Average O$_3$ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011 .................................................... 4-21
Figure 4–26  Monthly Average O$_3$ Concentration at Passive Monitoring Sites in Central Alberta during 2011 .................................................... 4-22
Abbreviations

AAAQO ........................................................... Alberta Ambient Air Quality Objective
AMS ................................................................. air monitoring station
CASA ............................................................... Clean Air Strategic Alliance
COPC ............................................................... Chemicals of Potential Concern
CPC ............................................................... Capital Power Corporation
CWS ............................................................... Canada-Wide Standard
EPEA ............................................................... Environmental Protection and Enhancement Act
H₂SO₄ .............................................................. sulphuric acid
HNO₃ .............................................................. nitric acid
IQR ................................................................. interquartile range
km ................................................................. kilometre
m³ ................................................................. cubic metre
MW ............................................................... megawatts
NAPS ............................................................. National Ambient Pollutant Surveillance
NAS ............................................................... National Academy of Sciences
NO ................................................................. nitric oxide
NO₂ ............................................................... nitrogen dioxide
NOₓ ............................................................... oxides of nitrogen
O₃ ................................................................. ozone
ppb ............................................................... parts per billion
PM ................................................................. particulate matter
PM₂.₅ .............................................................. particulate matter ≤ 2.5 μm
PM₁₀ .............................................................. particulate matter ≤ 10 μm
PAHs .............................................................. polycyclic aromatic hydrocarbons
R2 ................................................................. coefficient of determination
SO₂ ............................................................... sulphur dioxide
SO₃ ............................................................... sulphur trioxide
μg ................................................................. microgram
μm ............................................................... micrometre
U.S. EPA ......................................................... United States Environmental Protection Agency
UV ................................................................. ultraviolet
VOCs ............................................................. volatile organic compounds
WCAS ........................................................... West Central Airshed Society
1 Introduction

TransAlta Generation Partnership (TransAlta) and Capital Power Corporation (CPC) operate three coal-fired thermal generating stations, including Sundance, Keephills and Genesee, which are located in the Wabamun–Genesee area of west-central Alberta. Figure 1–1 shows the location of each of these generating stations. The three generating stations operate under the terms and conditions of their respective Alberta Environmental Protection and Enhancement Act (EPEA) approvals for construction, operation and reclamation, listed in Table 1–1. Collectively, the three generating stations have the capacity to generate a total of 3,994 megawatts (MW) to Alberta’s electrical grid.

The TransAlta Sundance generating station consists of six generating units; it is the largest coal-fired generating station in western Canada. Sundance is situated on the south shore of Lake Wabamun, approximately 70 kilometres (km) west of Edmonton, Alberta (Figure 1–1). The station has operated since 1970, with steady expansion throughout the 1970s from a single original generating unit to six generating units. Sundance 1 and 2 were removed from operation in December 2010. Sundance currently has a net generating capacity of 1,566 MW from Units 3 through 6.

TransAlta’s Keephills generating station is located 5 km south of Wabamun Lake (Figure 1–1). Unit’s 1 & 2 plants have been in operation since 1983. They have a net generating capacity of 766 MW and consist of two generating units. Keephills 3 began commercial operation on September 1, 2011. This plant is a 50/50 joint venture between TransAlta and CPC and it has a net generating capacity of 450 MW.

The Genesee generating station consists of three generating units. It is located 50 km southwest of Edmonton (Figure 1–1). CPC fully owns and operates Units 1 and 2, which have a net combined 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 CPC. Genesee 3 has a net generating capacity of 450 MW.

1.1 Environmental Monitoring Programs for Generating Stations

The generating stations operate under the EPEA approvals listed in Table 1–1. Under their EPEA approvals, the generating stations 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 station emissions.
- Generate an inventory of representative baseline data for the chemicals of potential concern (COPC).
- Provide data for assessing long-term impacts and for evaluating and implementing air quality management plans.
Location of TransAlta and Capital Power Coal-fired Generating Stations and Air Monitoring Area in the Wabamun-Genesee Area of Alberta
A component of the special environmental monitoring programs included developing and implementing an ambient air quality monitoring program. The ambient air quality monitoring program consists of the following elements (Figure 1–2):

- A continuous monitoring program for: sulphur dioxide (SO\textsubscript{2}), nitrogen dioxide (NO\textsubscript{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 micrometre (\(\mu\)m) (PM\textsubscript{2.5}) at two stations (Genesee AMS and Powers AMS); and ozone (O\textsubscript{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 \(\mu\)m (PM\textsubscript{10}), PM\textsubscript{2.5} and metals speciation of the PM\textsubscript{2.5} at two stations (Genesee AMS and Powers AMS).

- A passive monitoring program consisting of monthly passive monitoring for NO\textsubscript{2}, SO\textsubscript{2}, and O\textsubscript{3} at 21 locations in the Wabamun–Genesee area.

Sections within the EPEA approvals containing specific terms and conditions that refer to the ambient air quality monitoring program are provided in Table 1–1.

### Table 1–1 Alberta EPEA Operating Approvals for Three Generating Stations in the Wabamun–Genesee Area

<table>
<thead>
<tr>
<th>Facility</th>
<th>Net Generating Capacity (MW)</th>
<th>Location</th>
<th>Approval No. (as amended)</th>
<th>Applicable Approval Terms</th>
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<td>Sundance</td>
<td>1,566</td>
<td>3,4,8,9,10,16,17,20, and 31-52-04 W5M</td>
<td>9830-02-00</td>
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</tr>
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<td>Keephills</td>
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<tr>
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<td>1,212</td>
<td>25-50-03 W5M</td>
<td>773-02-00</td>
<td>Sections within Part 7</td>
</tr>
</tbody>
</table>

### 1.2 Purpose of Report

This annual report summarizes and discusses information collected as part of the 2011 ambient air monitoring program. These data provide a basis for developing an understanding of the state of air quality in relation to emissions from coal-fired generating stations 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 documents (TransAlta and CPC 2012a, b).
2 Background on Air Quality Parameters

A number of COPCs are potentially emitted from the coal-fired generating stations in the Wabamun–Genesee area. With respect to the ambient air monitoring program, these COPCs include: oxides of nitrogen (NO\textsubscript{x}), SO\textsubscript{2}, ground-level O\textsubscript{3} and airborne particulate matter. The importance of these COPCs is discussed below.

2.1 Oxides of Nitrogen

NO\textsubscript{x} is a generic term used to represent a group of reactive gases containing nitrogen and oxygen, mostly in the form of nitric oxide (NO) and NO\textsubscript{2}. The NO\textsubscript{x} concentration is calculated by adding together NO and NO\textsubscript{2} concentrations. High temperature combustion of hydrocarbon fuel sources produces NO and smaller quantities of NO\textsubscript{2} from reactions with nitrogen gas in the atmosphere. Most of the NO in ambient air rapidly turns into NO\textsubscript{2}. Almost every combustion source emits NO which reacts in the atmosphere to create NO\textsubscript{2} (including motor vehicles, generating stations, chemical plants, commercial and residential furnaces, gas stoves, heaters).

NO\textsubscript{2}, NO, volatile organic compounds, anthropogenic (man-made) and biogenic (from vegetation) hydrocarbons and carbon monoxide are all precursors in the formation of ground-level O\textsubscript{3} and photochemical smog (United States Environmental Protection Agency (U.S. EPA) 2008a, internet reference). NO\textsubscript{2} is an oxidant that can react to form other photochemical oxidants and can also react with compounds such as polycyclic aromatic hydrocarbons (PAHs) to form nitro-PAHs. Finally, NO\textsubscript{2} can also be oxidized to form nitric acid (HNO\textsubscript{3}), which contributes to the acidity of cloud, fog and rainwater, as well as to the formation of ambient particles.

The Alberta Ambient Air Quality Objectives (AAAQOs) for NO\textsubscript{x} are expressed as NO\textsubscript{2}. Therefore, NO\textsubscript{x} concentrations are typically expressed as NO\textsubscript{2} for comparison to the AAAQOs.

The Clean Air Strategic Alliance (CASA) (2006, internet reference) reported that the 10-year average concentration of NO\textsubscript{2} measured at a rural background location in Alberta (Hightower Ridge AMS) was 8 parts per billion (ppb) (15 microgram per cubic metre (μg/m\textsuperscript{3})). A listing and brief description of the AAAAQOs and other air quality standards are given in Section 2.5.

2.2 Sulphur Dioxide

SO\textsubscript{2} and sulphur trioxide (SO\textsubscript{3}) are produced from oxidation of trace amounts of sulphur during high temperature combustion of hydrocarbon fuels such as oil and coal. Industrial operations (e.g., electricity generation, petroleum and chemical manufacturing) contribute the majority of anthropogenic SO\textsubscript{2} emissions to the atmosphere. Transportation-related sources are estimated to contribute small amounts of sulphur emissions to the atmosphere (U.S. EPA 2008b, internet reference).

SO\textsubscript{2} can react with moisture in the atmosphere (and is oxidized) to form sulphuric acid (H\textsubscript{2}SO\textsubscript{4}), which contributes to acidity of cloud, fog, and rainwater. SO\textsubscript{3} emitted to the atmosphere reacts rapidly with moisture to form H\textsubscript{2}SO\textsubscript{4}, which condenses onto existing particles (when particle loadings are high) or acts as nuclei to form new particles (under low particle loadings) (U.S. EPA 2008b, internet reference).

CASA (2006, internet reference) reported that the 10-year average concentration of SO\textsubscript{2} measured at a rural background location in Alberta (Hightower Ridge AMS) was 2 ppb (5 μg/m\textsuperscript{3}).
2.3 Ground-Level Ozone

Ground-level \( \text{O}_3 \) can originate in two important ways – by being brought down to the surface from the tropospheric reservoir by daily (diurnal) mixing of the atmospheric boundary layer, and by being photochemically produced. Surface measurements alone are not sufficient for understanding characteristics of ground-level \( \text{O}_3 \) because the chemical composition of the surface layer largely depends on mixing from above (Zhang and Rao 1999).

*Role of atmospheric boundary layer mixing* – The presence of ground-level \( \text{O}_3 \) at the surface is strongly influenced by the daily development and dissipation of turbulent mixing within the atmospheric boundary layer. When the depth of the boundary layer increases during mid morning hours, \( \text{O}_3 \) suspended in the air is mixed downward to the earth's surface and surface concentrations increase (Singh et al. 1978; Taylor and Hanson 1992; Lovett 1994; Aneja et al. 2000; Steinbacher et al. 2004). Once atmospheric boundary layer mixing ceases during late evening and night hours, surface concentrations decrease due to scavenging (oxidation) reactions.

*Role of photochemical production* – In urban areas and areas downwind influenced by urban air masses, photochemically produced ground-level \( \text{O}_3 \) and other oxidants form by atmospheric reactions involving mainly two classes of chemical precursors: volatile organic compounds (VOCs) and \( \text{NO}_x \) (U.S. EPA, 2006, internet reference). VOCs refer to all carbon containing gas-phase compounds in the atmosphere, both biogenic and anthropogenic in origin.

Maximum \( \text{O}_3 \) concentrations from photochemical reactions usually occur four to six hours after maximum emissions of chemical precursors, and under conditions of light winds, usually downwind of urban areas (Chu 1995; U.S. EPA 1998). Weather patterns and meteorological conditions play a major role in establishing conditions favourable to photochemical \( \text{O}_3 \) formation and accumulation, and in terminating episodes of high \( \text{O}_3 \) concentrations (National Academy of Science (NAS) 1991). Episodes of high \( \text{O}_3 \) concentrations from photochemical production are associated with slow-moving, high-pressure weather systems.

Ground-level \( \text{O}_3 \) is driven by the atmospheric boundary layer mixing effect in areas away from urban emissions and is particularly dominant in the spring and early summer (March through June) period (Singh et al. 1978). Ground-level \( \text{O}_3 \) can be enhanced by photochemical reactions, particularly in the summer (June through August) period. CASA (2006, internet reference) reported that the 10-year average concentration of \( \text{O}_3 \) measured at a rural background location in Alberta (Hightower Ridge AMS) was 42 ppb (81 \( \mu \text{g/m}^3 \)).

2.4 Particulate Matter

Particulate matter (PM) is a general term used to describe mixtures of solid particles and liquid droplets (except for pure water) that are microscopic and found in the air. These mixtures can be considered combinations of larger particles called coarse particles and smaller particles called fine particles. Coarse particles have diameters greater than 2.5 \( \mu \text{m} \) and less than 10 \( \mu \text{m} \), particles with diameters less than 10 \( \mu \text{m} \) are referred to as \( \text{PM}_{10} \), while fine particles (\( \text{PM}_{2.5} \)) have diameters less than 2.5 \( \mu \text{m} \) (Health Canada 1999).

Coarse particles are mainly produced by abrasion at the earth’s surface or by suspension of biological material composed of microorganisms (e.g., bacteria, viruses, fungal spores, pollens) and fragments of living things (e.g., plant and insect debris) while the makeup of fine particles (i.e., \( \text{PM}_{2.5} \)) tends to be dominated by particles that form during combustion of material that has volatilized in combustion chambers and then re-condensed before emission to the atmosphere (U.S. EPA 2004, internet...
PM mixtures have a wide variety of sources in the environment (U.S. EPA 2004, internet reference). Anthropogenic sources can include:

- Stationary sources (e.g., fuel combustion for electrical utilities, residential space heating and cooking; industrial boilers; construction and demolition; mills and elevators used in agriculture; erosion from tilled lands; and waste disposal and recycling.)
- Mobile or transportation-related sources (e.g., direct emissions from highway vehicles and non-road sources, as well as fugitive dust from paved and unpaved roads.)

Biomass burning (e.g., forest fires, wood burned for fuel, and burning of vegetation cleared from land) also emits PM mixtures and other environmentally significant compounds (e.g., carbon monoxide, gaseous elemental mercury).

CASA (2006, internet reference) reported that the 10-year average concentration of PM$_{2.5}$ measured at a rural background location (Hightower Ridge AMS) was 2.3 μg/m$^3$.

### 2.5 Ambient Air Objectives, Guidelines and Standards

Air quality criteria are used to protect human health, safeguard the environment and assess aesthetic quality. Specific AAAQOs, guidelines and Canada-wide Standards (CWS) exist for the criteria air contaminants defined as COPC to aid with interpreting measured ambient levels of these pollutants. Current objectives, guidelines and standards are listed in Table 2–1.

#### Table 2–1 Ambient Air Quality Objectives, Guidelines and Standards for Specific Criteria Air Contaminants Defined as COPC Related to Generating Station Emissions in the Wabamun-Genesee Area

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Averaging Time</th>
<th>Alberta Ambient Air Quality Objective</th>
<th>Alberta Ambient Air Quality Guideline</th>
<th>Canada-Wide Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_x$ (as NO$_2$)</td>
<td>1 hour</td>
<td>300 μg/m$^3$ (159 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>annual</td>
<td>45 μg/m$^3$ (24 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>1 hour</td>
<td>450 μg/m$^3$ (172 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>125 μg/m$^3$ (48 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30-day</td>
<td>30 μg/m$^3$ (11 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>annual</td>
<td>20 μg/m$^3$ (8 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>1 hour</td>
<td>-</td>
<td>80 μg/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24-hour average based on 98th percentile value over 3 consecutive years</td>
<td>-</td>
<td>-</td>
<td>30 μg/m$^3$</td>
</tr>
<tr>
<td>O$_3$</td>
<td>1 hour</td>
<td>160 μg/m$^3$ (82 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8 hour average based on 4th highest value over 3 consecutive years</td>
<td>-</td>
<td>-</td>
<td>128 μg/m$^3$ (65 ppb)</td>
</tr>
</tbody>
</table>

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 monitoring site locations. Procedures and guidelines for measuring and analyzing the air quality parameters listed below are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC Earth & Environmental [AMEC] 2011). A schedule for the sampling program 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Continuous</th>
<th>Intermittent (every 6th day (NAPS) schedule)</th>
<th>Monthly (passives)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>NO₂</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>O₃</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Wind speed and direction, temperature, relative humidity</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>

3.1.1 Nitrogen Dioxide

NO₂ is analyzed at the Genesee, Meadows, Wagner, and Powers air monitoring stations. NO₂ is measured by chemiluminescence using the TECO 42C (Thermo Electron Corporation, Waltham, MA) or equivalent analyzer. NOₓ in air is converted to NO as it flows over a heated catalyst. The NO is then oxidized by O₃ 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 NO₂ basis.

3.1.2 Sulphur Dioxide

SO₂ is analyzed at the Genesee, Meadows, Wagner, and Powers air monitoring stations. SO₂ is measured with pulsed fluorescence using the TECO 43 (Thermo Electron Corporation, Waltham, MA) or equivalent analyzer. Air samples are bombarded with pulses of ultraviolet (UV) light that excite SO₂ molecules to higher energy levels. When the SO₂ molecules return to their original energy state, light is emitted; this light is measured in the analyzer and is proportional to the amount of SO₂ in air.

3.1.3 Ozone

O₃ is measured at the Genesee AMS with a TECO 49 UV-absorption ozone analyzer (Thermo Electron Corporation, Waltham, MA). 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 O₃ in air.

### 3.1.4 Fine Particulate Matter

Fine Particulate Matter (PM₂.₅) is measured at the Powers AMS and the 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.

### 3.1.5 Meteorology

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 2011, West Central Airshed Society (WCAS) technicians maintained and calibrated the analyzers at the continuous stations. The continuous data collected were reviewed for errors and omissions by WCAS personnel and the information was reported on a monthly, quarterly and annual basis. The raw data were also made 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 PM₁₀ and PM₂.₅ samples are collected at the 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 measuring and analyzing PM₁₀ and PM₂.₅ samples are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC 2011).

The Partisols separate particulates in sampled air according to size, which allows for size-selective collection on a filter. Technicians from Ambitech Inc. (Edmonton, AB) collect Partisol filters according to the Environment Canada National Air Pollution Surveillance (NAPS) Network schedule and ship the filters to Albert Innovates – Technology Solutions (Vegreville, AB) for gravimetric and metals analyses. WBK & Associates Inc. personnel review the analytical results on an as-received basis.

Results from metals analyses of 24-hour average PM₂.₅ samples are currently archived electronically. They will be used to undertake source apportionment, which is the quantitative identification of relative contributions of different source types to airborne particle concentrations. Source apportionment for PM₂.₅ 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 PM₂.₅ samples are required to undertake source apportionment (≥2 years of monitoring data). Greater than 400 samples have been archived from each station as part from this program. A schedule for the sampling program is presented in Table 3–1.

### 3.3 Passive Monitoring Program

Passive air monitors are deployed at 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 SO₂, NO₂, and O₃. Procedures and guidelines for collecting and analyzing SO₂, NO₂, and O₃ passive samplers are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC 2011).
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. Ambitech Inc. technicians collect the passive samplers and deploy fresh samplers within two days of the end of each month. The samplers are delivered to Maxxam Analytics (Edmonton, AB) for laboratory analyses. A schedule for the sampling program is presented in Table 3–1.
4 Results and Discussion

4.1 Continuous Monitoring Program

4.1.1 Percent Completeness

An important component for understanding quality of continuous monitoring data is completeness. Completeness indicates the percentage of time that a continuous monitor is up and operating (i.e., capturing valid data). In general, the Air Monitoring Directive (Alberta Environment 1989, internet reference) requires greater than 90% completeness. Tables 4–1 to 4–4 show data capture rates (% completeness) for air quality parameters at the four air monitoring stations in the Wabamun–Genesee area during 2011.

Table 4–1 Monthly and Annual Data Capture Rates (% completeness) for Genesee Air Monitoring Station during 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98.9</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>SO₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98.9</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>O₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98.9</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>93.2</td>
<td>100</td>
<td>100</td>
<td>99.3</td>
</tr>
<tr>
<td>PM₂.5</td>
<td>99.1</td>
<td>95.2</td>
<td>99.7</td>
<td>99.6</td>
<td>99.0</td>
<td>96.1</td>
<td>98.9</td>
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<td></td>
</tr>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>WDR</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>T₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>T₁₀</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>100</td>
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<td>100</td>
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<td>99.9</td>
</tr>
<tr>
<td>RH</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
</tbody>
</table>

NOTES:
Key: WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; T₁₀ = temperature at 10-metre height above ground; RH = relative humidity.

Table 4–2 Monthly and Annual Data Capture Rates (% completeness) for Meadows Air Monitoring Station during 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
<td>99.7</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>91.3</td>
</tr>
<tr>
<td>SO₂</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
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<td>100</td>
<td>99.6</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>85.1*</td>
</tr>
<tr>
<td>WSP</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.7</td>
<td>99.1</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>91.3</td>
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<tr>
<td>WDR</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.7</td>
<td>91.3</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
</tr>
<tr>
<td>T₂</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>91.3</td>
<td>99.1</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
</tr>
<tr>
<td>RH</td>
<td>99.5</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>91.3</td>
<td>99.1</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.1</td>
</tr>
</tbody>
</table>

NOTES:
Key: WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.
The SO₂ analyzer recorded anomalous readings due to an internal vacuum line failure caused by vibration of the vacuum pump. The pump was replaced. In addition, the uninterruptible power supply system failed and interrupted data collection at the station was believed at the time to be due to communication failure and station was not visited immediately. The SO₂ analyzer failure was reported to Alberta Environment (AE Reference Number 255234).
Except for the Meadows AMS in December, monthly data capture rates for all stations were well above the 90% criterion stipulated in the Air Monitoring Directive (Alberta Environment 1989, internet reference). High up-times indicate that equipment in the continuous air monitoring network was well operated and maintained.

### Table 4–3 Monthly and Annual Data Capture Rates (% completeness) for Powers Air Monitoring Station during 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.3</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
<td>100</td>
<td>99.5</td>
</tr>
<tr>
<td>SO₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>100</td>
<td>99.9</td>
<td>99.3</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
<td>100</td>
<td>99.5</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>99.9</td>
<td>100</td>
<td>99.3</td>
<td>100</td>
<td>100</td>
<td>98.8</td>
<td>99.2</td>
<td>98.9</td>
<td>99.3</td>
<td>94.5</td>
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<td>99.3</td>
<td>99.1</td>
</tr>
<tr>
<td>WSP</td>
<td>100</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.3</td>
<td>100</td>
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</tr>
<tr>
<td>WDR</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.3</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
<td>100</td>
<td>99.5</td>
</tr>
<tr>
<td>T₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.3</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
<td>100</td>
<td>99.5</td>
</tr>
<tr>
<td>RH</td>
<td>100</td>
<td>100</td>
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<td>100</td>
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<td>99.3</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
<td>100</td>
<td>99.5</td>
</tr>
</tbody>
</table>

**NOTES:**
- WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.

### Table 4–4 Monthly and Annual Data Capture Rates (% completeness) for Wagner Air Monitoring Station during 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td>100</td>
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<td>100</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.7</td>
<td>100</td>
<td>98.3</td>
<td>100</td>
<td>99.8</td>
</tr>
<tr>
<td>SO₂</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.7</td>
<td>100</td>
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<td>99.8</td>
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<tr>
<td>WSP</td>
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</tr>
<tr>
<td>T₂</td>
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<td>99.7</td>
<td>100</td>
<td>98.3</td>
<td>100</td>
<td>99.8</td>
</tr>
</tbody>
</table>

**NOTES:**
- WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.
- Bolded value indicates <90% completeness for monitoring period.

### 4.1.2 Air Pollutant Concentration Statistics

One method of displaying a set of air quality data is using box-and-whisker plots. Box-and-whisker plots help interpret the distribution of data because they only illustrate certain statistics rather than all of the data. The plots presented here show five values for individual pollutants collected at each air monitoring station during 2011: 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, as applicable. The bottom whisker is not shown in these plots because the values represented by bottom whiskers are very small and not essential for understanding the distribution of data.

#### 4.1.2.1 Nitrogen Dioxide

Figures 4–1 and 4–2 are box-and-whisker plots that compare key statistical values for 1-hour and 24-hour NO₂ concentrations observed at the four ambient air monitoring stations during 2011. For comparison purposes, box-and-whisker plots are shown in Figure 4–1 for a background station relative to the air monitoring area for the generating stations (Carrot Creek AMS, CASA 2012, internet reference) and an urban station (Edmonton East AMS, CASA 2012, internet reference). 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.

![Box-and-Whisker Plot of 1-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011](image)

**Figure 4–1**  Box-and-Whisker Plot of 1-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011

*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). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.

All of the benchmark NO₂ concentrations, other than the maximum value, were highest at the urban (Edmonton East) AMS for the 1-hour averaging periods (Figure 4–1), reflecting the important influence of motor vehicle emissions on ambient concentrations. For monitoring stations in the air monitoring area, annual average NO₂ concentrations ranged from 5.3 μg/m³ at Genesee AMS to 15 μg/m³ at Meadows AMS. These concentrations are higher than the 10-year average concentration reported by CASA (2006, internet reference) for the Hightower Ridge AMS (5 μg/m³). There were no exceedances of the AAAQO for NO₂ in 2011 for 1-hour (Figure 4–1) or 24-hour (Figure 4–2) averaging times. The 1-hour maximum value of 316 μg/m³ at the Powers AMS (Figure 4–1) occurred on May 15 corresponding to an event with strong winds in excess of 45 km/hr from the south southeast.

The 9th highest 1-hour concentration represents a 99.9th percentile concentration from a distribution of hourly values during a year. The 9th highest 1-hour NO₂ concentrations observed during 2011 ranged from 48 μg/m³ at the Genesee AMS to 128 μg/m³ at the Powers AMS. For comparison purposes, the 9th highest 1-hour NO₂ concentrations observed during 2011 at the Carrot Creek AMS and Edmonton East AMS were 75 and 115 μg/m³, respectively (CASA 2012, internet reference).

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 four air monitoring stations, the largest
IQR (i.e., largest box) occurred for the Meadows AMS for hourly data (Figure 4–1) and 24-hour data (Figure 4–2). However, the IQRs for NO$_2$ at the Meadows AMS were narrow (e.g., 18 µg/m$^3$ for hourly concentrations and 11 µg/m$^3$ for 24-hour concentrations), indicating little variation in hourly concentrations throughout 2011.

![Figure 4–2](image)

**Figure 4–2**  Box-and-Whisker Plot of 24-hour Average NO$_2$ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011

Note:  25$^{th}$ %ile (bottom of box), 50$^{th}$ %ile (line inside box), 75$^{th}$ %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). Some of the values cannot be clearly observed in the figure (e.g., the 25$^{th}$ to 75$^{th}$ percentiles) because their magnitudes are too small.

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. Cumulative distribution plots illustrated here show the values of the indicator (i.e., hourly concentration) on the vertical axis and percentage of the hours (and by inference the overall population) less than or equal to each value on the vertical axis.

The distributions were presented in this manner in order to facilitate interpretation when comparing several cumulative distributions in one figure. Distributions whose values are lower have lower concentrations and thus better air quality during the year than distributions whose values are higher for a given percentile. Figure 4–3 shows a cumulative distribution plot for hourly NO$_2$ concentrations at each of the stations in the Wabamun–Genesee area. Percentile values (50$^{th}$, 65$^{th}$, 80$^{th}$, 95$^{th}$, and 98$^{th}$) are shown in this plot to assist comparison with future data and allow examination of trends in ambient air pollutant concentrations using simple methods as described by Kindzierski et al. (2009, internet reference).

These percentile values can be calculated from year to year to examine changes to air quality over time. Statistically significant changes in these percentile values over a period of several years (e.g., >5 years) 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\textsubscript{2} concentrations were low at all four air monitoring stations (<61 µg/m\textsuperscript{3} for 98% of time during 2011).

![Cumulative Distribution Plot of 1-hour Average NO\textsubscript{2} Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2011](image)

**Figure 4–3** Cumulative Distribution Plot of 1-hour Average NO\textsubscript{2} Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2011

### 4.1.2.2 Sulphur Dioxide

Figures 4–4 and 4–5 are box-and-whisker plots for 1-hour and 24-hour SO\textsubscript{2} concentrations, respectively. Median (50\textsuperscript{th} percentile) hourly SO\textsubscript{2} concentrations at all four generating station air monitoring stations shown in Figure 4–4 were very low (≤1 µg/m\textsuperscript{3}). All 1-hour and 24-hour concentrations were well below AAAQOs. The 1-hour maximum value of 183 µg/m\textsuperscript{3} at the Powers AMS (Figure 4–4) occurred on May 23 corresponding to an event with mild winds of 15 km/hr from the east northeast. This direction is nowhere near the generating stations. The 9\textsuperscript{th} highest 1-hour SO\textsubscript{2} concentrations observed during 2011 ranged from 36 µg/m\textsuperscript{3} at the Powers AMS to 63 µg/m\textsuperscript{3} at the Wagner AMS. For comparison purposes, the 9\textsuperscript{th} highest 1-hour SO\textsubscript{2} concentrations observed during 2011 at the Carrot Creek AMS and Edmonton East AMS were 18 and 58 µg/m\textsuperscript{3}, respectively (CASA 2012, internet reference).

Annual average SO\textsubscript{2} concentrations at the four air monitoring stations represented less than 6.5% of the annual AAAQO for SO\textsubscript{2}. Annual mean 1-hour and 24-hour concentrations were less than the 10-year average measured at Hightower Ridge (5 µg/m\textsuperscript{3}). Of the four air monitoring stations, the Wagner AMS had the largest IQR (i.e., largest box) for 1 hour data (Figure 4–4) and 24-hour data (Figure 4–5). However, the IQR for SO\textsubscript{2} at this station was very narrow (e.g., ≤3 µg/m\textsuperscript{3} for hourly concentrations) indicating extremely small variation in hourly concentrations throughout 2011.

Figure 4–6 shows the cumulative distribution and key percentile values for hourly SO\textsubscript{2} concentrations at the Genesee, Wabamun, Meadows and Powers air monitoring stations. Other than at the Powers AMS, SO\textsubscript{2} cumulative distribution curves were similar for other stations. Overall, hourly SO\textsubscript{2} concentrations were very low at all four stations (<26 µg/m\textsuperscript{3} for 98% of time during 2011).
Figure 4–4  Box-and-Whisker Plot of 1-hour Average SO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011

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). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.

Figure 4–5  Box-and-Whisker Plot of 24-hour Average SO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011

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). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.
Figure 4–6 Cumulative Distribution Plot of 1-hour Average SO$_2$ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2011

4.1.2.3 Ozone

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 average O$_3$ concentration based on hourly concentrations at the Genesee AMS was 54 µg/m$^3$ in 2011. The 9$^{th}$ highest 1-hour O$_3$ concentration observed in 2011 at Genesee AMS was 122 µg/m$^3$. For comparison purposes, the 9$^{th}$ highest 1-hour O$_3$ concentrations observed at the Carrot Creek AMS and Edmonton East AMS were 122 and 124 µg/m$^3$, respectively (CASA 2012, internet reference). One-hour O$_3$ concentrations at the Genesee AMS did not exceed the Alberta Ambient Air Quality 1-hour objective of 160 µg/m$^3$ at any time during 2011.

The 25$^{th}$, 50$^{th}$, 75$^{th}$ and 98$^{th}$ percentile concentration values at the Edmonton East AMS were lower than that observed at the Genesee AMS and Carrot Creek AMS. This is consistent with central Alberta hourly O$_3$ trend data reported by Kindzierski et al. (2006) and Kindzierski (2006). A primary reason for these lower concentrations observed at the Edmonton East AMS are scavenging reactions 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 2011. Hourly O$_3$ concentrations were <106 µg/m$^3$ for 98% of time during 2011. This is well below the Alberta Ambient Air Quality 1-hour objective of 160 µg/m$^3$. 
Figure 4–7  Box-and-Whisker Plot of 1-hour Average O₃ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2011

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 O₃ Concentrations at the Genesee Air Monitoring Station during 2011
### 4.1.2.4 Fine Particulate Matter

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 2009, 2010 and 2011. Median (50$^{th}$ percentile) 24 hour PM$_{2.5}$ concentrations at both stations were low, <5 µg/m$^3$ for all years. The 98$^{th}$ percentile 24-hour PM$_{2.5}$ concentrations at both air monitoring stations were <22 µg/m$^3$ for all years. These values are below the CWS of 30 µg/m$^3$. Interquartile ranges for 24-hour PM$_{2.5}$ concentrations at both air monitoring stations were very narrow (<5 µg/m$^3$), indicating very little variation in 24-hour average concentrations throughout 2009, 2010 and 2011.

Figure 4–9 is notable in that maximum 24-hour PM$_{2.5}$ concentrations during 2010 were very high (140 and 220 µg/m$^3$, respectively at Powers and Genesee AMS), although 98$^{th}$ percentile concentrations and interquartile ranges in 2010 were similar to that in 2009 and 2011. Elevated hourly PM$_{2.5}$ concentrations were observed at both air monitoring stations during a 3-day period in August 2010 due to smoke from forest fires in northern British Columbia.

Figure 4–10 shows the cumulative distribution plot for hourly PM$_{2.5}$ concentrations measured at the Genesee and Powers air monitoring stations. Hourly PM$_{2.5}$ concentrations were low at these two stations, <16 µg/m$^3$ for 98% of the time during 2011.
4.1.3 Wind Speed and Direction Statistics

A wind rose plot is used to show information about the distribution 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.

Another method of displaying a year of wind data at the air monitoring stations is a wind class frequency distribution plot. These plots show the percent of time that different wind speeds occur. The 2011 annual wind rose plots and annual wind class frequency distribution plots for the four continuous air monitoring stations in the Wabamun–Genesee area are shown in Figures 4–11 to 4–18.

Winds blew from the north-northwest to west-southwester direction greater than 40% of the time at the four air monitoring stations (Genesee 50%, Figure 4–11; Meadows 47%, Figure 4-13; Powers 49%, Figure 4–15; and Wagner 43%, Figure 4–17). Winds blew approximately 18% of the time from the north-northwest to westerly direction at the Wagner air monitoring station (Figure 4–17).
Figure 4–11  Annual Wind Rose Plot for the Genesee Air Monitoring Station during 2011

Figure 4–12  Annual Wind Class Frequency Distribution Plot for the Genesee Air Monitoring Station during 2011
**Figure 4–13**  Annual Wind Rose Plot for the Meadows Air Monitoring Station during 2011

**Figure 4–14**  Annual Wind Class Frequency Distribution Plot for the Meadows Air Monitoring Station during 2011
Figure 4–15  Annual Wind Rose Plot for the Powers Air Monitoring Station during 2011

Figure 4–16  Annual Wind Class Frequency Distribution Plot for the Powers Air Monitoring Station during 2011
Section 4: Results and Discussion

Figure 4–17  Annual Wind Rose Plot for the Wagner Air Monitoring Station during 2011

Figure 4–18  Annual Wind Class Frequency Distribution Plot for the Wagner Air Monitoring Station during 2011
4.2 Intermittent Monitoring Program

Results of the intermittent PM monitoring program for 2011 are shown in Figure 4–19, (PM\textsubscript{2.5}), and Figure 4–20, (PM\textsubscript{10}). Figure 4–19 is a box-and-whisker plot of 24-hour average PM\textsubscript{2.5} data collected on a 1-in-6 day schedule (NAPS). Twenty-four hour average PM\textsubscript{2.5} concentrations were <19 µg/m\textsuperscript{3} at both the Genesee and Powers air monitoring stations for 98% of the time. Similar variation in 24-hour average PM\textsubscript{2.5} concentrations was observed at the two air monitoring stations. The IQRs were 4 µg/m\textsuperscript{3} at both Genesee and Powers AMS.

Figure 4–20 is a box-and-whisker plot of 24-hour average PM\textsubscript{10} concentrations at the Genesee AMS and Powers AMS during 2011. Twenty-four hour average PM\textsubscript{10} concentrations were <51 µg/m\textsuperscript{3} at both the Genesee and Powers air monitoring stations for 98% of the time. The IQRs for 24-hour average PM\textsubscript{10} concentrations were 11 µg/m\textsuperscript{3} at Genesee AMS and 16 µg/m\textsuperscript{3} at Powers AMS in 2011.

Figures 4–21 and 4–22 show 24-hour average PM\textsubscript{2.5} concentrations versus PM\textsubscript{10} concentrations at the Genesee and Powers air monitoring stations during 2011. Linear regression relationships were used to show the degree of comparison between PM\textsubscript{2.5} and PM\textsubscript{10} concentrations. The purpose was to show the ability of the PM\textsubscript{2.5} concentrations to predict PM\textsubscript{10} concentrations.

Coefficient of determination (R\textsuperscript{2}) values were calculated from PM\textsubscript{2.5}/PM\textsubscript{10} matched pair data for each air monitoring station (Genesee and Powers) and are shown in Figures 4–21 and 4–22. A coefficient of determination (R\textsuperscript{2}) is the proportion of sample variance of a response variable (PM\textsubscript{10} concentration) that is "explained" by predictor variables (PM\textsubscript{2.5} concentrations) when a linear regression is done.

![Figure 4–19](image-url)  
**Figure 4–19** Box-and-Whisker Plot of Intermittent 24-hour Average PM\textsubscript{2.5} Concentrations at Genesee and Powers Air Monitoring Stations in 2011  
Note: 25\textsuperscript{th} %ile (bottom of box), 50\textsuperscript{th} %ile (line inside box), 75\textsuperscript{th} %ile (top of box), maximum (top T), and 98\textsuperscript{th} %ile (diamond symbol).
Box-and-Whisker Plot of Intermittent 24-hour Average PM$_{10}$ Concentrations at Genesee and Powers Air Monitoring Stations in 2011

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

Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Genesee Air Monitoring Station during 2011

\[ y = 1.2x + 6.8 \]

\[ R^2 = 0.26 \]
Figure 4–22  Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Powers Air Monitoring Station during 2011

Results for the Genesee AMS ($R^2 = 0.26$, $n=61$) indicated that only 26 percent of variance in 24-hour average PM$_{10}$ concentrations was explained by variation 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 ($R^2 = 0.22$, $n=59$) indicated that only 22 percent of variance in 24-hour average PM$_{10}$ concentration was explained by variation in 24-hour average PM$_{2.5}$ concentrations. Again, these findings indicate that 24-hour average PM$_{2.5}$ measurements at the 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 2011 (Figure 1–2). Annual average concentrations were determined by averaging 12 monthly monitoring results at each passive site tabulated in Appendix A.

In addition, annual average concentrations during 2011 of NO$_2$, SO$_2$ and O$_3$ at selected continuous monitoring stations in the area were plotted for comparison purposes (i.e., the Violet Grove AMS and the Edmonton East AMS). This information was obtained from the CASA Data Warehouse for 2011 (CASA 2012, internet reference).

#### 4.3.1 Nitrogen Dioxide

Figure 4–23 is a bubble plot of annual average NO$_2$ concentrations measured at 18 NO$_2$ passive monitoring sites during 2011. Figure 4–23 indicates that annual NO$_2$ concentrations determined by passive monitors increase slightly from sites between Lake Wabamun to sites adjacent to the City of Edmonton. The highest annual average NO$_2$ concentration shown in Figure 4–23 was observed at the Edmonton East station (14 ppb or 26 µg/m$^3$) compared to a range of 1.3 to 2.0 ppb (2.0 to 4.0 µg/m$^3$) observed at passive sites located within 30 km of the generating stations. These data show that urban
source emissions contribute more to ambient NO$_2$ concentrations observed in and around the City of Edmonton than generating station emissions from the Wabamun–Genesee area.

### 4.3.2 Sulphur Dioxide

Figure 4–24 is a bubble plot of annual average SO$_2$ concentrations measured at 11 SO$_2$ passive monitoring sites during 2011. Annual average SO$_2$ concentrations were very low, ranging from 0.6 to 1.3 ppb (1.6 to 3.4 µg/m$^3$) across all sites. These low values and associated lack of spatial trend are 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, pers. comm.). This lack of trend is also consistent with predictions of future cumulative SO$_2$ emissions in the area associated with the Genesee generating station 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 4–25 is a bubble plot of annual average O$_3$ concentrations measured at 12 O$_3$ passive monitoring sites during 2011. Annual average O$_3$ concentrations observed at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24 to 32 ppb (48 to 64 µg/m$^3$). In general, lower annual average O$_3$ concentrations were observed within the City of Edmonton compared with passive monitoring sites directly east of the Wabamun–Genesee area (Figure 4–25). A partial explanation for this spatial trend is because of increased O$_3$ scavenging due to increased NOx emissions within the City of Edmonton (Kindzierski et al. 2006; Kindzierski 2006). This spatial trend is consistent with slightly increasing NO$_2$ concentrations observed towards the City of Edmonton, as shown in Figure 4–23.

The passive monitoring Sites 15 and 16 (Figures 4–23 and 4–25) 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 on which the generating stations 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 stations. Gillani et al. (1998) and U.S. EPA (1998) have indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occur between 30 and 100 km downwind of generating stations.

Passive monitoring Sites 15 and 16 were established to examine whether O$_3$ levels are higher, lower, or similar compared to levels from O$_3$ sampling sites closer to the generating stations. Site 15 is located 26.7 km away from Genesee AMS towards the southeast; while Site 16 is 39.8 km away from the station (Figure 1–2). These sites were established to help understand whether anthropogenic O$_3$ production may be occurring farther away from the stations. It was important to avoid siting these sampling locations near urban areas because NOx scavenging becomes more dominant, resulting in lower O$_3$ levels. Annual average O$_3$ concentrations at sites 15 and 16 were 8% and 5% smaller, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2011. The Violet Grove station is located 55 km to the southwest of the generating stations.

Figure 4–26 shows monthly average concentrations measured at O$_3$ passive monitoring sites during 2011. The highest monthly average O$_3$ concentrations observed in the network occurred in late winter/early spring, peaking in March. This temporal trend is consistent with historical data reported by He et al. (2005) and Kindzierski et al. (2006) for other O$_3$ monitoring sites in west-central Alberta. Seasonal variation in ground-level O$_3$ is influenced by stratospheric intrusion of O$_3$ that has been frequently observed in previous studies in Alberta (Sandhu 1999; Chaikowsky 2001).
Bubble Plot of Annual Average NO$_2$ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011.
Bubble Plot of Annual Average SO₂ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011

Acknowledgements:
Original Drawing by Stantec
Bubble Plot of Annual Average O₃ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2011
Figure 4–26  Monthly Average O₃ Concentration at Passive Monitoring Sites in Central Alberta during 2011

Note – refer to Figure 1–2 for location of passive monitoring sites.
5 Summary

A continuous program was conducted at the Genesee, Meadows, Wagner and Powers air monitoring stations in the Wabamun–Genesee area during 2011. Data capture rates for measured parameters at all of the air monitoring stations were above the 90% criterion for the year as required by the Air Monitoring Directive (Alberta Environment 1989, internet reference). High up-times were indicative that equipment in the continuous air monitoring network was well-maintained.

Overall, air quality was judged to be good at the monitoring stations during 2011, similar to that observed in previous years. A summary of the 2011 continuous monitoring data is as follows:

- Hourly NO₂ concentrations were very low at all four air monitoring stations (below 61 µg/m³ for 98% of the time). The observed 9th highest 1-hour NO₂ concentrations ranged from 48 µg/m³ at the Genesee AMS to 128 µg/m³ at the Powers AMS. For comparison purposes, the 9th highest 1-hour NO₂ concentrations at the Carrot Creek AMS and Edmonton East AMS during 2011 were 75 and 115 µg/m³, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 400 µg/m³.

- Hourly SO₂ concentrations were very low at all four air monitoring stations (below 26 µg/m³ for 98% of the time). The 9th highest 1-hour SO₂ concentrations ranged from 36 µg/m³ at the Powers AMS to 63 µg/m³ at the Wagner AMS. For comparison purposes, the 9th highest 1-hour SO₂ concentrations at the Carrot Creek AMS and Edmonton East AMS during 2011 were 18 and 58 µg/m³, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 450 µg/m³.

- The annual average O₃ concentration at the Genesee AMS was 54 µg/m³. Hourly O₃ concentrations at the Genesee AMS were below 106 µg/m³ for 98% of the time during 2011. The 9th highest 1-hour O₃ concentration at the Genesee AMS was 122 µg/m³. For comparison purposes, the 9th highest 1-hour O₃ concentrations at the Carrot Creek AMS and Edmonton East AMS were 122 and 124 µg/m³, respectively. O₃ concentrations at the Genesee AMS did not exceed the Alberta Ambient Air Quality objective of 160 µg/m³ at any time during 2011.

- Median (50th percentile) 24-hour PM₂.₅ concentrations at the Genesee and Powers air monitoring stations were very low (below 5 µg/m³). The 98th percentile 24-hour PM₂.₅ concentrations at both air monitoring stations were below 22 µg/m³. This is well below the 24-hour Canada Wide Standard of 30 µg/m³.

During 2011, twenty-four hour average PM₂.₅ and PM₁₀ samples were collected at the Genesee and Powers air monitoring stations according to a NAPS six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2011:

- Twenty-four hour average PM₂.₅ concentrations were below 19 µg/m³ at both the Genesee and Powers air monitoring stations for 98% of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations.

- Twenty-four hour average PM₁₀ concentrations were below 51 µg/m³ at both the Genesee and Powers air monitoring stations for 98% of the time.
Passive air monitors were deployed at 21 stations in the Wabamun–Genesee area during 2011. The 2011 passive data are summarized as follows:

- At passive sites located within 30 km of the generating stations, annual average NO$_2$ concentrations ranged from 1.3 to 2.0 ppb (2.0 to 4.0 µg/m$^3$), whereas at the Edmonton East AMS the annual average NO$_2$ concentration was 26 µg/m$^3$. Annual NO$_2$ concentrations determined by passive monitors showed a small increase between 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 within and adjacent to the City of Edmonton. Urban source emissions are more important contributors to ambient NO$_2$ concentrations in and around the City of Edmonton compared to emissions from generating stations located in the Wabamun-Genesee area.

- Annual average SO$_2$ concentrations were very low, ranging from 0.6 to 1.3 ppb (1.6 to 3.4 µg/m) 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.

- Annual average O$_3$ concentrations at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24 to 32 ppb (48 to 64 µg/m$^3$). Sites 15 and 16 are located greater than two to four-hours travel time downwind of the generating stations along an imaginary northwest line on which the generating stations are located. Previous work by others has indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occurs between 30 and 100 km downwind of generating stations (within the range of where these two passive monitoring sites are located). Site 15 is located 26.7 km away from Genesee AMS towards the southeast; while Site 16 is 39.8 km away from the station. Annual average O$_3$ concentrations at sites 15 and 16 were 8% and 5% smaller, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2011. The Violet Grove station is located 55 km to the southwest of the generating stations.
6 References

6.1 Literature Cited


Kindzierski, W.B. 2006. Analysis of historical O₃ and PM₂.₅ trends from ambient air monitoring data in central Alberta. *Air Quality 2006: Piecing the Puzzle, the Fourth Canadian Workshop on Air Quality*, 13 to 16 February 2006, Banff, AB.


TransAlta Generation Partnership and Capital Power Corporation  
Ambient Air Monitoring Program  
Section 6: References


### 6.2 Personal Communications


### 6.3 Internet Sites


# Appendix A  Passive Monitoring Data for 2011

## Table A-1  2011 NO$_2$ Passive Monitoring Data (monthly average concentration in ppb)

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