2009 Ambient Air Monitoring Strategy for Alberta

A report to the CASA Board from the AMSP Project Team

September 2009

Acknowledgements

Members of the Ambient Monitoring Strategic Plan Team showed long-term dedication and commitment to the challenges presented by their tasks. The volunteer time given to this project by individuals and organizations was significant and far exceeded original expectations. This project would not have been completed without their dedication to improving ambient air quality monitoring in the province.

The Project Team also gratefully acknowledges the financial contributions provided in support of the team's work. Special thanks to those stakeholders who provided support by hosting meetings and staff resources behind the scenes.

About CASA

The Clean Air Strategic Alliance (CASA) is a multi-stakeholder partnership composed of representatives selected by industry, government and non-government organizations. Stakeholders are committed to developing and applying a comprehensive air quality management system for all Albertans.

All CASA groups and teams, including the board of directors, make decisions and recommendations by consensus. Recommendations are likely to be more effective and long lasting than those reached through adversarial processes.

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Preface

This report recommends an updated Ambient Air Monitoring Strategic Plan for Alberta. It is an important step in the ongoing management of the province's ambient air quality and is a foundation for the emerging Cumulative Environmental Management work in Alberta. The Plan incorporates elements from the current system and proposes new elements that will lead to a more comprehensive and responsive system.

The Ambient Monitoring Strategic Plan (AMSP) Project Team worked diligently and in good faith to reach consensus on the Plan. Throughout the process, representatives from all sectors provided their views and perspectives, identified concerns and offered alternative solutions. This Plan includes a set of recommendations, negotiated by the team and agreed to as a package. All recommendations were agreed to by consensus with the exception of recommendations 20 and 21, which focus on funding the new Ambient Air Monitoring Network for Alberta. These recommendations were blocked by Alberta Environment and alternate wording has been supplied to the AMSP Project Team and is provided in this report. The AMSP Project Team suggests that this Plan be considered in its entirety. If it is fragmented in any way, the overall Plan can no longer be regarded as a package with full stakeholder support.

The AMSP project team recognizes that the Alberta Government has recently initiated several frameworks. The project team recommends that these initiatives consider the AMSP in their development. These initiatives include, but are not limited to:

- The development of regional plans under the Land-use Framework supported by The Alberta Land Stewardship Act;
- The implementation of a Cumulative Effects Management System and regional approach to coordinate environmental monitoring through the Integrated Monitoring, Evaluation and Reporting Framework;
- Potential changes to monitoring requirements through the Regulatory Alignment and Enhancement Project for Upstream Oil and Gas and Oil Sands; and
- The renewed Clean Air Strategy.

The CASA project team recognizes that the implementation or the timing of the recommendations of the AMSP may change as these initiatives evolve. In this regard, Alberta Environment commits to report annually to the CASA Board on the implementation status of the Plan.

Executive Summary

The Government of Alberta released a new Land-use Framework for Alberta in December 2008. The Framework is aimed at improving decision making around land-use planning, considering impacts of economic development and population growth on the finite capacity of our air, land and water ecosystems.

The first strategy of the Land-use Framework is to develop regional plans for seven new land-use regions covering the province. Alberta's approach to develop the environmental component of land-use regional plans is through a Cumulative Effects Management System. This System will consider, holistically, the combined impacts of industrial and non-industrial stresses on the environment.

A fundamental requirement of cumulative effects management is accurate, complete and appropriate monitoring information. This will allow informed decisions around land-use planning and will minimize the risk of decisions that may lead to unacceptable impacts of development on the environment. The 2009 CASA Ambient Monitoring Strategic Plan (AMSP) contains monitoring strategies that will allow the appropriate monitoring data to be collected that will inform cumulative effects management and land-use planning for Alberta.

A Strategic Plan for Air Quality Monitoring in Alberta was approved by CASA (the Clean Air Strategic Alliance) in 1995 followed by an Implementation Plan in 1997. Since this first strategic plan was developed, the extent, pace and expectations of ambient air monitoring in Alberta have changed significantly, including:

- Increased levels of industrial activity along with increased population;
- More rapid than expected formation of airshed zones, with an associated increase in ambient monitoring by the zones;
- Implementation of several CASA frameworks that have created a need for specific types of monitoring and data (Particulate Matter and Ozone Management Framework, Acid Deposition Management Framework, Air Management Framework for the Electricity Sector);
- Improved technologies for monitoring and for collecting and managing data; and
- New air monitoring guidelines.

For these reasons, the CASA Board formed the Ambient Monitoring Strategic Planning Project Team to develop a new strategic plan, using the 1995 plan as its foundation. The 2009 CASA AMSP is specifically intended to: (1) identify and address current air monitoring gaps in areas where there are concerns about human health, acid deposition and smog formation; (2) improve responsiveness to emerging air quality issues in Alberta that will result from population and industry growth; (3) address funding and implementation issues that resulted in the 1995 plan not being fully implemented; and (4) focus air and deposition monitoring on collecting the appropriate information that is needed for cumulative effects management.

The 2009 Ambient Monitoring Strategic Plan

An integrated province-wide ambient air monitoring system is a fundamental underpinning to Alberta's air quality management system. This system will continue to include large industrial emitters, but the proposed new system will add and expand a number of sub-programs, and also

introduce a mechanism for funding monitoring of emissions from small industrial and diffuse sources.

The 2009 CASA AMSP contains the following components, further described in the report:

(1) An *Ambient Air Monitoring Framework* for Alberta consisting of a long-term vision, principles, goals and monitoring objectives
(2) *Managing The Monitoring System*, which outlines responsibilities for various agencies and organizations in maintaining the monitoring network as well as performance measurement
(3) The *Proposed New Ambient Monitoring Network Design* consisting of the following seven monitoring sub-programs:
    a. Population-based Monitoring Sub-program
    b. Ecosystem-based Monitoring Sub-program
    c. Ozone Monitoring Sub-program
    d. Boundary Transport Monitoring Sub-program
    e. Background Monitoring Sub-program
    f. Pattern Recognition Monitoring Sub-program
    g. Industry Compliance Monitoring Sub-program
(4) A *Funding System for the New Air Monitoring System* consisting of funding principles, a funding formula and an example of how to calculate the funding contribution based on emissions
(5) A *Data and Information Management System* focusing on developing strategies to actively and reliably provide information to Albertans
(6) An *Implementation Plan* that recommends the order and priority for implementation.

The enhanced network will:

- Make adjustments to improve the representativeness of current monitoring in Edmonton and Calgary;
- Contain at least one air monitoring station in each population centre with more than 20,000 people;
- Periodically assess air quality at communities with a population between 10,000 and 20,000 using portable monitoring;
- Improve acid deposition monitoring (wet and dry) by doubling the size of the existing network to adequately assess deposition throughout the province;
- Increase monitoring of smog forming chemicals (such as PM, ozone and their precursors) upwind and downwind of affected airsheds;
- Improve monitoring to assess transport across Alberta's borders and to measure background air quality;
- Increase the passive monitoring network to cover the whole province;
- Incorporate those industrial site-specific monitoring stations that can also help to meet regional and provincial monitoring objectives into the provincial network; and
- Improve dissemination of data and communication of information on ambient air quality to all Albertans.

The seven monitoring subprograms proposed by the 2009 AMSP are displayed in Figure 1.

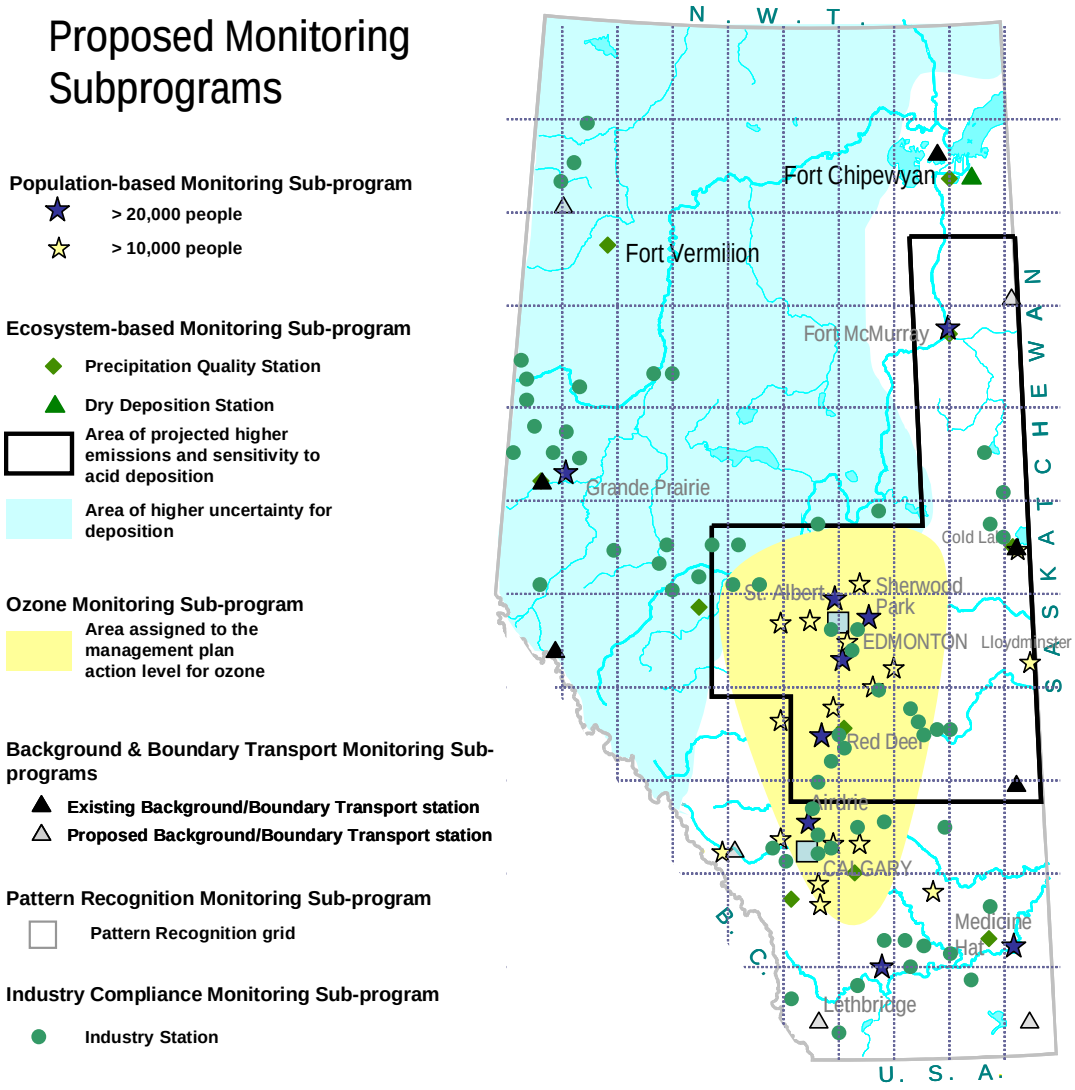


Figure 1. Existing and proposed monitoring recommended by the 2009 AMSP.

Funding the Enhanced System

The AMSP team is proposing a funding formula that is simple, fair, objective, open, transparent, and understandable. The formula uses a consistent charge per tonne on emissions throughout the province. The formula is based on the emitter-pay principle, with the understanding that a sustainable and long term funding mechanism will be developed by the Government of Alberta to pay for ambient air quality monitoring.

Figure 2 shows the changes in funding requirements from the current system to the new emitter-pay system. The funding for the total network represented in this figure includes the following monitoring programs: provincial sub-programs, mobile and emergency, airsheds, and industrial compliance (facility specific industry monitoring). Once the new network is in place, the increased annual operating costs will be about $4.8 million. Under the proposed emitter-pay system, about 70% of these costs are attributed to non-industrial sources ($3.4 million) and 30% are attributed to industrial sources ($1.4 million).

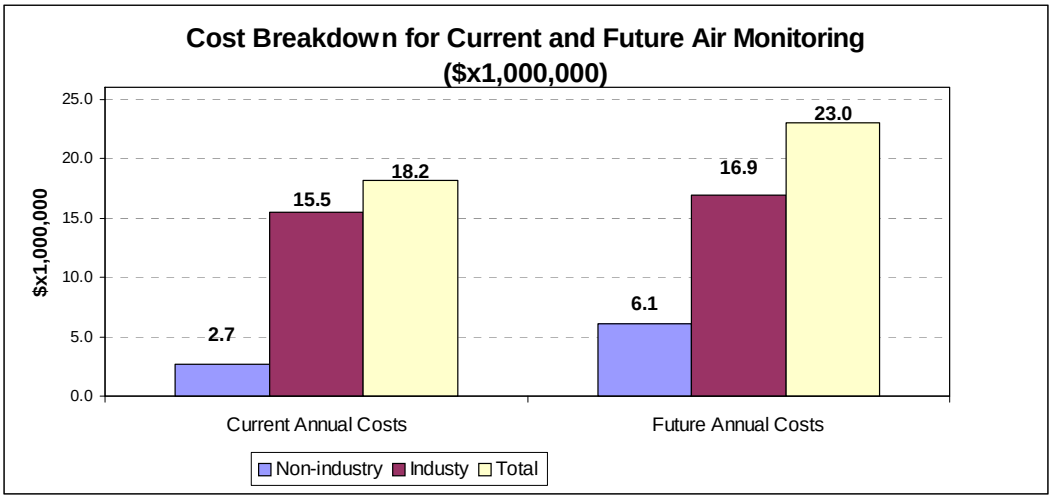


Figure 2. Annual Cost Breakdown for the Proposed Air Monitoring System

Implementing the Enhanced System

The AMSP team is proposing that all funds and equipment be allocated over the first four years following the CASA board's approval of the AMSP, and that the entire system be fully implemented and operating within five years. Total cost for implementing the new infrastructure will be close to $11-million over four years including new capital equipment and annual operations. After year four, the annual costs for the provincial network are projected to be $4.4 million per year. Figure 3 illustrates the funding needed to implement new monitoring proposed by the strategic plan over five years.

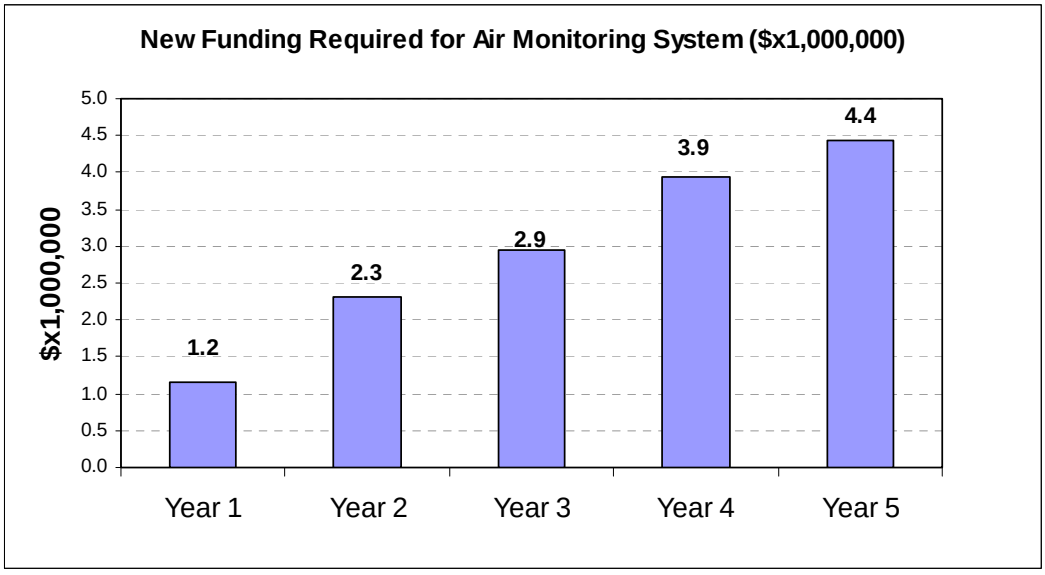


Figure 3. Annual funding required for new air monitoring system proposed by the AMSP.

Recommendations of the 2009 AMSP

The report consists of 28 recommendations, described in Table 1 below. Note that the CASA AMSP Project Team did not achieve consensus regarding Recommendation #20 (Funding to implement the enhanced ambient air monitoring system) and Recommendation #21 (Ensuring long-term sustainable funding). These recommendations focus on the Government of Alberta (GOA) providing certainty to funding the monitoring proposed by the 2009 AMSP. The GOA cannot make this long-term commitment and did offer alternative wording for these recommendations. Discussion of these non-consensus recommendations are contained in Section 7.1 and Appendix H of this report.

The AMSP project team acknowledges the on going development of new strategic initiatives by the Government of Alberta to manage the environment on a regional, cumulative-effects basis through the Land-use Framework and the Integrated Monitoring, Evaluation and Reporting Framework. The AMSP team recommends that the Air Monitoring Strategic Plan be considered and used as input into the development and implementation of regional plans or regional monitoring strategies as well as the renewed Clean Air Strategy. The AMSP team agrees that a provincial monitoring plan is required to fulfill the monitoring objectives stated in this report, and that the 2009 Ambient Air Monitoring Strategic Plan is the best air monitoring plan for the province and residents of Alberta at this time. The team also recognizes that actual monitoring priorities, station locations and timelines may be restructured as the environment (physical, economic, social and political) changes over time. However, the fundamental principles presented in this report are still comprehensive, scientifically-based and peer reviewed.

Table 1. 2009 AMSP Recommendations

	Recommendation	Page #
#1	***Adoption and review of the framework for Alberta's air monitoring system*** *The Ambient Monitoring Strategic Plan (AMSP) Project Team recommends that:* *CASA adopt the framework, consisting of the vision, principles, goals and objectives, and review the framework after ten years following the date of approval.*	27
#2	***Multi-stakeholder Implementation Committee*** *The AMSP Project Team recommends that:* *A Multi-stakeholder Implementation Committee be established by Alberta Environment to manage implementation and evaluate progress of the new ambient air quality monitoring system recommended in this Strategic Plan.*	27
#3	***Annual work plan*** *The AMSP Project Team recommends that:* *The MIC develop an annual work plan to be approved by Alberta Environment, coordinated with GOA budget cycle beginning in Fiscal Year following approval.*	27
#4	***Review of strategic plan*** *The AMSP Project Team recommends that:* *CASA establish a new team to review and revise the strategic plan every five years, commencing five years following board approval.*	27

	Recommendation	Page #
#5	***Data Quality Objectives*** *The AMSP project team recommends that:* *The MIC define draft Data Quality Objectives for each monitoring sub-program within one year after the MIC is formed. These Data Quality Objectives will be reviewed on an on-going basis.*	35
#6	***Monitoring input from CASA project teams*** *The AMSP Project Team recommends that the CASA Board and Secretariat initiate the following actions related to monitoring and data issues:* *1. in the Terms of Reference for Project Teams, as appropriate, require as a specific task the identification of any network as related monitoring and or data needs related to any of their recommendations;* *2. that Project Teams be formally requested, on an annual basis, to provide any network monitoring or data issues, needs or concerns that have arisen from their work to be recorded by the Secretariat and sent to the Multi-Stakeholder Implementation Committee (or subsequent equivalent or AENV). These should also be retained as reference material for use by the next AMSP Project Team; and* *3. that CASA members be formally polled as part of the CASA coordination workshop regarding their level of satisfaction with, and recommendations for, the ambient monitoring network (it is recommended that this be done in conjunction with the establishment of the AMSP Project Team undertaking the update of the Strategic Plan (recommendation 4)).*	38
#7	***Adoption of the seven sub-programs*** *The AMSP Project Team* recommends that CASA approve the provincial ambient air monitoring network, initially consisting of the following seven sub-programs: *1. Population-based monitoring sub-program,* *2. Ecosystem monitoring sub-program, including acid deposition monitoring,* *3. Ozone monitoring sub-program,* *4. Boundary Transport monitoring sub-program,* *5. Background monitoring sub-program,* *6. Pattern recognition-monitoring sub-program, and* *7. Industrial compliance monitoring sub-program*	40

	Recommendation	Page #
#8	***Improved air monitoring for urban centres*** *The AMSP project team recommends that the MIC consider in their workplan the following in determining future air monitoring for urban areas:* *a) Use an objective, scientific defensible process to determine the appropriate monitoring for Edmonton and Calgary.* *b) Where possible, incorporate existing monitoring conducted by industry, airsheds and government into urban monitoring networks.* *c) Assess the need for two monitoring stations in municipalities with a population greater than 50,000.* *d) Assess the need for one permanent monitoring station in municipalities with a population greater than 20,000.* *e) Assess the monitoring needs for monitoring in municipalities with a population less than 20,000.* *f) Use the Air Monitoring Guidance Tool or equivalent in the decision making process for determining the priority for new monitoring.* g) *Review population growth in urban centres annually to determine the need for additional monitoring.*	45
#9	***Ecological monitoring*** *The AMSP team recommends that Alberta Environment as part of their annual planning:* • *Evaluate opportunities for better coordination of air, land, water and biodiversity monitoring programs in Alberta. This should involve developing integrated monitoring stations to monitor all media within a given area.*	49
#10	***Advice for acid and nitrogen deposition monitoring stations*** *The AMSP team recommends that airsheds and the MIC consider the following when designing a deposition monitoring network:* • *Locating at least one dedicated acid and/or nitrogen deposition monitoring station near important source emitting areas.* • *Establishing at least one dedicated monitoring site in an area that represents a lower loading condition for comparison (background station).* • *Evaluating the use of passive samplers for SO_2, HNO_3, NH_3 and NO_2 to support dry deposition monitoring.* • *Define acid and nitrogen deposition monitoring protocols to be applied province-wide for wet and dry deposition.* • *Ensure that comparable monitoring approaches for wet and dry deposition are used across the province.*	49

	Recommendation	Page #
#11	***Re-designing the acid deposition monitoring network*** *The AMSP team recommends that the MIC redesign the provincial wet and dry deposition monitoring network, focusing on areas of predicted high deposition, high receptor sensitivity and high uncertainty, also giving consideration to the existing long-term precipitation quality data base. In redesigning the acid deposition network, the following should be considered:* • *Expand the network to include more monitoring in areas with high deposition and high receptor sensitivity.* • *Expand the network to include areas of high uncertainty.* • *Implement instrumentation that would allow both wet and dry deposition calculation at all monitoring sites.* • *The addition of approximately eight to twelve new wet and dry deposition stations to meet the needs mentioned in the previous three bullets. Scientific rationale will have to be provided when determining the number and location of these stations.*	50
#12	***Precipitation quality gradient monitoring program*** *The AMSP team recommends that:* • *The MIC consider implementing a 3 to 5 year precipitation quality monitoring program to characterize the precipitation quality gradient across Alberta. The program would consist of 16 to 20 monitoring sites with the east-west transect bisecting the Calgary-Edmonton corridor and the north-south transect along the Calgary-Edmonton corridor.* • *Environment Canada, in consultation with the MIC, implement a study to quantify the reliability of precipitation volume data.*	50
#13	***Ozone monitoring in the affected area of Alberta*** *The AMSP team recommends that:* • *The MIC and the affected airsheds design an ambient monitoring network for ozone, its precursors and products, for the affected airsheds that are assigned to the Management Plan action level. The monitoring program will consider monitoring for ozone, ozone precursors and ozone products upwind and downwind of the affected airsheds.* • *The MIC look for opportunities to optimize the current monitoring stations in the affected area of Alberta based on the proposed network design.*	53

	Recommendation	Page #
#14	***Boundary Transport monitoring*** *The AMSP team recommends that the MIC:* *a) Consider results of the province-wide network design project in determining how to address air pollutants entering and leaving the province;* *b) Determine the suitability of existing stations to assess border transport of air pollutants (i.e., Fort Chipewyan, Hightower Ridge, Beaverlodge, Esther, Cold Lake and Medicine Hat as well as industrial compliance monitoring stations). If these stations are suitable, they should be added to the network; and* *c) Assess the suitability of proposed new boundary transport monitoring stations in the Kananaskis area, Pincher Creek/Waterton area, northwestern Alberta, and northeastern Alberta near the Saskatchewan border, on the Saskatchewan side of the Alberta-Saskatchewan border and if the results are favourable, bring these stations into the program.* *d) Develop a methodology and/or set of criteria for determining the suitability of stations for both boundary transport and background monitoring.*	56
#15	***Visibility*** *The AMSP team recommends that:* *The MIC investigate the opportunity to collaborate on the visibility monitoring program under development by Environment Canada over the next 3 to 5 years.*	56
#16	***Background monitoring*** *The AMSP team recommends that the MIC* *a) Consider results of the province-wide network design project in determining how to address background air quality in Alberta;* *b) Determine the suitability of existing monitoring stations to assess background air quality (Hightower Ridge and Beaverlodge); and* *c) Consider establishing background air monitoring stations in the Kananaskis area, Pincher Creek/Waterton area and northwestern Alberta.* *d) Develop a methodology and/or set of criteria for determining the suitability of stations for both boundary transport and background monitoring.*	57
#17	***Background monitoring upwind of large industrial complexes*** *The AMSP team recommends that the MIC:* • *Evaluate background monitoring upwind of large industrial complexes in Alberta and determine adequacy, identify gaps and make recommendations to Alberta Environment, airsheds and industry.* • *Address gaps and ensure that background monitoring is conducted upwind of large industrial complexes throughout Alberta.*	57
#18	***Pattern Recognition network design*** *The AMSP team recommends that the MIC:* • *Do a scientific, objective analysis to determine the appropriate network density for a province-wide network that will spatially represent air quality in Alberta.* • *Use industry, airshed and government monitoring stations where possible to address gaps in air monitoring. An assessment of where these gaps are and what stations could be used to fill these gaps is required.*	59

	Recommendation	Page #
#19	***Rationalizing industry monitoring*** *The AMSP team recommends that the MIC:* • *Look for opportunities with industry, airsheds and AENV to rationalize air monitoring currently being conducted by industry.* • *Provide guidance for industry, airsheds (if present in the region) and AENV in the evaluation of facility specific compliance monitoring stations.* • *Make recommendations to industry, airsheds and AENV regarding which stations might be incorporated into the monitoring network.*	62
#20	***Funding to implement the enhanced ambient air monitoring system (non-consensus recommendation)*** *The AMSP Project Team recommends that:* *a) Alberta Environment commit to annual funding through the Government of Alberta's budgeting process to cover the cost of monitoring emissions attributed to diffuse emitters.* *b) Large and small industrial emitters fund their portion of the enhanced provincial network according to the funding formula.* *c) For large industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees industry's funding contribution to the enhanced network by committing to pursue payment through regulatory mechanisms.* d) *For small industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees small industry's contribution to the network by either pursuing payment through regulatory mechanisms or covering their contribution and then retroactively applying the long-term funding mechanism when it is implemented.*	68
#21	***Ensuring long-term sustainable funding (non-consensus recommendation)*** *The AMSP Project Team recommends that:* 1. *To ensure long-term sustainable funding for the Ambient Monitoring Strategic Plan (i.e., after the first four years), Alberta Environment develop within two years, a sustainable long-term funding mechanism that ensures equitable contributions from large industrial, small industrial and diffuse emitters.* 2. *Alberta Environment implement this funding mechanism in the subsequent two years.*	68
#22	***Data management principles*** *The AMSP Project Team recommends that:* *CASA accept the principles of the new data management system.*	71
#23	***Mandatory submission of data to a central data management system (currently, the CASA Data Warehouse.)*** *The AMSP Project Team recommends that:* *Alberta Environment develop a mechanism within one year following board approval to facilitate mandatory submission of all ambient air quality monitoring data in Alberta to a central data management system within a prescribed time period.*	71

	Recommendation	Page #
#24	***Funding the central data management system*** *The AMSP Project Team recommends that:* *The Multi-Stakeholder Implementation Committee consider funding for the central data management system as part of the overall air monitoring system costs.*	72
#25	***Determining the needs of data users*** *The AMSP recommends that:* *Within one year of board approval Alberta Environment conduct a survey to determine the needs of data users and what information would be most useful to users and provide the report to the Multi-Stakeholder Implementation Committee*.	72
#26	***A comprehensive emissions inventory*** *The AMSP Project Team recommends that:* *Alberta Environment develop and maintain a comprehensive GIS-based provincial inventory of all relevant emission sources that influence provincial air quality commencing within one year following board approval.*	73
#27	***Priority and timelines for implementation*** *The AMSP project team recommends that:* • *The Ambient Monitoring Strategic Plan be implemented according to the 5-year timeline suggested by the AMSP Implementation Subgroup, as outlined in Table 11 of the Implementation Plan. Where specific timelines are not mentioned in the recommendations, they are captured in the seven sub-programs discussed in the AMSP.* • *The MIC have flexibility to modify the implementation timeline according to any new priorities.*	76
#28	***Alignment of AMSP with Government of Alberta Direction*** *The AMSP project team recommends that:* • *AENV consider the 2009 AMSP report, associated recommendations and the ambient air monitoring network design in the development and implementation of new regional environmental plans and regional monitoring through the renewed Clean Air Strategy, Alberta Land-use Framework and Integrated Monitoring, Evaluation and Reporting Framework. The team recognizes that the technical portion of the AMSP report will need to be responsive to changes in the environment (physical, economic, social and political) and that actual monitor locations may change accordingly.* • *AENV report back to the CASA Board annually on the implementation status of the 2009 AMSP.*	79

1 Introduction

1.1 Air Quality in Alberta

Air quality deteriorates when certain substances from human or natural sources accumulate in the atmosphere. Human activities that generate air emissions include industrial point sources such as oil and gas facilities and power generation plants; smaller commercial operations such as dry cleaners; residential furnaces; agriculture; and transportation. Natural sources include things like fires, volcanoes, and emissions from vegetation and microbial activity. Air quality is also affected by a range of other factors, such as weather conditions and topography.

Air quality is an important factor in our quality of life. Reduced air quality can affect the health of humans and ecosystems. In Alberta, ambient air quality is monitored by industry, *airshed zones*, Alberta Environment (AENV) and Environment Canada. Presently, ambient air quality monitoring is done on four scales:

- Local
- Regional
- Provincial
- National

Shortly after the Clean Air Strategic Alliance (CASA) was formed in 1994, respondents to a CASA survey said their primary concern was the impact of air emissions on human health, followed closely by effects of air quality on ecosystems. A fundamental requirement for addressing both of these concerns is the availability of good air quality data. Obtaining credible and reliable information on ambient air quality and assessing its effects on human and ecosystem health continues to be a high priority for CASA stakeholders and other decision makers.

1.2 Managing Alberta's Air Quality

Ambient air monitoring has always been a key element of Alberta's comprehensive air quality management system, but it is only one component. Alberta Environment's comprehensive approach to managing air quality uses scientific, economic, and social information to achieve its objectives. Risk assessment is an inherent part of air quality management systems and is being incorporated into the decision- and policy-making processes; thus, estimates of uncertainty must be associated with the air quality data collected.

The elements of Alberta's comprehensive air quality management system are listed below:

• Environmental Assessment Process	• Emissions Inventories
• Approvals	• Air Modeling
• Compliance and Enforcement	• Research
• Inspections and Abatement	• Ambient Air Quality Objectives
• Source Emissions Monitoring	• **Ambient Air Monitoring**
• Source Emission Standards	• Reporting
• Product Standards	• Information and Education

Each of these components is described briefly in Appendix A.

1.3 Context for 2009: The 1995 Ambient Monitoring Strategic Plan

Ambient monitoring has been a key element of Alberta's air quality management system since the system was developed in the 1960s and 1970s. By the 1990s, it was clear that the existing system could not meet the growing need for reliable, consistent and integrated air quality information. CASA established the Ambient Air Quality Monitoring Project Team, and asked it to redesign the monitoring system to better support and respond to assessments of both human and ecosystem health. The result, in 1995, was Alberta's first ambient monitoring strategic plan.

The 1995 Ambient Monitoring Strategic Plan focused on establishing permanent core provincial stations, with monitoring to be shared by airshed zones, industry, the provincial government and the federal government. These stations were intended to provide a scientifically sound foundation for ambient air quality evaluations in, and correlations with, four key areas: human health, ecosystem health, *transboundary transport*, and visibility. This plan also proposed a common data management protocol for the entire provincial air quality monitoring system through which automated data summaries could be prepared in different formats for a variety of uses.

CASA then established an implementation team to oversee the execution of the Plan. By 1997, new monitoring stations had been added to the system and a new data management system was successfully piloted. A key product was a comprehensive, centralized, publicly-accessible website of ambient air quality information, which later became the CASA Data Warehouse. One of the implementation team's recommendations was that overall stewardship of the Alberta Ambient Air Quality Monitoring System rest with CASA. This recommendation led to the formation of the Alberta Ambient Air Quality Monitoring System *Operations Steering Committee*.

Thirty-one percent of the network envisioned in the 1995 Ambient Monitoring Strategic Plan was already in place when the 1995 plan was prepared. By 2002, the network of stations was 48% complete, and as of September 2007, about 54% of the network was in place.[1] The existing *provincial monitoring network* includes:

- *continuous monitoring* at 14 health effects stations[2],
- six ecological effects stations,
- continuous particulate ($PM_{2.5}$) monitoring to replace intermittent monitoring at many locations
- three transboundary transport and visibility stations, and
- one mobile monitoring unit.

These stations are operated by Alberta Environment, Environment Canada, several airshed zones and industry. Data from airshed zone and government stations is contained in the CASA Data Warehouse, online at www.casadata.org. Appendix B describes the design and management of Alberta's current ambient air quality monitoring network.

[1] The goal had been to have the 1995 plan fully in place by 2000.
[2] Refers to wording in the 1995 strategic plan. In the 2009 strategic plan, the name "health effects" stations has been changed to "population-based" stations.

Although progress was made, commitment to implementing the 1995 strategic plan faded in the first few years after its inception. The Plan was set in time and unable to respond to changes in the landscape of air monitoring in Alberta. Some of these changes included the transition from monitoring by government and industry to regional *airshed monitoring*, monitoring to support information requirements for provincial and national air quality frameworks, and the evolution of monitoring technologies and monitoring strategies. The main reason that the 1995 plan was not fully implemented is that it did not include a funding formula to ensure the long-term sustainability of monitoring stations. Commitment to funding is required for the successful implementation of the 2009 monitoring plan. These factors have been considered and incorporated into the 2009 plan.

The success of the new air monitoring strategic plan described in this document will require true commitment to implementation, both horizontally across organizations and vertically within organizations. This ongoing commitment will be needed to secure the resources to implement the monitoring strategy. Also, the new monitoring plan will need to be reviewed and revised periodically by stakeholders that conduct air monitoring and by stakeholders that use air monitoring data.

2 Ambient Air Monitoring Framework

Maintaining and developing an air monitoring network, and related support systems to gather, store and disseminate data, needs to be guided by goals, objectives and principles. These provide the framework for specific air quality monitoring programs. Details on applying and implementing the framework, are described more fully in sections 3 - 9 of this document.

- Sections 3, 4 and 5 make up the Ambient Monitoring Strategic Plan and recommend a specific approach for air monitoring in Alberta over the next three to five years, using the framework for guidance.
- Sections 6, 7 and 8 describe in detail the proposed new monitoring network and sub-networks, funding and data management of the integrated system.
- Section 9 is the Implementation Plan, also with a three-to-five year lifespan, which recommends the order and priority for implementing the proposed new monitoring network.

2.1 Vision, Principles, Goals, and Objectives

The framework contains the vision, principles, goals, and objectives that should be part of, or considered in, any comprehensive air monitoring program and related strategic and implementation plans. The framework is the foundation on which air quality monitoring programs are planned, developed, implemented, reviewed and modified. Because the vision, principles, and goals are regarded as fundamental and somewhat timeless, the framework is not expected to change significantly over time. The objectives of the framework may change as monitoring priorities and needs evolve.

Vision

Alberta's ambient air monitoring system, sustained equitably by all emitters, will provide high quality data to address all provincial-scale air issues. In this regard, the roles, responsibilities and relationships between provincial, airshed and *compliance monitoring* must be clearly articulated and understood by all participants. The vision of Alberta's ambient air monitoring system is that it provides the data required to:

a) Assess short- and long-term air quality on a provincial scale; and
b) Respond to specific local and regional air quality issues and concerns.

Principles

The following principles will guide all ambient air monitoring:

1. The data gathered from Alberta's ambient air quality and deposition monitoring network will be reliable and representative.
2. Alberta's ambient air and air-related deposition will be monitored using strategies and technologies that are consistent with best practices and end-use needs and will include *remote sens*ing and computer modeling to support and inform physical monitoring.
3. The monitoring of Alberta's ambient air will be responsive to changes in base conditions, such as population, emission sources, and profiles, and to changes in scientific or technical knowledge.

4. Evolution of, and enhancements to, the ambient monitoring system will be constantly considered as opportunities arise, and will be guided by technological advancements.
5. The air quality and deposition information generated will be used by many stakeholders, who need to be involved in ensuring the system is effective.
6. The process of managing the overall system will include multi-stakeholder consultation and collaboration.
7. Sampling programs will be designed so that uncertainties around results and representativeness can be assessed, which in turn makes it possible to undertake risk assessments using network data.
8. Funding for the system will be on an emitter-pay basis.

Goals

Three goals will guide the ongoing development of Alberta's ambient air and deposition monitoring system:

Goal 1 – Gather the right data
Collect reliable and representative temporal and spatial data on Alberta's ambient air quality and related deposition.

Goal 2 – Gather data in an efficient way
Collect air quality and related deposition data in an efficient and economically sustainable way.

Goal 3 – Disseminate data and information
Use ambient air quality and deposition data to produce information that is relevant and credible. This data and information will be easily accessible to the people of Alberta in a timely manner.

Monitoring Objectives

In the planning, development, implementation, review and modification of Alberta's ambient air and deposition monitoring system, the following monitoring objectives need to be considered and addressed on a priority basis, recognizing that priorities may change over time.

The objectives are intended to clarify what will be monitored, how it will be monitored and what we will do with the data. The objectives of the air monitoring system are to collect the data needed to:

1. Support human health risk assessments for both urban and rural populations as related to outdoor air quality.
2. Characterize *background* air quality in Alberta.
3. Quantify the exposure to air quality on ecosystem and animal health.
4. Characterize air quality entering or leaving the province (boundary transport).
5. Address gaps in air quality and deposition monitoring for Alberta.
6. Support the monitoring and reporting requirements associated with air quality or deposition management frameworks and other obligations.
7. Verify or calibrate air pollutant dispersion, transformation and deposition models and ground truth *remote sensing* data.

8. Detect poor air quality events so the public can be notified.
9. Determine air quality relative to ambient air quality objectives, guidelines, standards or criteria.
10. Provide chemical profiles for source apportionment.
11. Determine long-term trends.

2.2 Applying the Framework

The framework is intended to guide the planning, development, implementation and review of Alberta's air monitoring system, which includes issues such as:

- The physical elements of the network including siting, methods of monitoring and data collection and sampling periods;
- System management and funding;
- Data management and information dissemination; and
- System review.

These aspects are described in detail in the remainder of the report. Overarching considerations are noted briefly below and are intended to guide the design and implementation of the network elements.

System Management

A steward is required to ensure the effective operation of the ambient monitoring system. This mechanism will take the form of a single multi-stakeholder body, modeled on Alberta Environment's Ambient Air Quality Objective Setting Process. Those with a stake in the outcome will participate in the process and strive to reach consensus. However, if consensus cannot be reached, the final responsibility and accountability for decisions rests with the Alberta Environment on behalf of the Government of Alberta. Performance measures and a regular review of the system are also needed to confirm its effectiveness and efficiency.

System Funding

Appropriate funding for the ambient air quality monitoring system is fundamental to its success. In essence, funding is based on the principle of "emitter pay," which means that pollution sources must be identified and costs apportioned in a fair and equitable manner. This approach has three key assumptions:

- Large emitters will pay directly to fund the system;
- The Government of Alberta will develop a sustainable and long-term funding mechanism to cover the costs of monitoring emissions from non-regulated small industrial and diffuse emissions sources; and
- Data and information from this monitoring system will be publicly available. However, data users whose specific needs require additional system resources will pay the costs associated with meeting those needs.

Costs of funding the air monitoring system will be determined and assigned using a formula that is simple, fair, objective, open, transparent and understandable. The formula will include provisions to ensure long-term funding and will reward those who reduce their emissions.

Data and Information Management

Knowledge systems provide data, information, and learning opportunities which support the operation of the air quality management system. Knowledge systems have three elements:

- Acquiring and interpreting new information;
- Conducting research and keeping abreast of scientific developments; and
- Education and outreach for sharing knowledge.

A successful centralized air quality data and information management system should:

- Include all air quality data collected in the province and provide the appropriate caveats regarding the uncertainties and limitations of the data;
- Provide data in a form that can be used by technical and non-technical users, along with tools and guidance to correctly interpret the data; and
- Provide the public with the information they need to a) take action to reduce their impact on air quality, and b) take precautions to protect their health.

Framework and System Review

It is expected that the monitoring sites, methodologies, priorities and data management elements of the Ambient Air Quality Monitoring Strategic Plan will be reviewed every three to five years to ensure that the system continues to operate efficiently and effectively, and to clarify any questions or issues that may arise as a result of implementation. This review would assess current and possible future sites, as well as verify that recommendations arising from previous reviews had been implemented.

This framework should be reviewed at least every ten years by a multi-stakeholder group to ensure it remains relevant to the existing air quality management needs and issues in Alberta.

3 2009 Ambient Monitoring Strategic Plan

Since the first Ambient Monitoring Strategic Plan (AMSP) was developed in 1995, the extent, pace and expectations of ambient air monitoring in Alberta have changed significantly, including:

- Increased levels of industrial activity along with increased population;
- More rapid than expected formation of airshed zones, with an associated increase in ambient monitoring by the zones;
- Implementation of several CASA frameworks that have created a need for specific types of monitoring and data (Particulate Matter and Ozone Management Framework, Acid Deposition Management Framework, Air Management Framework for the Electricity Sector);
- Improved technologies for monitoring, collecting and managing data; and
- New air monitoring guidelines.

Because the 1995 plan was not fully implemented, Alberta's ambient air monitoring system needs to "catch up." The present network needs to be expanded to fill gaps in areas where there are concerns over human health, acid deposition, monitoring of smog formation, and other important issues. Alberta's air monitoring network also needs to be able to respond to emerging issues and growth. In addition, ambient air quality monitoring is critical for cumulative effects management, which is a foundation of Alberta's overall environmental management approach.

An integrated province-wide ambient air monitoring system is a fundamental underpinning to effective air quality management. Such a system would continue to include large industrial emitters, but the proposed new system would add and expand a number of sub-programs, and it would also introduce a mechanism for funding monitoring of emissions from small industrial and diffuse sources.

The 2009 Ambient Monitoring Strategic Plan is designed to be able to incorporate new ideas and knowledge without requiring changes to the fundamental approach. Periodic changes and enhancements can be proposed to both the Strategic Plan and the Implementation Plan through the multi-stakeholder process described in section 4. That process will define the work plan for reviewing and updating the network and system priorities over a three- to five-year period and may result in additional stakeholder consultation, as required.

The 2009 Ambient Monitoring Strategic Plan and associated monitoring network are designed to be robust and flexible enough to meet a variety of existing and new province-wide objectives. At a high level, the strategic plan and monitoring network will:

1. Integrate air monitoring that is now being done in Alberta at the local, regional, provincial and national levels.
2. Respond to air quality management frameworks developed to address specific issues.
3. Respond to projected changes in Alberta's growing economy such as increases in air emissions and population growth.
4. Integrate new monitoring technologies that have been developed and improved over the last decade and incorporate emerging technologies.
5. Provide a scientifically defensible basis for establishing new monitoring stations and *rationalizing* existing stations and networks.

6. Provide an approach to air monitoring that considers the uncertainty associated with monitoring data, and in turn identifies potential risks.
7. Provide appropriate air quality and deposition data to inform policy and enable cumulative effects management.
8. Define *Data Quality Objectives*.

The ambient air quality monitoring system proposed in this strategic plan must be able to address both existing and new air related information needs in an efficient and cost-effective manner. It should provide:

- The data and information needed by air quality management decision makers on a provincial and regional scale.
- Ambient air quality monitoring data and information that enable the correlation of ambient air chemistry and meteorological data with data on human health and exposure, ecosystem health, and emission sources.
- Air quality data that is in a readily accessible and interchangeable form for use by local, regional, and provincial stakeholders as well as national and international users where appropriate.

The 2009 Ambient Monitoring Strategic Plan has five main components, described in detail in sections 4 to 8. These are:

- **Managing The Monitoring System.** This section (section 4) examines options for managing, reviewing and improving the system.
- **Designing The Ambient Air Monitoring Network.** This section (section 5) outlines the actual monitoring network design and approach for characterizing air quality in Alberta.
- **Proposed New Ambient Monitoring Network Design.** This section (section 6) gives the actual "dots on the map", describing seven monitoring sub-programs.
- **Funding Air Monitoring.** This section (section 7) describes mechanisms for funding the monitoring system and emissions inventory development.
- **Data and Information Management System.** This section (section 8) describes the flow of data and information from the monitoring network to ensure it is adding value and providing benefits to a wide range of data users and Albertans as a whole.

Recommendations are included, as appropriate, in each section.

4 Managing The Monitoring System

4.1 Historical System Management

After the 1995 Ambient Monitoring Strategic Plan was adopted, the Alberta Ambient Monitoring Implementation Design team (AAMID) managed the Alberta Ambient Air Quality Monitoring System (AAAQMS) on an interim basis from 1996 through 1997. In accordance with the AAMID team recommendations in its 1997 report to the CASA board, CASA assumed overall stewardship of the AAAQMS through a consensus-based *Operations Steering Committee* (OSC). Alberta Environment acts as System Manager, with responsibility for day-to-day decisions and administration of the AAAQMS and reports to the OSC on various activities and accomplishments. The OSC provides regular status reports to the CASA board. Figure 1 illustrates the reporting structure for the AAAQMS.

Depending on the issue, the System Manager also has the discretion to convene and use an ad-hoc technical advisory group with membership from airshed zones, government, the public or industry. This group discusses and reviews potential enhancements, obtains feedback on operations, and approves minor changes to the AAAQMS. The group functions primarily through correspondence (e-mail or fax) with face-to-face meetings as required.

The OSC meets at least twice per year to check progress and provide approval for annual implementation plans as well as provide status reports to the CASA board. Concerns have been raised about the overall effectiveness of this model in implementing the previous strategic plan, and the 2009 Strategic Plan has attempted to address those concerns.

4.2 Future System Management

The team considered three management options for the Ambient Air Quality Management System and recommends creation of a Multi-stakeholder Implementation Committee (MIC), modeled after Alberta Environment's Ambient Air Quality Objective-Setting process. (Other management options considered are described in Appendix C.)

The MIC will provide overall direction and oversee implementation of the strategic plan. More specific responsibilities of the MIC include, but are not limited to:

- Developing an annual work plan aimed at implementing portions of the strategic plan.
- Developing a process to review and, as necessary, revise the strategic plan and the implementation plan every three to five years.
- Tracking progress in achieving the objectives of the strategic plan through development of performance management tools.
- Establishing policies and procedures for the operation of the MIC and its subcommittees.

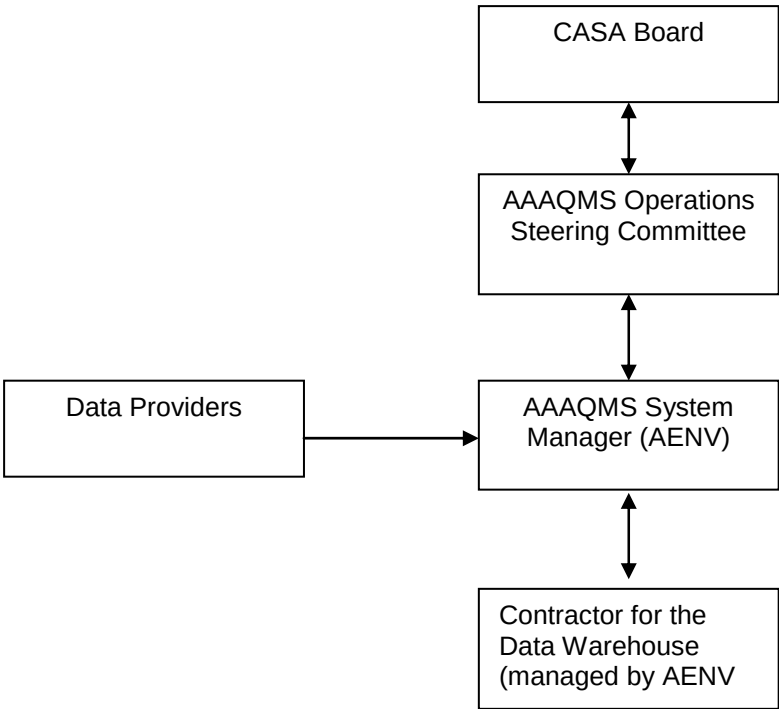


Figure 1. Current Organizational Reporting Structure for the AAAQMS
(from the 1997 AMSP Implementation Project Team Report)

Stakeholders involved in air monitoring will be consulted as part of the implementation process and the MIC will strive to operate by consensus. If consensus cannot be achieved, the final responsibility and accountability for decisions will rest with Alberta Environment on behalf of the Government of Alberta. Terms of reference for the MIC will further define the roles and responsibilities of participants. The MIC will include members from the provincial government, federal government, industry, airshed zones, and environmental associations. The MIC may also have members from municipal and/or rural government associations and data user groups. Each sector representative will be expected to represent their entire sector rather than their personal or organizational views. Alberta Environment will chair the committee and provide secretarial support.

Sub-committees of the MIC may be formed as needed to address specific issues identified in the strategic plan. These could include network implementation, funding, data and information management, and education and outreach.

The MIC will meet three to four times per year and will be accountable for implementing the Ambient Monitoring Strategic Plan. Details on the implementation may be dealt with by MIC subcommittees or by individual monitoring organizations. The AMSP project team envisions that the MIC will annually review and report on progress in implementing the strategic plan and identify potential improvements. The MIC would also determine whether the system continues to meet Alberta's needs, and would recommend modifications as appropriate. The MIC will report to the Director responsible for air monitoring within Alberta Environment. Annual written and oral reports on the implementation of the strategic plan will be provided to the Director by the MIC and presented to the CASA Board.

The entire management framework would be reviewed every three to five years to ensure that continuous improvement is indeed occurring. These reviews need to be aligned with the various fiscal years of governments, airshed zones, and industry to ensure efficient implementation of changes. CASA will be responsible for reviewing the strategic plan every five years, beginning five years after board approval of the strategic plan.

Recommendation 1: Adoption and review of the framework for Alberta's air monitoring system
The Ambient Monitoring Strategic Plan (AMSP) Project Team recommends that:

CASA adopt the framework, consisting of the vision, principles, goals and objectives, and review the framework after ten years following the date of approval.

Recommendation 2: Multi-stakeholder Implementation Committee
The AMSP Project Team recommends that:

A Multi-stakeholder Implementation Committee be established by Alberta Environment to manage implementation and evaluate progress of the new ambient air quality monitoring system recommended in this Strategic Plan.

Recommendation 3: Annual work plan
The AMSP Project Team recommends that:

The MIC develop an annual work plan to be approved by Alberta Environment, coordinated with GOA budget cycle beginning in Fiscal Year following approval.

Recommendation 4: Review of strategic plan
The AMSP Project Team recommends that:

CASA establish a new team to review and revise the strategic plan every five years, commencing five years following board approval.

4.3 Responsibilities of Monitoring Agencies and Organizations

Management of air quality in Alberta requires a good understanding of past and current air quality conditions and also estimates of future trends. A comprehensive database of air quality information is essential to such an understanding. The AMSP project team believes that the Alberta Minister of Environment should have clear responsibility to collect air quality data, or to see that this is done.

Various organizations undertake ambient air and deposition monitoring in Alberta and have a variety of responsibilities, as illustrated in Table 2. The MIC, not listed in the table, will give guidance and provide recommendations on siting and monitoring activities, but largely will act to oversee implementation and evaluate progress of the monitoring system.

Station selection, installation, operation and maintenance are the responsibility of the station owner. However, the owner of the station may have a third party conduct these activities through a signed agreement or contract. The station owner selects the station in cooperation with siting protocols defined by Alberta Environment. The Ambient Monitoring Strategic Plan and siting criteria in the Air Monitoring Directive will be used when selecting station location for all operators including government, airshed and industry stations. Station maintenance will generally be the responsibility of the operator, with major upgrades, such as the addition of new equipment, being the responsibility of the station owner.

Table 2. Responsibilities of Monitoring Agencies and Organizations

Activity	Conducted by*	Reporting to	Funded by
Station Management			
Station Selection	Airsheds or AENV/industry/EC/Health representative	AENV	AENV airsheds, industry
Station Installation	Airsheds or AENV/industry/EC	AENV Environment Canada	AENV airsheds, industry, Environment Canada
Station operation	Airsheds or AENV/industry	AENV, airsheds, Environment Canada	AENV airsheds, industry, Environment Canada
Station Maintenance and upgrades	Airsheds or AENV/industry	AENV, airsheds, Environment Canada	AENV, airsheds, industry, Environment Canada
Data Management			
Data collection	AENV, airsheds	Stakeholders and public	AENV
Data quality assurance/quality control	AENV, airsheds	Stakeholders and public	AENV
Database Operation	AENV, airsheds	Stakeholders and public	AENV
Loading data into database	AENV, airsheds and industry	Stakeholders and public	AENV
Database Maintenance and upgrades	AENV	Stakeholders and public	AENV
Data sharing: Web	AENV, airsheds	Stakeholders and public	AENV
Information Management			
Data analysis and reporting	Airsheds, AENV, AHW, industry, Environment Canada	Stakeholders and public	AENV, airsheds
Information Dissemination	Airsheds, AENV, AHW, industry, Environment Canada	Stakeholders and public	Airsheds, AENV, industry, Environment Canada

* Conducted by airsheds in regions where they have been established. For other regions, AENV and industry will work together to complete the activity.

Data collection and quality control are the responsibility of the station operator. Alberta Environment ensures that defined data quality standards are in place to meet the *Data Quality Objectives* of the monitoring station or monitoring network. The data will be validated prior to being loaded into the central data warehouse, which is operated and maintained by Alberta Environment. Alberta Environment is ultimately responsible for the quality of the data submitted to the data warehouse and is also responsible for the availability of data and summary information reports through the data warehouse.

Data and information dissemination to outside stakeholders is the responsibility of airsheds, government and industry. Alberta Environment and Alberta Health and Wellness are responsible for

informing the public of the state of air quality in the immediate term (poor air quality notification) and long term (state of the environment reporting). Airsheds provide value-added air quality information through their websites and through regional projects with the media or educational institutions. Industries may proactively provide information and data to the public from their monitoring stations. In the future, it is anticipated that industry will be required to submit ambient data in electronic format to AENV. Individual approvals may also contain requirements for additional data and information reporting.

4.4 System Performance Measurement

Performance measures need to be developed and used to determine if commitments are being met and how well the process is working. Performance measures should be:

- Specific: Relevant and sufficient to measure the range and complexity of identified goals, outcomes and results.
- Meaningful: Understandable to decision makers and consumers of performance information.
- Achievable: Reasonable expectations of Government of Alberta performance, and attainable targets.
- Reliable: Statistically sound with consistent, accurate data.
- Timely: Provide cost-effective performance information when needed for decision making and accountability.

Examples of systems performance measures include:

- Ability of the monitoring network data to answer the questions of interest;
- Ability of the monitoring network to provide data with uncertainty levels for meeting *Data Quality Objectives*;
- Percentage of monitoring stations identified in the Plan that are newly established;
- Percentage of audit passes by monitoring station and/or instrument;
- Percentage of monitoring stations submitting data on time to provincial website; and
- Number (percentage increase) of co-located, cross-media monitoring stations (sites for air/soils, precipitation/water quality, air/agricultural).

5 Designing The Ambient Air Monitoring Network

The first step in designing an air quality monitoring network is to determine what questions need to be answered by the monitoring and to what level of certainty the questions must be answered. The monitoring objectives inform decisions on site selection, parameters to be measured, monitoring duration, sampling frequency, choice of monitoring equipment, quality control and quality assurance requirements, data acquisition needs, and data analysis and reporting needs. The basic principles and objectives considered in the design of the network are described in the framework (section 2), and the elements to be considered in making decisions about monitoring are illustrated in Figure 2.

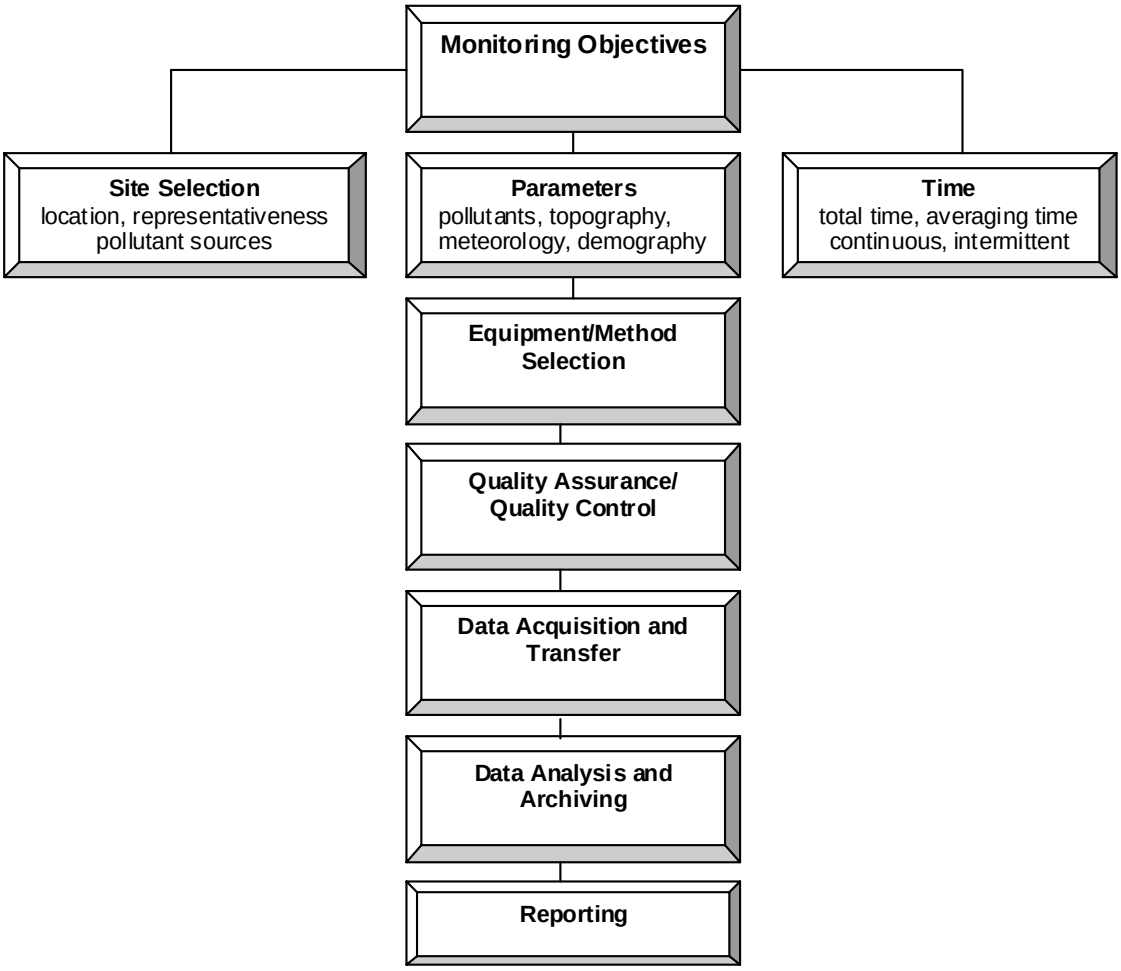


Figure 2. Conceptual Overview of the Design of a Monitoring Station or Network

In the planning, development, implementation, review and modification of Alberta's ambient air monitoring system, the monitoring objectives noted in section 2.1 need to be considered and addressed on a priority-need basis, which may change over time.

To address the overarching vision of characterizing air quality in Alberta, the following monitoring needs and related sub-networks are suggested to address the specific monitoring objectives (referred to in parentheses):

(1) Population-based monitoring sub-program (will address Objectives 1, 5, 8, 9, 10 and 11),
(2) Ecosystem-based monitoring sub-program, including *Acid Deposition Monitoring* (will address Objectives 2, 3, 4, 5, 6, 7, 10 and 11),
(3) Ozone monitoring sub-program (will address Objectives 1, 2, 5, 6, 7, 8, 9 and 10),
(4) Boundary Transport monitoring sub-program (will address Objectives 2, 4, 5, 7 and 11),
(5) Background monitoring sub-program (will address Objectives 2, 4, 5, 7 and 11),
(6) Pattern Recognition monitoring sub-program (will address Objectives 2, 4, 5, 7 and 11), and
(7) Industry Compliance monitoring sub-program (will address Objective 6).

The design of the network and sub-networks needs to consider the monitoring elements identified in Figure 2, as well as an assessment of measurement uncertainty, which data users will need to make decisions. Number of locations, technology selected, and the frequency of monitoring will all be influenced by these requirements, as illustrated in Box 1.

Box 1: Examples of Application of Monitoring Elements in Network Design

Location - The location of monitoring sites should be closely linked to the monitoring objectives. For example, if the monitoring objective is to collect data to assess human health effects related to ambient air quality, the monitoring stations will likely be located in population centres or at other locations where people are exposed to air pollutants. In the case of the ecosystem health objective, a robust scientific rationale is needed to determine the density and location of monitoring stations to meet this monitoring objective.

Parameters monitored - The air pollutants to be measured at the monitoring sites will depend on the monitoring objective. For example, if the monitoring objective is to collect data to assess ecological health, then parameters such as sulphur compounds, nitrogen compounds, base cations, and precipitation quality would be monitored to determine acid deposition loading to the environment.

Type and duration of monitoring - The monitoring type and monitoring duration refer to the requirement for continuous or integrated monitoring. If the monitoring objective is to collect data to assess human health or assess air quality in areas where concentrations are approaching the ambient air quality objectives, or near an industrial facility where emissions could be harmful during an upset condition, then continuous techniques would likely be used so that hourly data could be collected. If the monitoring objective was to determine the spatial variation of air pollution for a particular area, then passive integrated monitoring may be used to collect data on a monthly basis. Appendix D describes various ambient air quality monitoring techniques.

Monitoring methodology, QA/QC and data acquisition, analysis and reporting - After the sites, parameters, monitoring types and duration have been determined, the monitoring equipment and method, quality assurance/quality control (QA/QC) protocols, data acquisition equipment, data analysis procedures and reporting procedure can be determined. Also essential is an assessment of the measurement uncertainty, which data users will need to make decisions. This will influence the technology selected.

The Multi-stakeholder Implementation Committee will continually evaluate and improve the network from a scientific, practical and economic perspective. This process will consider new and emerging air quality issues; the availability of better scientific information for monitoring network design; and continued improvement in the integration process for national, provincial, regional and local scales of monitoring. Appendix E provides an air monitoring guidance tool for determining where air monitors should be located to maximize effectiveness.

The full monitoring network and its sub-networks are described in detail in section 6, Proposed New Ambient Monitoring Network Design.

5.1 Data Quality Objectives

Data Quality Objectives (DQOs) have assumed a formalized meaning largely as the result of a document prepared by the US Environmental Protection Agency (EPA). The EPA published the *Guidance for the Data Quality Objectives Process EPA QA/G-4* in 1994 to ensure that all monitoring is conducted in an appropriate and cost-effective manner. This document defined the steps to developing DQOs, and these steps have become the "DQO Process".

The Ambient Monitoring Strategic Plan (AMSP) is an application of the DQO process to air quality monitoring in Alberta. The AMSP is broader than a typical DQO result since it considers in parallel, multiple objectives (such as regional, ecosystem and transboundary issues) with the goal of optimizing resources and finding overlapping applications for data wherever possible.

The AMSP does not strictly follow the outline of the EPA's DQO guidelines, but the steps are reproduced. The linkages between the AMSP and the DQO process can be identified (Table 3). As a step to establishing this relationship, a summary of DQO appears below, with excerpts from the introduction to the EPA document:

> ***What are DQOs?***
> *DQOs are qualitative and quantitative statements derived from the outputs of the first six steps of the DQO Process that:*
> *1) Clarify the study objective;*
> *2) Define the most appropriate type of data to collect;*
> *3) Determine the most appropriate conditions from which to collect the data; and*
> *4) Specify tolerable limits on decision errors which will be used as the basis for establishing the quantity and quality of data needed to support the decision.*
>
> *The DQOs are then used to develop a scientific and resource-effective data collection design.*
>
> ***What is the DQO Process?***
> *The DQO Process is a strategic planning approach based on the Scientific Method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect.*
>
> *The DQO Process consists of seven steps… The output from each step influences the choices that will be made later in the Process. Even though the DQO Process is depicted as a linear sequence of steps, in practice it is iterative; the outputs from one step may lead to reconsideration of prior steps. This iteration should be encouraged since it will ultimately lead to a more efficient data collection design. During the first six steps of the DQO Process, the planning team will develop the decision performance criteria (DQOs) that will be used to develop the data collection design. The final step of the Process involves developing the data collection design based on the DQOs. The first six steps should be completed before the planning team attempts to develop the data collection design because this final step is dependent on a clear understanding of the first six steps taken as a whole. .., the iterative link between the DQOs and the Optimize the Design step*

[can be] *illustrated by double arrows, which signify that it may be necessary to revisit any one or more of the first six steps to develop a feasible and appropriate data collection design. Above all, every step should be completed before data collection begins.*

DQO Steps

Step 1	*State the Problem*	*Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem*
Step 2	*Identify the Decision*	*Identify what questions the study will attempt to resolve, and what actions may result*
Step 3	*Identify the Inputs to the Decision*	*Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.*
Step 4	*Define the Study Boundaries*	*Specify the time periods and spatial area to which decisions will apply. Determine when and where data should be collected*
Step 5	*Develop a Decision Rule*	*Define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions*
Step 6	*Specify Tolerable Limits on Decision Errors*	*Define the decision maker's tolerable decision error rates1 based on a consideration of the consequences of making an incorrect decision*
Step 7	*Optimize the Design*	*Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource effective design that meets all DQOs*

5.2 Relationship of the Ambient Monitoring Strategic Plan to DQO

The documents that comprise the AMSP were not formally structured around the DQO process but can generally be related to the seven steps either by a summary of the documents or by linking sections of the documents with the steps of the DQO process.

The Framework forms a high level overview and includes the pieces that address the first three steps of the DQO process in broad terms. The Strategic Plan revisits the first three steps in more detail and then lays out the next three steps. The Implementation Plan outlines the current design and describes the steps and broad direction for changing and/or augmenting the current plan to better meet the objectives corresponding to Step 7.

A slightly more detailed approach is to map the documents and the main sections to the seven steps in the DQO process. The separation of the documents into these categories is slightly artificial and frequently arbitrary, but it demonstrates how the AMSP addresses the DQO process as well as highlights some aspects of DQOs that are not thoroughly covered in the AMSP. The links are shown in Table 3 below.

Table 3. Linkages between the AMSP and the Data Quality Objectives Process

	DQO Step	*AMSP Link*
Step 1	*State the Problem*	The Framework Document mostly fits here; particularly the sections on Vision and Goals and some of the details described in the Objectives section.
Step 2	*Identify the Decision*	The Framework Document objectives correspond to a higher level grouping of specific decisions.
Step 3	*Identify the Inputs to the Decision*	The Strategic Plan document starts to address this with the discussion of the need for an update as well as the detailed objectives specified for system management, monitoring and data and information management.
Step 4	*Define the Study Boundaries*	This section is supported by the 11 monitoring objectives and is developed in the Implementation Plan, the network design objectives and in the decision tools. This is also covered by discussions of resources in the Strategic Plan.
Step 5	*Develop a Decision Rule*	The AMSP document has little material focused on this section but refers to other sources such as provincial legislation or the Canada Wide Standards.
Step 6	*Specify Tolerable Limits on Decision Errors*	Part of this aspect is covered in the funding discussions in the Strategic Plan. The Implementation Plan also addresses this with discussion of the Air Monitoring Directive (*AMD*) and the application to air monitoring in Alberta.
Step 7	*Optimize the Design*	The Implementation Plan would be the high level version with details supplied in the individual airshed plans.

Overall, the AMSP document covers much of the DQO process but with a more generalized focus. The DQO process is primarily issue-driven whereas the AMSP is more directed to establishing and maintaining data collection that can be used for ongoing and retrospective examination of issues.

Recommendation 5: Data Quality Objectives

The AMSP project team recommends that:

The MIC define draft Data Quality Objectives for each monitoring sub-program within one year after the MIC is formed. These Data Quality Objectives will be reviewed on an on-going basis.

5.3 Characterizing Air Quality in Alberta

A fundamental strategic task involves developing an ambient monitoring provincial network that will characterize air quality spatially and temporally. Data Quality Objectives must first be defined for this network. This exercise is expected to result in a network of air monitoring “super stations” that

will be permanently located and will be changed only through a formal scientific network evaluation process. Over time, the network will be improved to become more cost effective while still meeting the overarching monitoring objective.

The approach will look at the province as a whole and determine what is needed to adequately represent air quality on a provincial scale and over the long-term (100-year perspective). Existing monitoring stations may comprise a large portion of this network, which will be dynamic and responsive to changes in data quality objectives and network optimization. The resulting monitoring network will be able to assess background air quality, the spatial variation of air quality and the long-term trend of air quality in the province.

In designing a province-wide air monitoring network, specific objectives of the monitoring sub-programs described in detail in section 6 will be addressed. These include the monitoring objectives related to boundary transport, background air quality and spatial representation of air quality in the province.

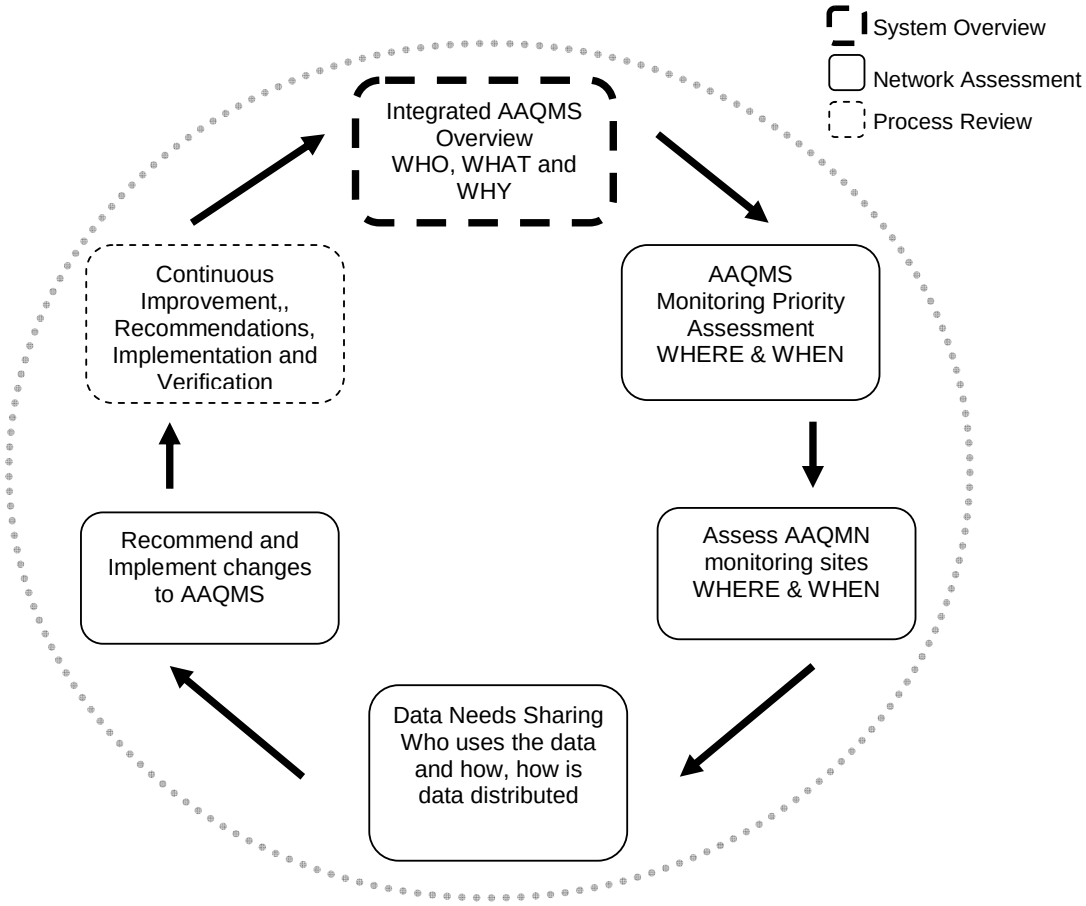
5.4 Review of the Monitoring Network

It is expected that the monitoring sites, methodologies, priorities and data management elements of the Ambient Air Quality Monitoring Strategic Plan will be reviewed every three to five years to ensure that the system continues to operate efficiently and effectively. This will involve asking questions like:

- Are the right parameters being measured at existing sites to meet the system's goals and objectives?
- Do population and industry growth, other emerging concerns, new CASA frameworks or new standards and guidelines warrant new monitoring stations in particular locations?
- Is the system making the best use of stationary and portable stations?
- Are the various monitoring technologies being used efficiently and effectively?
- Are data users satisfied with data access and reporting systems?
- Do Data Quality Objectives need to be revised?

This review would assess current and possible future sites, and verify that recommendations arising from previous reviews had been implemented. The starting point for assessing monitoring sites is to determine what the primary objective of monitoring is at that site, and whether or not other objectives could also be met using that site. Monitoring beyond the base province-wide network can be done in support of objectives in five main areas: human health, ecological health, boundary transport, data gaps and compliance.

The project team supports the "plan, do, check, adjust" approach for characterizing environmental management systems. This approach is illustrated in Figure 3 and is described briefly below.



AAQMN: Ambient Air Quality Monitoring Network
AAQMS: Ambient Air Quality Monitoring System

Figure 3. Proposed Approach for Reviewing the Ambient Air Quality Monitoring Network in Alberta

Integrated Ambient Air Quality Monitoring System (AAQMS) Overview
This step outlines why we monitor ambient air quality, who is involved (airshed zones, provincial government, etc.), what they do (monitoring locations, technologies, methodologies) and how this is all integrated. Integration occurs between the various levels of monitoring in the province in the planning and implementation of the overall monitoring network. Specifically, the levels of monitoring (the monitoring network, technologies and methods) as well as the CASA Data Warehouse and the Multi-stakeholder Implementation Committee should be combined into one system where all components are periodically evaluated and assessed to ensure that they are performing adequately. Integration also occurs between the various components of the current ambient air quality monitoring operating in Alberta.

AAQMS Monitoring Priority Assessment
In this step, the Multi-stakeholder Implementation Committee determines or negotiates what the monitoring priorities are and makes recommendations.

Assess AAQMS Monitoring Sites
Using appropriate site assessment tools, assess the current and future AAQM sites (as well as verify that the recommendations made in the last review round were in fact implemented). Ask WHERE do we monitor and WHEN do we monitor. In addition, WHERE in the future are we going to monitor and WHEN are we going to do this?

Data Needs Sharing
Review and evaluate the CASA Data Warehouse to ensure that it is meeting everyone's data and operational needs as well as regulatory requirements for data input, and make recommendations.

Recommend and Implement Changes to AAQMS
Review all of the recommendations and confirm that the funding and implementers are available and on side.

Continuous Improvement
Review this process to ensure that we are doing the job that we are supposed to be doing. Make improvement recommendations and implement.

5.5 Input from CASA Project Teams

CASA project teams often use ambient monitoring data to guide or inform their deliberations, and during these deliberations may identify data gaps or monitoring issues. Teams may also develop frameworks or plans that have monitoring components or related data needs.

It is desirable that these data or monitoring issues and needs be brought to the attention of the Multi-Stakeholder Implementation Committee (MIC) and also recorded for use at the next review of the Ambient Monitoring Strategic Plan. To help ensure this occurs, the AMSP team identified the need for a specific recommendation that would encourage and enhance the linkages between ambient monitoring network activities and the work of CASA teams.

Recommendation 6: Monitoring input from CASA project teams
The AMSP Project Team recommends that the CASA Board and Secretariat initiate the following actions related to monitoring and data issues:

1. *in the Terms of Reference for Project Teams, as appropriate, require as a specific task the identification of any network related monitoring and or data needs as related to any of their recommendations;*
2. *that Project Teams be formally requested, on an annual basis, to provide any network monitoring or data issues, needs or concerns that have arisen from their work to be recorded by the Secretariat and sent to the Multi-Stakeholder Implementation Committee (or subsequent equivalent or AENV). These should also be retained as reference material for use by the next AMSP Project Team; and*
3. *that CASA members be formally polled as part of the CASA coordination workshop regarding their level of satisfaction with, and recommendations for, the ambient monitoring network (it is recommended that this be done in conjunction with the establishment of the AMSP Project Team undertaking the update of the Strategic Plan (recommendation 4)).*

6 Proposed New Ambient Monitoring Network Design

The overarching objective of the monitoring network described in this strategic plan is to characterize air quality and deposition in Alberta. To this end, the monitoring network has been reviewed, re-evaluated and, where necessary, re-designed. The proposed province-wide network is based on a suite of sub-programs, designed to meet specific monitoring objectives, with the intent of identifying synergies across the sub-programs. For example, in some cases a single monitoring station may be able to meet several specific objectives. The following key elements of the network design are influenced by and closely linked to the monitoring objectives:

- The location and number of monitoring sites.
- The air pollutants to be measured at the monitoring sites.
- The type and duration of monitoring (i.e., continuous or integrated monitoring).
- Monitoring equipment and methodology, quality assurance/quality control (QA/QC) protocols, data acquisition equipment, data analysis procedures and reporting procedures.

This section describes in detail the various sub-programs that are proposed to address the 11 monitoring objectives described in section 2.Essentially, this is the "dots on the map" that indicate where ambient air monitoring should be done in Alberta, along with the rationale for the overall network design. The 2009 network design builds on the work done by the earlier CASA teams in the 1990s, but reflects the significant economic and demographic changes that have occurred in Alberta since then.

In total, seven sub-programs are proposed:

1. Population-based Monitoring Sub-program
2. Ecosystem-based Monitoring Sub-program
3. Ozone Monitoring Sub-program
4. Boundary Transport Monitoring Sub-program
5. Background Monitoring Sub-program
6. Pattern Recognition Monitoring Sub-program
7. Industry Compliance Monitoring Sub-program

An eighth sub-program for mobile and emergency response monitoring is described in section 6.8 but is not treated as part of the main, long-term monitoring network.

Alberta Environment commissioned Dr. Neil Cape from the Centre for Ecology & Hydrology in the United Kingdom to review and evaluate Alberta's existing air quality and deposition monitoring system.[3] The work done by Dr. Cape, an internationally-recognized air monitoring expert, and his colleagues validated the team's approach and offered valuable insights into areas that warranted further consideration. Dr. Cape provided an independent assessment of Alberta's current monitoring network and made recommendations for improvements in monitoring related to acid deposition, ozone and particulate matter, and transboundary monitoring. He also provided advice on air quality criteria for protecting environmental and human health. The recommendations made by Dr. Cape

[3] Alberta Environment. 2008. Air Pollutant and deposition monitoring networks in Alberta - A review and recommendations for potential future networks. Prepared by Centre for Ecology & Hydrology, Edinburgh Research Station, United Kingdom, in association with WBK & Associates Inc. http://environment.gov.ab.ca/info/library/8041.pdf.

were taken into account by the AMSP project team and are included implicitly in the design of the seven monitoring subprograms described in the 2009 AMSP.

Recommendation 7: Adoption of the seven sub-programs
The AMSP Project Team recommends that CASA approve the provincial ambient air monitoring network, initially consisting of the following seven sub-programs:

1. *Population-based monitoring sub-program,*
2. *Ecosystem monitoring sub-program, including acid deposition monitoring,*
3. *Ozone monitoring sub-program,*
4. *Boundary Transport monitoring sub-program,*
5. *Background monitoring sub-program,*
6. *Pattern recognition-monitoring sub-program, and*
7. *Industrial compliance monitoring sub-program*

6.1 Population-based Monitoring Sub-program

The **Population-based Monitoring Sub-program** is designed primarily to collect air quality data that will represent major population centres in Alberta. This program will directly address monitoring objectives 1, 8 and 11 (from section 2.1). These are:

- Quantify potential outdoor exposure of humans in rural and urban populations (Monitoring Objective #1).
- Detect poor air quality events so the public can be notified (Monitoring Objective #8).
- Determine long term trends (Monitoring Objective #11).

Air quality data collected by population-based monitoring can also be used to address monitoring objectives 5 (gaps in monitoring air quality), 9 (determine air quality relative to ambient objectives) and 10 (chemical profiles for source apportionment).

The population of Alberta in 2008 was about 3.5 million based on population data from Alberta Municipal Affairs[4]. Alberta's population is projected to be 3.9 million in 2015 and 4.1 million in 2020[5]. This represents increases of 10% by 2015 and 15% by 2020. Areas of the greatest expected population growth are the large urban centres and bedroom communities for these urban centres with close to 80% of this growth projected for the Calgary, Edmonton, Red Deer, Lethbridge and Grande Prairie Census Divisions. An appropriate increase in air monitoring in population centres of Alberta will be necessary to adequately represent this anticipated population growth.

Population-based monitoring stations are intended to provide data that can support human health risk assessments but are not intended to measure human exposure to air pollution. One of the primary uses of data collected by population-based monitoring stations is to inform the public of air quality episodes associated with large-scale events such as smog or transport of forest fire smoke to urban locations. On a periodic basis, the population and projected populations of major centres will be reviewed to determine if any new growth warrants additional temporary or permanent air monitoring. The AMSP team is proposing four categories of population-based monitoring: Edmonton and Calgary, urban centres greater than 50,000, urban centres between 20,000 and 50,000, and

[4] Based on the 2008 population statistics from Alberta Municipal Affairs (http://www.municipalaffairs.gov.ab.ca/mc_official_populations.cfm).
[5] Based on projections from Alberta Finance and Enterprise (http://www.finance.alberta.ca/publications/statistics/index.html).

municipalities between 10,000 and 20,000. Monitoring in areas with air quality concerns will help determine air quality trends and ensure low-resolution data is available to measure improvement. Major population centres in Alberta are indicated in Figure 4.

Table 4 shows the cost of the population-based monitoring sub-program. The shaded cells indicate stations now in place and parameters now being monitored. Many of the monitoring stations recommended as part of this sub-program are already in place and are operated by Alberta Environment, airsheds or industry. The total cost of new monitoring is also included in this table.

6.1.1 Monitoring Strategy for Edmonton and Calgary

The city of Edmonton has a population[6] of 752,412 in an area of 684 km^2. Based on population, Edmonton is the fifth largest city in Canada. Calgary is the fourth largest city in Canada by population (1,042,892) and covers an area of 790 km^2. Two new airsheds have been formed that cover these two cities; the Alberta Capital Airshed Alliance and the Calgary Region Airshed Zone.

Edmonton and Calgary need the appropriate number, density and type of monitoring stations to adequately represent air quality, taking into consideration the nature and location of pollution sources in and near each city. Monitoring will need to represent current air quality and respond to the expected population and industry growth over the coming decades. Since both Edmonton and Calgary are in the management plan action level for ozone, special consideration for monitoring ozone, ozone precursors and ozone products will need to be considered upwind, downwind and within these cities (see section 6.3). The number and location of monitoring stations and the parameters monitored at each station should be justified using tools such as: (a) temporary monitoring in areas where there is currently no monitoring station, (b) detailed air emission inventories for industrial and non-industrial sources, (c) risk-based analysis of ambient air and emissions data against the desired Data Quality Objectives, (d) modeling of air emissions and ambient concentrations, and (e) public complaints about air quality in a specific area. Application of these tools may indicate that less or more monitoring is required for a specific area of the city.

To better understand air quality, the AMSP project team recommends that temporary air monitoring should be conducted for one year in areas of Edmonton and Calgary where there is currently no monitoring data. Based on this data, it can be determined if air quality is significantly different from other existing monitoring locations in each city. If air quality is significantly different, then a permanent station should be considered to represent that quadrant. A permanent monitoring station should also be considered if there are significant public complaints or unique emission sources (e.g., industry, heavy traffic areas). Temporary monitoring should be used at urban locations to better represent areas of concern near major traffic arteries or industrial sources, and to determine concentrations of pollutants that are not routinely monitored at permanent monitoring stations (such as specific air toxics, ozone precursors or ozone products). Temporary monitoring should include the use of portable continuous and integrated air monitoring supplemented by a grid of passive monitors.

[6] Based on the 2008 population statistics from Alberta Municipal Affairs (http://www.municipalaffairs.gov.ab.ca/mc_official_populations.cfm).

Municipalities with Population > 20,000

Municipality	2008 Population
CALGARY	1,042,892
EDMONTON	752,412
WOOD BUFFALO, Regional Municipality of	88,131
RED DEER	87,816
STRATHCONA COUNTY	85,521
LETHBRIDGE	83,960
MEDICINE HAT	60,426
ST. ALBERT	58,501
GRANDE PRAIRIE	50,227
ROCKY VIEW NO. 44, M.D. OF	34,597
AIRDRIE	34,116
PARKLAND COUNTY	29,679
LEDUC	20,529

Municipalities with Population from 10,000 to 20,000

Municipality	2008 Population
OKOTOKS	19,996
FOOTHILLS NO. 31, M.D. OF	19,736
SPRUCE GROVE	19,496
STURGEON COUNTY	19,165
RED DEER COUNTY	19,108
GRANDE PRAIRIE NO. 1, COUNTY OF	17,989
FORT SASKATCHEWAN	16,793
LLOYDMINSTER	16,786
CAMROSE	16,543
COCHRANE	14,653
BROOKS	13,581
COLD LAKE	12,860
LEDUC COUNTY	12,730
CHESTERMERE	12,589
MOUNTAIN VIEW COUNTY	12,570
STONY PLAIN	12,363
CANMORE	12,039
CLEARWATER COUNTY	11,826
WETASKIWIN	11,673
LACOMBE	11,562
STRATHMORE	11,335
SYLVAN LAKE	11,115
BEAUMONT	10,820
HIGH RIVER	10,716
WETASKIWIN NO. 10, COUNTY OF	10,535
LACOMBE COUNTY	10,507
LETHBRIDGE, COUNTY OF	10,302
LAC STE. ANNE COUNTY	10,220
YELLOWHEAD COUNTY	10,045
MACKENZIE COUNTY	10,002

Municipalities with Population from 5,000 to 10,000

Municipality	2008 Population	Municipality	2008 Population	Municipality	2008 Population
HINTON	9,769	OLDS	7,248	BONNYVILLE	5,896
WHITECOURT	9,202	ROCKY MOUNTAIN HOUSE	7,231	SADDLE LAKE FIRST NATION	5,883
LAC LA BICHE COUNTY	9,123	MORINVILLE	7,228	BARRHEAD NO. 11, COUNTY OF	5,845
BONNYVILLE NO. 87, M.D. OF	9,047	BRAZEAU COUNTY	7,040	STETTLER	5,843
BANFF	8,721	SLAVE LAKE	7,031	WAINWRIGHT	5,775
PONOKA COUNTY	8,640	WESTLOCK COUNTY	6,910	CROWSNEST PASS, Municipality of	5,749
EDSON	8,365	DRAYTON VALLEY	6,893	BEAVER COUNTY	5,676
WHEATLAND COUNTY	8,164	NEWELL NO. 4, COUNTY OF	6,862	SAMSON CREE NATION	5,550
DRUMHELLER	7,932	CYPRESS COUNTY	6,729	VEGREVILLE	5,520
VERMILION RIVER, COUNTY OF	7,900	TABER, M.D. OF	6,714	GREENVIEW NO. 16, M.D. OF	5,464
TABER	7,821	PONOKA	6,576	ST. PAUL	5,441
INNISFAIL	7,691	DEVON	6,361	WILLOW CREEK NO. 26, M.D. OF	5,337
ATHABASCA NO. 12, COUNTY OF	7,592	PEACE RIVER	6,315	KNEEHILL COUNTY	5,218
CAMROSE COUNTY	7,577	COALDALE	6,177	STETTLER NO. 6, COUNTY OF	5,216
BLOOD TRIBE	7,555	ST. PAUL NO. 19, COUNTY OF	5,925	REDCLIFF	5,096

Figure 4. Population Centres in Alberta

* Map source: Alberta Municipal Affairs and Housing – Population 2008 - http://www.municipalaffairs.gov.ab.ca/mc_official_populations.cfm

Table 4. Cost of the Population-based Monitoring Sub-program

Monitoring Station	Ozone	Oxides of Nitrogen	Carbon Monoxide	Sulphur Dioxide	Continuous Particulates ($PM_{2.5}$)	Hydrocarbons	Hydrogen Sulphide	Ammonia	Total Reduced Sulphur	Continuous BTEX	Continuous Particulates (PM10)	Particulate Composition	Volatile Organic Compounds	Semi Volatile Organic Compounds	Wind Direction and Speed	Temperature and/or Humidity	Data Logger	Data System	Shelter	Total Capital Equipment Cost (x1000)	New Capital Equipment Cost (x1000)	Total Annual Operating Cost (x1000) **	New Annual Operating Cost (x1000)**
Edmonton *																							
Edmonton Central	X	X	X		X	X						X	X			X	X	X	X	208	0	165	0
Edmonton East	X	X	X	X	X	X	X			X			X	X	X	X	X	X	X	278	35	165	0
Edmonton South	X	X	X	X	X	X	X				X				X	X	X	X	X	258	35	60	0
Edmonton Portable Unit	Unit will be able to monitor two or three selected parameters																			100	100	50	50
Subtotal																				**844**	**170**	**440**	**50**
Calgary *																							
Calgary Central	X	X	X		X	X				X	X	X	X	X		X	X	X	X	288	35	195	0
Calgary Northwest	X	X	X		X	X									X	X	X	X	X	188	0	60	0
Calgary East	X	X	X	X	X	X	X								X	X	X	X	X	223	0	60	0
Calgary Portable Unit	Unit will be able to monitor two or three selected parameters																			100	100	50	50
Subtotal																				**799**	**135**	**365**	**50**
Smaller Urban Communities																							
Red Deer	X	X	X	X	X	X	X								X	X	X	X	X	223	0	60	0
Strathcona County (Sherwood Park)	X	X	X	X	X	X	X						X	X	X	X	X	X	X	243	123	165	105
Municipality of Wood Buffalo (Fort McMurray)	X	X	X	X	X	X			X				X	X	X	X	X	X	X	248	20	165	105
Lethbridge	X	X	X	X	X	X	X	X							X	X	X	X	X	253	0	60	0
St. Albert	X	X	X		X	X									X	X	X	X	X	188	188	60	60
Medicine Hat	X	X	X		X	X									X	X	X	X	X	188	0	60	0
Grande Prairie	X	X	X	X	X	X			X						X	X	X	X	X	228	0	60	0
M.D. of Rocky View	X	X	X	X	X	X	X								X	X	X	X	X	223	223	60	60
Parkland County	X	X	X	X	X	X	X								X	X	X	X	X	223	223	60	60
Airdrie	X	X	X	X	X	X	X								X	X	X	X	X	223	223	60	60
Leduc	X	X	X	X	X	X	X								X	X	X	X	X	223	223	60	60
Subtotal																				**2,463**	**1,223**	**870**	**510**
Five Portable Units for Communities with a Population between 10,000 and 20,000																							
Portable Unit 1	X	X	X	X	X	X	X	X	X						X	X	X	X	X	278	0	75	0
Portable Unit 2	X	X	X	X	X	X	X	X	X						X	X	X	X	X	278	0	75	0
Portable Unit 3	X	X	X	X	X	X	X	X	X						X	X	X	X	X	278	278	75	75
Portable Unit 4	X	X	X	X	X	X	X	X	X						X	X	X	X	X	278	278	75	75
Portable Unit 5	X	X	X	X	X	X	X	X	X						X	X	X	X	X	278	278	75	75
Subtotal																				**1390**	**834**	**375**	**225**
Total for Population-based Subprogram																				**5,496**	**2,362**	**2,050**	**835**

Shading indicates that instrument or station is currently in place or that an existing station or instrument can be used for this purpose.
"Total Capital Equipment" and "Total Annual Operating" costs refer to existing + proposed for sub-program.
* At least one station in Edmonton and Calgary will monitor for BTEX, particulate composition, VOCs and PAHs.
** Operating costs include laboratory analysis costs.

6.1.2 Monitoring Strategy for Smaller Urban Centres

Excluding Edmonton and Calgary, Alberta has seven municipalities with a population greater than 50,000 and four municipalities with a population between 20,000 and 50,000. Municipalities with more than 50,000 people are Strathcona County (including Sherwood Park), St. Albert, the Regional Municipality of Wood Buffalo (including Fort McMurray), Grande Prairie, Red Deer, Lethbridge and Medicine Hat. The Municipal District of Rockyview (Calgary area), Airdrie, Parkland County (west of Edmonton) and Leduc have populations between 20,000 and 50,000.

In cities with a population over 20,000, at least one permanent comprehensive monitoring station should be considered; strategically located to represent air quality in these communities. Some of these communities will require more than one station to adequately represent air quality. The scientific basis for locating these stations can be determined through: (1) application of air quality modeling if the appropriate emissions inventory is available; (2) uncertainty analysis relative to defined Data Quality Objectives; and (3) temporary (minimum of one year) air monitoring studies. The major purpose of these stations is to report air quality to the public, notify the public of air quality events and determine long-term trends in air quality for communities with a population between 20,000 and 50,000.

Monitoring stations located in small urban centres should monitor, at a minimum, the parameters that are required to calculate Alberta's *Air Quality Index*, with two of those parameters being ozone (O_3) and fine particulate matter ($PM_{2.5}$). Consideration should be given to excluding sulphur dioxide (SO_2) from the list of parameters that need to be monitored if the community is remote from significant SO_2 sources. Additional parameters may need to be monitored on a case-by-case basis depending on local sources and air quality issues.

6.1.3 Monitoring Strategy for Municipalities with a Population > 10,000

Less comprehensive or portable monitoring should be conducted in communities with between 10,000 and 20,000 people. This monitoring may use comprehensive portable monitoring stations placed in these communities on a periodic basis (e.g., for one year in a five year rotation). Less intensive permanent monitoring could be conducted depending on the issue. If the community is near intensive industrial activity or downwind from a large urban centre, a permanent monitoring station may be needed. The level of monitoring in these communities may be customized in response to specific local parameters, such as the type of industry (refineries, gas plants, oil sands operations, confined feeding operations, etc).

Thirty municipalities in Alberta have a population between 10,000 and 20,000. Many of these municipalities now have a permanent comprehensive monitoring station operated by an airshed, or a permanent less comprehensive station (not an Air Quality Index station) operated by an airshed or industry. A scientific rationale is needed to determine which of these communities will require monitoring and the type of monitoring necessary (permanent or portable). An Air Monitoring Guidance Tool has been developed as a useful mechanism to set priorities for monitoring in these municipalities and for defining the type of monitoring that needs to take place (see Appendix E). The need for monitoring or improved monitoring in these communities will be determined through regional airshed monitoring programs and as a result of the uncertainty analysis against defined Data Quality Objectives that will identify gaps in the monitoring network.

For communities with between 10,000 and 20,000 people, program costs are based on portable monitoring being conducted for a minimum of one year in every five. These stations will be equipped with a full complement of continuous monitoring equipment to address local and regional issues. Integrated monitoring equipment will also be available for these portable monitoring stations and used when appropriate. A total of five portable monitoring stations would be needed to monitor the 30 municipalities in this population range at the suggested monitoring frequency.

Recommendation 8: Improved air monitoring for urban centres
The AMSP project team recommends that the MIC consider in their workplan the following in determining future air monitoring for urban areas:

a) Use an objective, scientific defensible process to determine the appropriate monitoring for Edmonton and Calgary.
b) Where possible, incorporate existing monitoring conducted by industry, airsheds and government into urban monitoring networks.
c) Assess the need for two monitoring stations in municipalities with a population greater than 50,000.
d) Assess the need for one permanent monitoring station in municipalities with a population greater than 20,000.
e) Assess the monitoring needs for monitoring in municipalities with a population less than 20,000.
f) Use the Air Monitoring Guidance Tool or equivalent in the decision making process for determining the priority for new monitoring.
g) *Review population growth in urban centres annually to determine the need for additional monitoring.*

6.2 Ecosystem-based Monitoring Sub-program

The Ecosystem-based Monitoring Sub-program will monitor parameters that can be used to determine impacts or potential impacts of air pollution on land, water and vegetation. Specific air monitoring objectives to be addressed by this sub-program are 3, 6 and 7 (from section 2.1) indicated below:

- Quantify the exposure to air quality on ecosystem and animal health (Monitoring Objective #3).
- Support the monitoring and reporting requirements associated with air quality or deposition management frameworks and other obligations (Monitoring Objective #6).
- Verify or calibrate air pollutant dispersion, transformation and deposition models and ground truth *remote sensing* data (Monitoring Objective #7).

Ecosystem monitoring stations can also be used to address monitoring objectives 2 (background air quality), 4 (boundary transport), 5 (gaps in monitoring air quality and deposition), 10 (chemical profiles for source apportionment) and 11 (long-term trends).

A comprehensive ecosystem monitoring network is necessary to understand the cumulative effects of air pollutants on environmental receptors. Inputs to the location of monitoring stations include a) modeled ambient air pollution levels from current and projected emission sources, b) modeled levels of acid deposition, c) ecosystem sensitivity to air pollution, and d) gaps in the existing network. The monitoring network that is developed will be reviewed and modified based on updated scientific assessments and an evaluation of the appropriate monitoring network density to meet the objective.

The proposed sub-program will focus on air parameters that can be used to estimate wet and dry deposition in Alberta. Although much of the monitoring effort to date has focused on wet deposition, in reality, the most significant portion of the deposition in Alberta is estimated to be in dry form. Monitoring in areas of future industrial development should enhance baseline data. Adjusting the resolution of ecosystem-based monitoring systems should increase the reliability of assessments for keeping clean areas clean and continuous improvement.

6.2.1 Modeled Ambient Concentrations and Acidic Deposition

The Acid Deposition Assessment Group (ADAG) recently completed the 2004 acid deposition assessment. Included in this assessment was a calculation of modeled acidic deposition and comparison of the modeled numbers to receptor sensitivities. The RELAD (REgional Lagrangian Acid Deposition) model was used to predict annual ambient sulphur dioxide and nitrogen dioxide levels as well as potential acid input (PAI) in Alberta for the years 1995 and 2000. Projected ambient levels and deposition for 2010 were also predicted by the RELAD model. The results of this analysis are presented in the report, *2004 Acid Deposition Assessment for Alberta: A report of the Acid Deposition Assessment Group* prepared for Alberta Environment and the ADAG by WBK & Associates Inc. (2006).

Environment Canada's Criteria Air Contaminant (CAC) emissions inventory (for 1995, 2000 and projected 2010) was used as input for the RELAD model. This emissions data showed that sulphur dioxide emissions in Alberta dropped from 608 kilotonnes per year (kt/yr) in 1995 to 502 kt/yr in 2000, but are projected to increase to 563 kt/yr in 2010. For nitrogen dioxide, total emissions for the province increased from 667 to 718 kt/yr over 1995 to 2000 and are predicted to increase to 837 kt/yr in 2010.

6.2.2 Receptor Sensitivity Mapping

Part of the ADAG 2004 acid deposition assessment included updates to receptor sensitivity mapping for Alberta. The revised receptor sensitivity map is calculated for a one degree by one degree grid. More detailed receptor sensitivity information is available for specific areas of the province such as the oil sands area of northeastern Alberta. The receptor sensitivity map is based on the original ADAG report produced for 1999 and was revised based on new information from environmental impact assessments for new facilities, monitoring data for biological and ecological effects, other sampling surveys and research studies.

Based on this receptor sensitivity map, most of the province, including northeastern Alberta, has high sensitivity to acid deposition. Low to moderate sensitivity is indicated in areas of northern Alberta, central Alberta and in the foothills area of southwestern Alberta. However, the receptor sensitivity classifications are a coarse grid resolution for the entire province, and receptor sensitivities within these grid cells can vary substantially based on the diversity of biological receptors in a specific area.

6.2.3 Comparison of Modeled Deposition to Receptor Sensitivity

The ADAG's evaluation was done by overlaying predicted acid deposition, expressed as PAI (potential acid input), on a receptor sensitivity map and comparing the deposition to the critical,

target and monitoring loads defined by the Acid Deposition Management Framework (1999)[7]. The percentage of the critical, target and monitoring loads were then presented for each grid cell in the province.

The results of this comparison showed that modeled acid deposition rates are lower than the most stringent acid deposition target (monitoring load) for 1995, 2000 and 2010 modeled scenarios (Figure 5). However, the results do show that by 2010, areas of the province are approaching 100 percent of the monitoring load, due mainly to projected increasing emissions in the oil sands area. The Acid Deposition Management Framework defines target loads based on protecting low, moderate and high sensitivity soils.

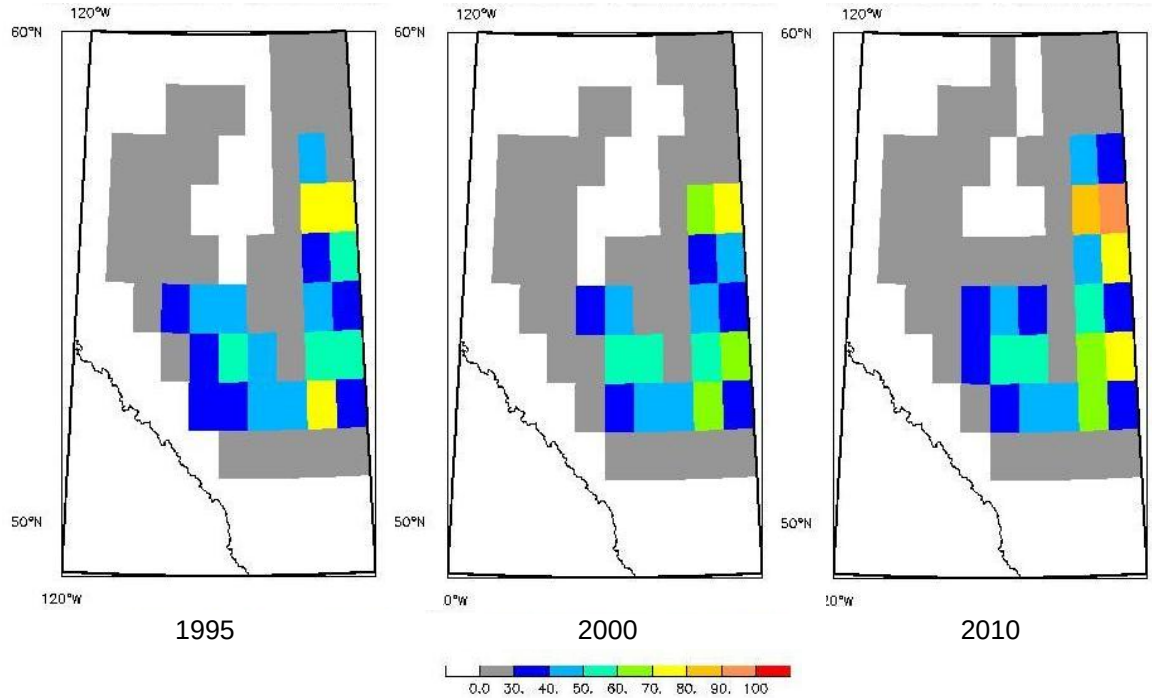


Figure 5. Revised Acid Deposition Loading in Alberta as a Percent of the Monitoring Load for the Years 1995, 2000, and 2010 (projected)

6.2.4 Assessment of Monitoring Gaps

As part of the review of Alberta's existing network, a preliminary assessment of monitoring gaps was performed by identifying areas of high uncertainty in the existing wet deposition network. The results are provided in the report, *Air Pollutant and deposition monitoring networks in Alberta - a review and recommendations for potential future networks.* [8] A coarse *kriging* approach was used to identify areas of the province where additional wet deposition monitoring is needed to improve the certainty or representativeness of data collected by the network. The results of this assessment for sulphate,

[7] Alberta Acid Deposition Monitoring Framework (http://environment.alberta.ca/1966.html)

[8] Alberta Environment. 2008. Air Pollutant and deposition monitoring networks in Alberta - a review and recommendations for potential future networks. Prepared by Centre for Ecology & Hydrology, Edinburgh Research Station, United Kingdom in association with WBK & Associates Inc. http://environment.gov.ab.ca/info/library/8041.pdf.

nitrate and ammonium are indicated in Figure 6. Based on these results, a significant expansion of Alberta's wet deposition network is necessary to adequately represent all areas of the province. The abovementioned report suggests a doubling of the existing wet deposition network, especially in the northwest, central and foothills areas of Alberta. This assessment also suggests establishing a temporary network of precipitation monitors in a north-south and east-west configuration across the province to gain an improved understanding of the precipitation quantity gradient in Alberta. This information would assist in establishing permanent wet deposition monitoring stations. Additional work is needed to further refine and quantify the need for more wet deposition monitoring stations.

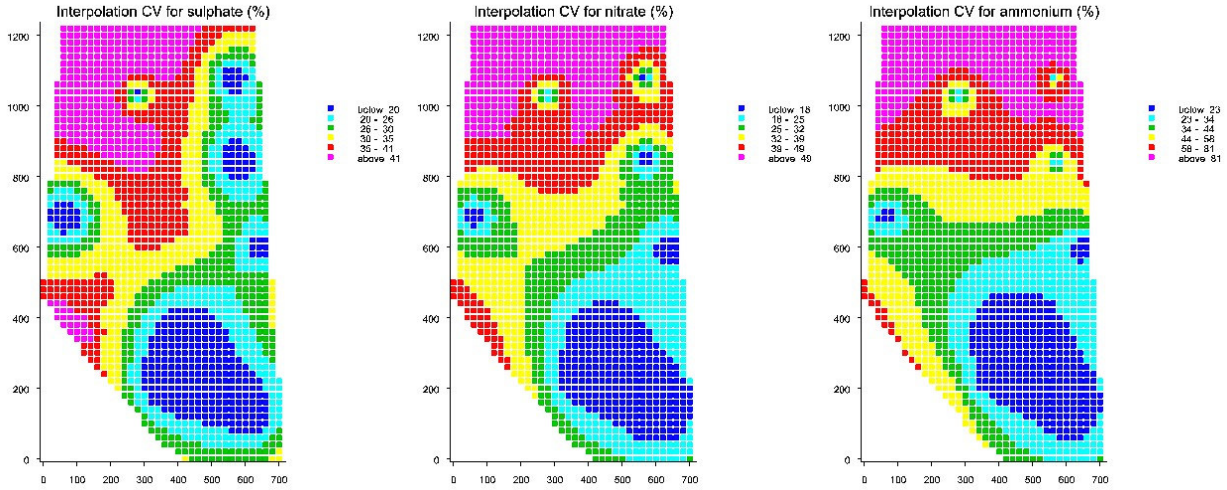


Figure 6. Uncertainty Assessment Based on Wet Sulphate, Nitrate and Ammonium Deposition Data (Alberta Environment, 2008)

6.2.5 Regional Deposition Monitoring

As part of the ADAG's work, Alberta Environment commissioned a study to look at the current approaches for measuring and estimating dry deposition and to determine a technically sound, scientifically robust, and economical approach for estimating dry deposition in airsheds. The study done by WBK & Associates Inc. (2004)[9] recommended that:

1. A regional monitoring network for dry deposition include dedicated monitoring at:
    - a site in the vicinity of emissions sources to capture local influences of nitrogen and sulphur species deposition, and
    - a site removed from regional sources to measures deposition of sulphur and nitrogen species representative of a regional background.
2. The spatial variation of dry deposition in the airshed should be captured using a less expensive monitoring technique such as a *passive* sampling system.

The study also recommends further application of monitoring systems for nitrogen compounds such as HNO_2 (nitrous acid) and HNO_3 (nitric acid). *Passive monitors* for these compounds and for

[9] WBK & Associates Inc. (WBK). 2005. Review and Assessment of Methods for Monitoring and Estimating Dry Deposition in Alberta. Report prepared for Alberta Environment. October 2005. 54 pp. http://environment.gov.ab.ca/info/library/8108.pdf

ammonia are being tested by the Wood Buffalo Environmental Association for application in the oil sands region.

As a result of the ADAG studies, the CASA AMSP project team recommends that a high priority be given to wet and dry deposition-related monitoring in regions of Alberta where acidifying emissions are expected to increase in conjunction with development activity (e.g., oil sands) and in areas where receptor sensitivity is high. Further, common acceptable monitoring protocols for wet and dry deposition need to be defined by Alberta Environment and applied uniformly by airsheds, industry and Alberta Environment to ensure that data can be compared and interpreted province-wide for wet and dry deposition.

6.2.6 Recommendations for Monitoring

Province-wide air modeling, receptor sensitivity and gap analysis information provide a valuable starting point for managing acidifying emissions. However, more direct measurements are needed to provide accurate information on acid deposition. Presently, there is only limited monitoring of wet deposition and the parameters necessary to calculate dry deposition in the province. The existing monitoring network needs to be further evaluated, rationalized and improved to ensure that the right information is being collected to meet the monitoring objectives. Opportunities to coordinate air, land, water and biodiversity monitoring also need to be explored to ensure the availability of the best information to assess the impacts of air quality on this ecosystem. Figure 7 shows existing wet and dry deposition monitoring stations, areas of projected higher emissions and sensitivity to acid deposition, and areas of high uncertainty based on wet deposition data in Alberta.

Table 5 shows the estimated cost of additional monitoring that is needed to adequately measure deposition in Alberta based on available information. The cost estimates include doubling the existing wet deposition monitoring network from ten to twenty stations and adding comprehensive dry deposition monitoring at half (ten) of these sites. The location of existing and new monitoring deposition sites will be determined through a more complete assessment conducted by Alberta Environment. Also included in Table 5 is the cost of a temporary wet deposition monitoring network recommended to provide a better understanding the precipitation quantity and wet deposition gradient across the province. The need for this temporary network will be considered by the MIC subsequent to the completion of the site location assessment conducted by Alberta Environment. The cost estimate considers weekly sampling for precipitation quality and bi-weekly sampling for dry deposition.

Recommendation 9: Ecological monitoring

The AMSP team recommends that Alberta Environment as part of their annual planning:

- *Evaluate opportunities for better coordination of air, land, water and biodiversity monitoring programs in Alberta. This should involve developing integrated monitoring stations to monitor all media within a given area.*

Recommendation 10: Advice for acid and nitrogen deposition monitoring stations

The AMSP team recommends that airsheds and the MIC consider the following when designing a deposition monitoring network:

- *Locating at least one dedicated acid and/or nitrogen deposition monitoring station near important source emitting areas.*

- *Establishing at least one dedicated monitoring site in an area that represents a lower loading condition for comparison (background station).*
- *Evaluating the use of passive samplers for SO_2, HNO_3, NH_3 and NO_2 to support dry deposition monitoring.*
- *Define acid and nitrogen deposition monitoring protocols to be applied province-wide for wet and dry deposition.*
- *Ensure that comparable monitoring approaches for wet and dry deposition are used across the province.*

Recommendation 11: Re-designing the acid deposition monitoring network

The AMSP team recommends that the MIC redesign the provincial wet and dry deposition monitoring network, focusing on areas of predicted high deposition, high receptor sensitivity and high uncertainty, also giving consideration to the existing long-term precipitation quality data base. In redesigning the acid deposition network, the following should be considered:

- *Expand the network to include more monitoring in areas with high deposition and high receptor sensitivity.*
- *Expand the network to include areas of high uncertainty.*
- *Implement instrumentation that would allow both wet and dry deposition calculation at all monitoring sites.*
- *The addition of approximately eight to twelve new wet and dry deposition stations to meet the needs mentioned in the previous three bullets. Scientific rationale will have to be provided when determining the number and location of these stations.*

Recommendation 12: Precipitation quality gradient monitoring program

The AMSP team recommends that:

- *The MIC consider implementing a 3 to 5 year precipitation quality monitoring program to characterize the precipitation quality gradient across Alberta. The program would consist of 16 to 20 monitoring sites with the east-west transect bisecting the Calgary-Edmonton corridor and the north-south transect along the Calgary-Edmonton corridor.*
- *Environment Canada, in consultation with the MIC, implement a study to quantify the reliability of precipitation volume data.*

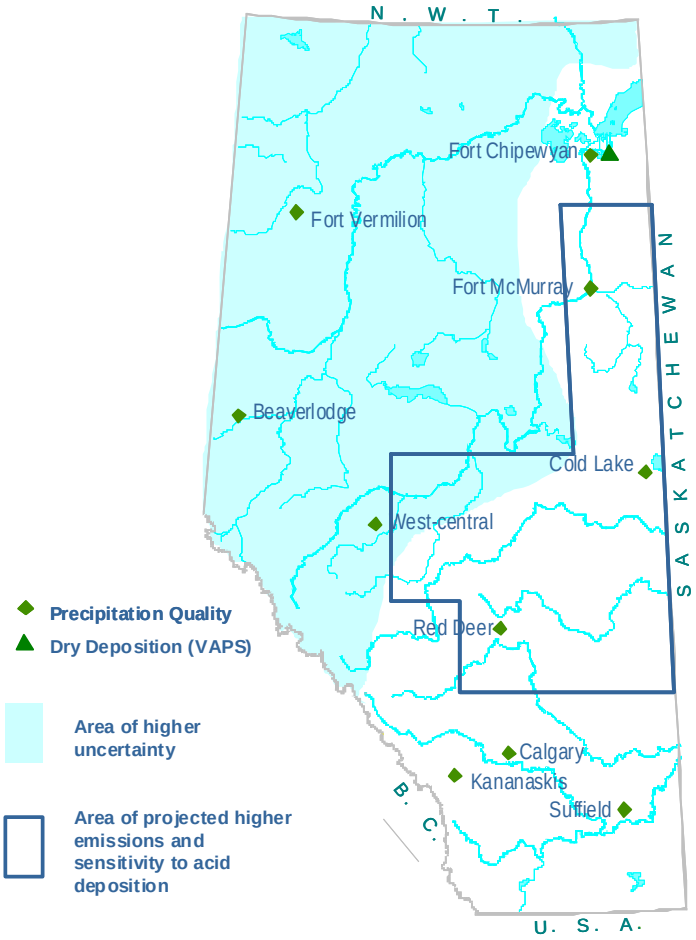


Figure 7. Existing Wet and Dry Deposition Monitoring Stations, Areas of Projected Higher Emissions and Sensitivity to Acid Deposition, and Areas of Higher Uncertainty Based on Wet Deposition Data in Alberta

Table 5. Cost of the Ecosystem-based Monitoring Sub-program

Monitoring Station	Wet Deposition	Dry Deposition	Intensive Meteorology	Total Capital Equipment Cost (x1000)	New Capital Equipment Cost (x1000)	Total Annual Operating Cost (x1000)***	New Annual Operating Cost (x1000)***
Acid Deposition Stations							
Ten Existing Wet Deposition Stations *	X			80	0	100	0
Ten New Wet and Dry Deposition Stations **	X	X	X	410	377	360	334
Subtotal				**490**	**377**	**460**	**334**
3 to 5 Year Wet Deposition Monitoring Program							
Temporary Wet Deposition Monitoring Program (16 stations)	X			128	128	160	160
Subtotal				**128**	**128**	**160**	**160**
Total Ecosystem-based Subprogram				**618**	**505**	**620**	**494**

Shading indicates that instrument or station is currently in place or that an existing station/instrument can be used for this purpose.
"Total Capital Equipment" and "Total Annual Operating" costs refer to existing + proposed for sub-program.
* Includes ten wet deposition stations operated by AENV and one operated by WCAS.
** Includes one existing dry deposition station at Fort Chipewyan.
*** Operating costs include laboratory analysis costs.

6.3 Ozone Monitoring Sub-program

The Ozone Monitoring sub-program is designed primarily to address monitoring objective 6:

- Provide data for assessing the PM/Ozone Management Framework triggers.

Additional monitoring objectives addressed by this sub-program are 1 (outdoor exposure of humans to air pollution), 2 (background air quality), 5 (gaps in monitoring air quality), 7 (check models), 8 (detect poor air quality), 9 (determine air quality relative to standards) and 10 (provide chemical profiles for source apportionment).

Canada-wide Standards (CWS) for fine particulate matter ($PM_{2.5}$) and ozone were established by the Canadian Council of Ministers of the Environment in June 2000. The CASA PM and Ozone Management Framework[10] was developed as Alberta's jurisdictional implementation plan for achieving these standards by the 2010 target date and was endorsed by the CASA Board in September 2003. Alberta Environment is responsible for ongoing annual assessments of ambient air quality data in the province and reporting in relation to the action triggers defined by the CASA PM and Ozone Management Framework. The results of the first five annual assessments (2001-03, 2002-04, 2003-05, 2004-06 and 2005-2007) indicate that ambient levels of both $PM_{2.5}$ and ozone were below the Canada-wide Standards at all Alberta monitoring stations after removing episodes caused by natural, background or trans-boundary influences. However, the management plan action level for

[10] CASA Particulate Matter and Ozone Management Framework: http://www.casahome.org/public/uploads/PMO3_ManagementFrameworkSEP-18-2003.pdf

ozone was exceeded at air monitoring stations located in the Edmonton and Calgary Census Metropolitan Areas, the Fort Air Partnership, the West Central Airshed Society and the Parkland Airshed Management Zone. Areas assigned to the management plan action level were notified in 2006 of the need to develop an air quality management plan to ensure that ozone levels remain below the Canada-wide Standard. Airsheds in these regions worked with stakeholders and submitted air quality management plans in December 2008. Information on these management plans, the annual assessments and the CASA Framework are available at Alberta Environment's website (http://www.environment.alberta.ca/1970.html).

Parts of the province outside the affected area are experiencing significant population and industrial growth. Specifically, the oil sands region will see increased air emissions of ozone precursors over the next two decades. This region is now in the surveillance action level for ozone, but with the projected increase in emissions, a plan is needed to improve monitoring of ozone, ozone precursors and ozone products in northeastern Alberta. The Wood Buffalo Environmental Association and Cumulative Effects Management Association are assessing the need for a proactive ozone management approach in northeastern Alberta.

As indicated in Figure 8, a large portion of central Alberta has been assigned to the management plan action level for ozone based on available monitoring information. To adequately assess ozone formation in these areas, improved monitoring for ozone, ozone precursors and ozone products in the affected airsheds is necessary. Additional monitoring is proposed for ozone, ozone precursors and products upwind and downwind of Edmonton and Calgary and at the appropriate locations within, upwind and downwind of the affected airsheds. This monitoring should be conducted during the "ozone season" (May to September) for a minimum of five years. Implementing the appropriate equipment at existing stations may satisfy this monitoring need. All ozone stations would require VOC monitoring on a three-day schedule and the downwind stations would require additional monitoring of peroxyacetyl nitrate (PAN) and/or other ozone products. All stations would also require continuous monitoring for ozone and oxides of nitrogen. Table 6 shows the proposed monitoring stations and associated costs for the ozone sub-program.

Recommendation 13: Ozone monitoring in the affected area of Alberta
The AMSP team recommends that:

- *The MIC and the affected airsheds design an ambient monitoring network for ozone, its precursors and products, for the affected airsheds that are assigned to the Management Plan action level. The monitoring program will consider monitoring for ozone, ozone precursors and ozone products upwind and downwind of the affected airsheds.*
- *The MIC look for opportunities to optimize the current monitoring stations in the affected area of Alberta based on the proposed network design.*

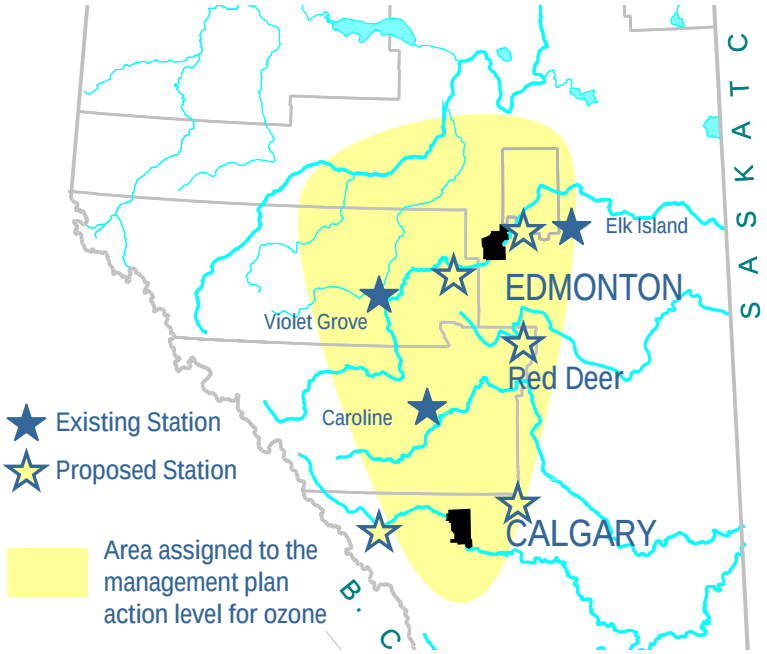


Figure 8. Area Assigned Into the Management Plan Action Level for Ozone

Table 6. Cost of the Ozone Monitoring Sub-program

Monitoring Station	Ozone	Oxides of Nitrogen	Continuous Particulates (PM2.5)	Volatile Organic Compounds	Peroxyacetyl nitrate (PAN)	Wind Direction and Speed	Temperature and/or Humidity	Data Logger	Data System	Shelter	Total Capital Equipment Cost (x1000)	New Capital Equipment Cost (x1000)	Total Annual Operating Cost (x1000) ****	New Annual Operating Cost (x1000) ****
WCAS Upwind Station (Violet Grove)	X	X	X	X		X	X	X	X	X	130	10	80	50
WCAS Downwind Station/ACAA Upwind Station**	X	X	X	X	X	X	X	X	X	X	160	40	80	50
ACAA Downwind Station/FAP Upwind Station	X	X	X	X	X	X	X	X	X	X	160	160	80	80
FAP Downwind Station (Elk Island)	X	X	X	X	X	X	X	X	X	X	160	40	80	50
PAMZ Upwind Station (Caroline)	X	X		X		X	X	X	X	X	95	10	80	50
PAMZ Downwind Station	X	X		X	X	X	X	X	X	X	125	125	80	80
CRAZ Upwind Station***	X	X	X	X		X	X	X	X	X	130	10	80	50
CRAZ Downwind Station	X	X	X	X	X	X	X	X	X	X	160	160	80	80
Total for Ozone Subprogram*											**1,120**	**555**	**640**	**490**

Shading indicates that instrument or station is currently in place or that an existing station or instrument can be used for this purpose.
"Total Capital Equipment" and "Total Annual Operating" costs refer to existing + proposed for sub-program.
* Based on monitoring during the ozone season from May to September.
** The population-based subprogram suggests a station in Parkland County which could also be a ozone subprogram monitoring station.
*** The population-based subprogram suggests a station in the M.D. of Rocky View which could also be a ozone subprogram monitoring station.
**** Operating costs include laboratory analysis costs.

6.4 Boundary Transport Monitoring Sub-program

The Boundary Transport Monitoring sub-program will address monitoring objective 4:

- Characterize air quality entering or leaving the province.

Boundary transport monitoring will also address monitoring objectives 2 (background air quality), 5 (gaps in monitoring air quality), 7 (check models and remote sensing data) and 11 (long-term trends).

Monitoring near Alberta's borders was recommended in the original strategic plan to measure the quality of air as it enters and leaves the province. In Alberta, several existing monitoring stations meet this objective, many of which also meet the objective of monitoring background air quality representative of specific parts of the province. Existing and suggested boundary transport stations are shown in Figure 9 (see page 59).

The Hightower Ridge station was intended to monitor air quality upwind of Alberta. About 50 to 75 km north of Hinton, this station characterizes background air quality at an elevated location in the west-central part of Alberta. This location is also appropriate for characterizing air pollutants entering the province and is fundamental for air quality assessments such as those required by the CASA PM and Ozone Management Framework.

The Beaverlodge monitoring station is about 50 km west of Grande Prairie. Significant nearby oil and gas activity may mean that this station is inadequate for characterizing air pollutants entering northwest Alberta. Consideration should be given to moving the station further west to a location that is at least 50 km from local sources, but given the density and dynamics of the oil and gas industry, this may not be practical. The Beaverlodge station may still be appropriate for characterizing regional background air quality at a rural location in northwestern Alberta.

One of the purposes of the Fort Chipewyan station was to monitor air quality at a practical location (i.e., with available power and access) in northeastern Alberta that could represent background air quality and air pollutants leaving the province. Given the projected increases in air emissions from the oil sands area and the increased concern in Saskatchewan about air pollution from the oil sands, consideration should be given to locating a permanent, continuous air monitoring station near the Alberta/Saskatchewan border to properly characterize air pollutants leaving northeastern Alberta. A station at this location may now be practical using the shelter and power technology in place at the Hightower Ridge station.

The original strategic plan recommended air monitoring in southwestern Alberta (Pincher Creek-Waterton) to a) assess visibility issues allegedly caused by transport of pollutants from Alberta to Montana, b) characterize air pollutants entering the province from B.C., and c) fill a gap in air quality monitoring. Consideration should be given to establishing a new station in this area or 'piggy-backing' on industry monitoring conducted at the Shell Waterton location. Environment Canada is developing a visibility monitoring program in "pristine"/natural areas across the country, with a station planned for the mountain parks of Alberta. Collaboration may be possible between Alberta and Environment Canada on this program.

Because of the need to manage air quality and, specifically, photochemical pollution in the Calgary area, consideration should be given to re-establishing a monitoring station in the Kananaskis area west of Calgary. Data from this site would be useful in assessing air pollutants transported from B.C. into the Calgary airshed and for future air quality assessments in the Calgary area.

Air monitoring stations located in the Medicine Hat, Esther and Cold Lake areas may also be useful for assessing air pollutants leaving Alberta from the central and southern regions. Additional data analysis is needed for these monitoring stations to confirm that they meet this objective.

Further air modeling on a province-wide scale using current and future emission scenarios should be used to verify air monitoring locations and determine the number of stations needed to characterize air pollutants entering and leaving the province. Suggested monitoring stations, parameters and their associated cost for boundary transport monitoring are indicated in Table 7 (see page 58).

Recommendation 14: Boundary Transport monitoring
The AMSP team recommends that the MIC:

a) Consider results of the province-wide network design project in determining how to address air pollutants entering and leaving the province;
b) Determine the suitability of existing stations to assess border transport of air pollutants (i.e., Fort Chipewyan, Hightower Ridge, Beaverlodge, Esther, Cold Lake and Medicine Hat as well as industrial compliance monitoring stations). If these stations are suitable, they should be added to the network; and
c) Assess the suitability of proposed new boundary transport monitoring stations in the Kananaskis area, Pincher Creek/Waterton area, northwestern Alberta, and northeastern Alberta near the Saskatchewan border, on the Saskatchewan side of the Alberta-Saskatchewan border and if the results are favourable, bring these stations into the program.
d) Develop a methodology and/or set of criteria for determining the suitability of stations for both boundary transport and background monitoring.

Recommendation 15: Visibility
The AMSP team recommends that:

The MIC investigate the opportunity to collaborate on the visibility monitoring program under development by Environment Canada over the next 3 to 5 years.

6.5 Background Monitoring Sub-program

The Background Monitoring sub-program will address monitoring objective 2:

- Characterize background air quality in Alberta.

Other monitoring objectives addressed by this sub-program include 4 (boundary transport), 5 (air quality monitoring gaps), 7 (check models and remote sensing data) and 11 (long term trends).

Background air quality can be monitored a) in a pristine environment not significantly affected by human activities, b) at a location remote from local or regional air pollution sources, and c) upwind of an area that contains significant emission sources.[11] Because of the quantity and density of air emission sources in Alberta, it is difficult to find a location that will measure pristine air quality. Some of the stations suggested as boundary transport stations could also monitor upwind air quality (e.g., Hightower Ridge, Beaverlodge, Kananaskis). Additional background air monitoring may be needed in regions upwind of large emission sources (e.g., Fort McMurray, Fort Saskatchewan, Wabamun) or large urban areas such as Calgary and Edmonton. Additional analysis of air emissions

[11] Upwind monitoring sites become emission source integration sites during downwind periods and can therefore serve dual purposes.

data and existing monitoring activities is needed to determine the need for more background and upwind monitoring stations. Suggested background monitoring locations are indicated in Figure 9 (page 59).

Continuous, permanent air quality monitoring stations need to be established to monitor background air quality and air quality near provincial/territorial and national borders. These stations will monitor sulphur dioxide, oxides of nitrogen, ozone and fine particulate matter using continuous analyzers. Additional monitoring for volatile organic compounds should be added at stations in western Alberta during the ozone season (May to September). Also, visibility monitoring should be added to address the new particulate matter annex as part of the Canada-U.S. air quality agreement. For the purpose of estimating costs, a total of ten background and boundary transport stations are recommended. The number and density of these stations will need to be assessed using a more rigorous scientific process to determine if ten stations are adequate to meet these monitoring objectives. Table 7 shows the cost of the background and boundary transport monitoring sub-program.

Recommendation 16: Background monitoring
The AMSP team recommends that the MIC

e) Consider results of the province-wide network design project in determining how to address background air quality in Alberta;
a) Determine the suitability of existing monitoring stations to assess background air quality (Hightower Ridge and Beaverlodge); and
b) Consider establishing background air monitoring stations in the Kananaskis area, Pincher Creek/Waterton area and northwestern Alberta.
c) Develop a methodology and/or set of criteria for determining the suitability of stations for both boundary transport and background monitoring.

Recommendation 17: Background monitoring upwind of large industrial complexes
The AMSP team recommends that the MIC:

- *Evaluate background monitoring upwind of large industrial complexes in Alberta and determine adequacy, identify gaps and make recommendations to Alberta Environment, airsheds and industry.*
- *Address gaps and ensure that background monitoring is conducted upwind of large industrial complexes throughout Alberta.*

Table 7. Cost of the Background and Boundary Transport Monitoring Sub-program

Monitoring Station	Ozone	Oxides of Nitrogen	Sulphur Dioxide	Continuous Particulates ($PM_{2.5}$)	Volatile Organic Compounds	Wind Direction and Speed	Temperature and/or Humidity	Data Logger	Data System	Shelter	Total Capital Equipment Cost (x1000)	New Capital Equipment Cost (x1000)	Total Annual Operating Cost (x1000) *	New Annual Operating Cost (x1000) *
Northwest Alberta	X	X	X	X	X	X	X	X	X	X	170	170	120	120
Beaverlodge	X	X	X	X	X	X	X	X	X	X	170	10	120	60
Hightower Ridge	X	X	X	X	X	X	X	X	X	X	170	10	120	60
Kananaskis	X	X	X	X	X	X	X	X	X	X	170	170	120	120
Pincher Creek/Waterton	X	X	X	X	X	X	X	X	X	X	170	170	120	120
Southeast Alberta	X	X	X	X		X	X	X	X	X	160	160	60	60
Esther	X	X	X	X		X	X	X	X	X	160	70	60	0
Cold Lake	X	X	X	X		X	X	X	X	X	160	0	60	0
Alta/Sask Border	X	X	X	X		X	X	X	X	X	160	160	60	60
Fort Chipewyan	X	X	X	X		X	X	X	X	X	160	0	60	0
Total Background and Trans-boundary Subprogram											**1,650**	**920**	**900**	**600**

Shading indicates that instrument or station is currently in place or that an existing station or instrument can be used for this purpose.
"Total Capital Equipment" and "Total Annual Operating" costs refer to existing + proposed for sub-program.
* Operating costs include laboratory analysis costs.

6.6 Pattern Recognition Monitoring Sub-program

The Pattern Recognition Monitoring sub-program will address monitoring objective 5:

- Address gaps in air quality and deposition monitoring for Alberta.

Other monitoring objectives addressed by this sub-program are 2 (background air quality), 4 (boundary transport), 7 (check models and remote sensing data) and 11 (long-term trends).

To get a comprehensive picture of ambient air quality levels on a provincial scale, a grid of passive samplers should be established province-wide. Data gathered by this network would be used to create a monthly and annual spatial map of air pollutant levels for the entire province. The data could also be used to resolve long-term trends in air quality. Pollutants monitored using passive techniques would include ozone, sulphur dioxide, nitrogen dioxide, and, on a site specific basis, nitric oxide, nitric acid, ammonia, hydrogen sulphide and/or organic vapors.

Prior to establishing the new network, passive samplers must go through a certification process that ensures their acceptability for use in Alberta. Also, network modeling is needed to determine the network density required to meet the monitoring objectives. The network density should be reviewed when sufficient data has been collected. This would involve performing a geostatistical analysis to determine the optimum density for each parameter or pollutant. The passive sampling network would be integrated with existing passive sampling networks operated by airshed zones, Alberta Environment and industry. Initially, a passive grid with a coarse spacing (one degree by one degree) is recommended to fill gaps in the existing monitoring network. This would require about 100

sampling sites. A conceptual passive sampling grid is illustrated in Figure 9 and the cost of this grid is detailed in Table 8.

Recommendation 18: Pattern Recognition network design

The AMSP team recommends that the MIC:

- *Do a scientific, objective analysis to determine the appropriate network density for a province-wide network that will spatially represent air quality in Alberta.*
- *Use industry, airshed and government monitoring stations where possible to address gaps in air monitoring. An assessment of where these gaps are and what stations could be used to fill these gaps is required.*

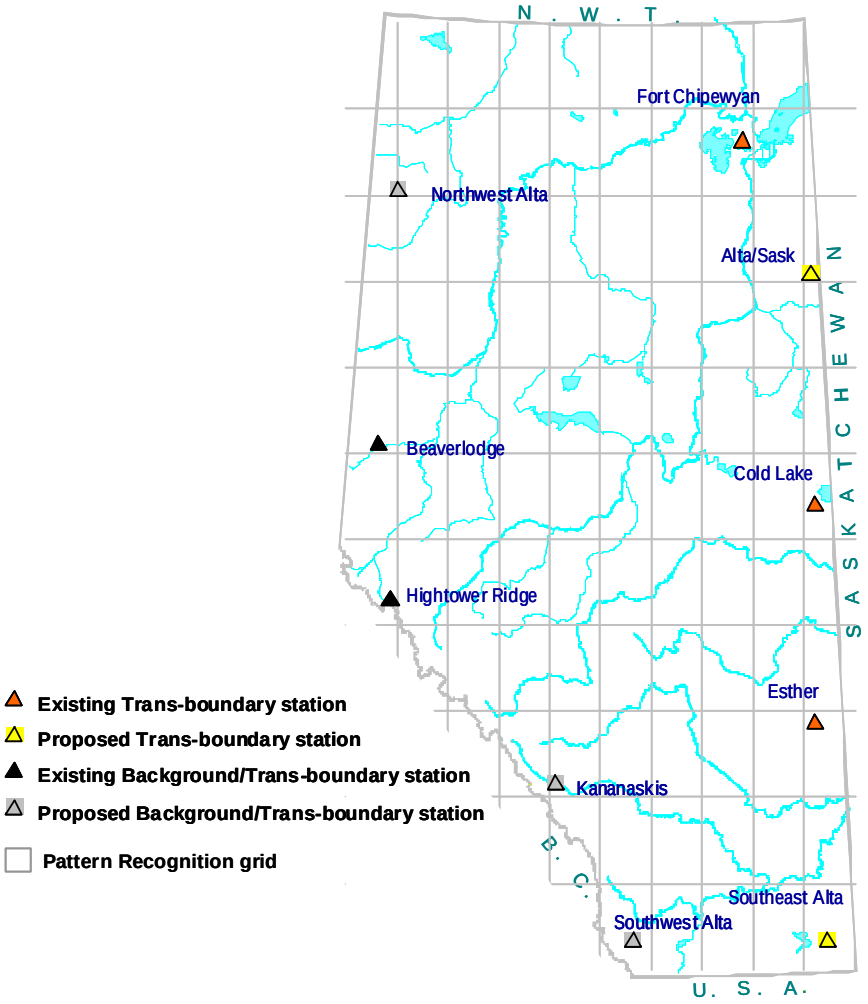


Figure 9. Boundary Transport, Background and Pattern Recognition Monitoring Sub-Programs

Table 8. Cost of the Pattern Recognition Monitoring Sub-program

Monitoring Station	Passive Ozone	Passive Nitrogen Dioxide	Passive Sulphur Dioxide	Passive Ammonia	Passive Hydrogen Sulphide	Shelter	Total Capital Equipment Cost (x1000)	New Capital Equipment Cost (x1000) *	Total Annual Operating Cost (x1000) ****	New Annual Operating Cost (x1000) ****
40 Existing Passive Sampling Stations	3	3	3			4	12	0	115	0
20 New Passive Sampling Stations (SO_2, NO_2, O_3) **	1	1	1			2	6	1	58	58
20 New Passive Sampling Stations (SO_2, NO_2, O_3) ***	1	1	1			100	104	100	418	418
20 New Passive Sampling Stations (SO_2, NO_2, O_3, H_2S, NH_3)	1	1	1	1	1	2	9	1	78	78
Add 10% for duplicates and 10% for blanks	6						6	0	134	111
Total Spatial Grid							**137**	**101**	**802**	**664**

Shading indicates that instrument or station is currently in place or that an existing station or instrument can be used for this purpose.
"Total Capital Equipment" and "Total Annual Operating" costs refer to existing + proposed for sub-program.
* Alberta Environment owns enough passive sampler holders and shelters to accommodate the province-wide spatial grid.
** Stations are accessible by road.
*** Stations are not accessible by road.
**** Operating costs include laboratory analysis costs.

6.7 Industry Compliance Monitoring Sub-program

The Industry Compliance Monitoring sub-program involves the integration of site or facility specific industry compliance monitoring stations into the provincial network. It will explicitly address monitoring objective 6:

- Determine air quality relative to ambient air quality objectives, guidelines, standards or criteria.

Existing and future industry compliance stations could also be upgraded to address many of the other ten monitoring objectives for the provincial air monitoring network depending on their location and the near-by emissions sources.

Industries with approvals to operate in Alberta are required to control their emissions so that ambient levels of air pollution downwind of their industry are below the Ambient Air Quality Objectives[12] established by Alberta Environment to protect public health and ecosystems. Industry presently operates 88 continuous ambient monitoring stations in Alberta; 58 stations are permanently located and 30 conduct temporary monitoring for two to six months per year. These stations are located to monitor the maximum predicted modeled air pollutant concentrations downwind of a specific facility. Where there is an industrial complex, monitoring stations may be located where the predicted maximum concentration is expected to occur from the combined emissions of all facilities. Further effort is needed by Alberta Environment, airsheds and industry to *rationalize* industry

[12] Alberta's Ambient Air Quality Objectives: http://www.environment.alberta.ca/613.html

monitoring station locations, look for duplication and integrate these stations into a province-wide monitoring network. The industry monitoring stations and networks need to be assessed and recommendations made to improve the efficiency of the networks and ensure that industry monitoring will be able to manage future growth in industrial emissions.

Industries that are required to monitor air quality are indicated in Figure 10; airshed stations are not included in this figure.

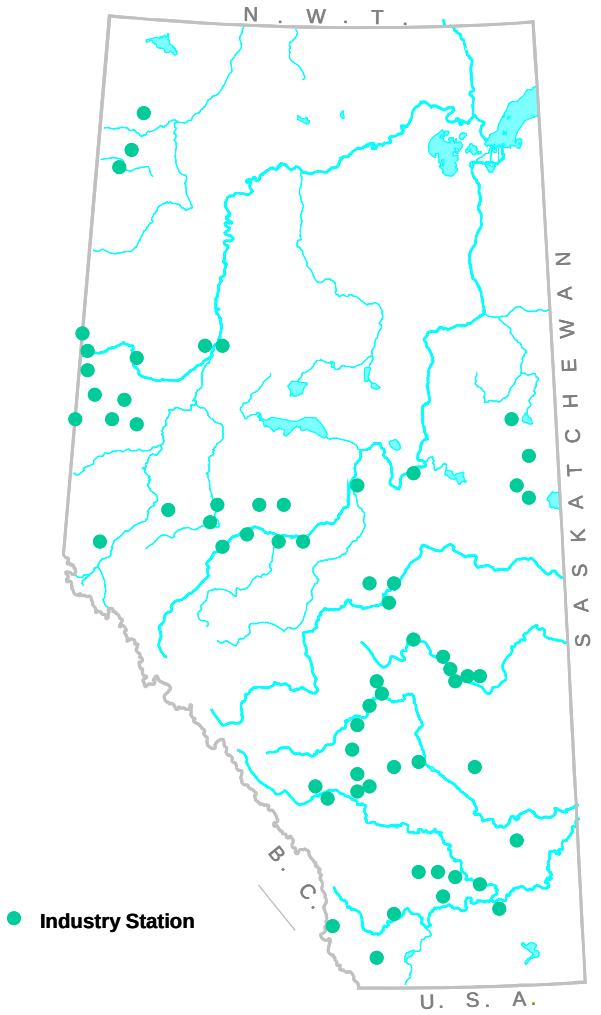


Figure 10. Industry Sites Where Air Quality Must Be Monitored

Recommendation 19 represents a shift from the current approach of monitoring individual facilities to an approach that coordinates industry monitoring with the *provincial monitoring network*. There are times when the provincial network requires monitoring that may not fit into local network priorities. Facility or site specific industry compliance monitoring data should inform assessments of continuous improvement. Local airsheds, including all stakeholders, have input into station formation or relocation.

Recommendation 19: Rationalizing industry monitoring
The AMSP team recommends that the MIC:

- *Look for opportunities with industry, airsheds and AENV to rationalize air monitoring currently being conducted by industry.*
- *Provide guidance for industry, airsheds (if present in the region) and AENV in the evaluation of facility specific compliance monitoring stations.*
- *Make recommendations to industry, airsheds and AENV regarding which stations might be incorporated into the monitoring network.*

6.8 Mobile and Emergency Response Monitoring

Organizations such as Alberta Environment, Environment Canada, the Energy Resources Conservation Board, the City of Edmonton, the City of Calgary and some airsheds have the capability to conduct mobile or emergency air quality monitoring. Alberta Environment's Mobile Air Monitoring Laboratory (MAML) is used to: (a) obtain province-wide air quality data; (b) explore potential sites for Alberta's permanent monitoring network; (c) identify potential problem areas; and (d) respond to community air quality concerns. A mobile unit/vehicle was built in 2003 by the City of Calgary and Alberta Environment to monitor air quality impacts from emergencies in the Calgary area. A similar unit was built in 2005 for the Edmonton area.

In addition, the Energy Resources Conservation Board operates mobile units equipped to monitor pollutants associated with sour gas releases. The Wood Buffalo Environmental Association is building capacity to monitor air quality for both investigative and emergency response purposes. Environment Canada operates mobile monitoring units aimed at addressing large scale research issues in Canada. The Environment Canada units were used in 2005 to conduct a pilot study aimed at understanding the photochemical smog issue in the Alberta Capital Region.

Alberta Environment is looking at its mobile and emergency response programs to determine the most effective uses for investigative, ambient, emergency response and research purposes. A policy document on the use of these units will be developed by Alberta Environment and available for use by other organizations.

7 Funding Air Monitoring

Industry and Alberta Environment fund their own air monitoring activities. Funding for airsheds recognizes the multi-stakeholder nature of these groups and takes into account in-kind (people, resources) and capital contributions from industry and government. Funding is generally based on the 'emitter-pays' principle with members paying in proportion to their emissions levels. This can be determined or estimated directly, or a surrogate such as production levels can be used. Some sectors are treated differently, based on their ability to pay.

As indicated in Table 9, the current cost of ambient air monitoring in Alberta (including *continuous*, *intermittent*, *passive*, *static*, *acid deposition*, mobile and emergency monitoring) is close to $30-million for capital equipment and just over $18-million for annual operations. Industry currently pays 79% of these costs and government covers the remaining 21%. Current contributions by funder to capital and operating costs are shown in Figure 11.

Table 9. Current* Cost of Ambient Air Monitoring in Alberta

Monitoring Program Operator	Total Capital Cost ($x1000)	Total Annual Operating and Analytical Costs ($x1000)	Contribution to Total Costs (%)
Alberta Environment	3,783	1,203	10%
Environment Canada	1,712	638	5%
Airsheds (Non-industry)	1,888	861	6%
Airsheds (Industry)	10,779	7,404	38%
Industry	11,681	8,082	41%
Total	**29,844**	**18,187**	**100%**

*As of February 2009.

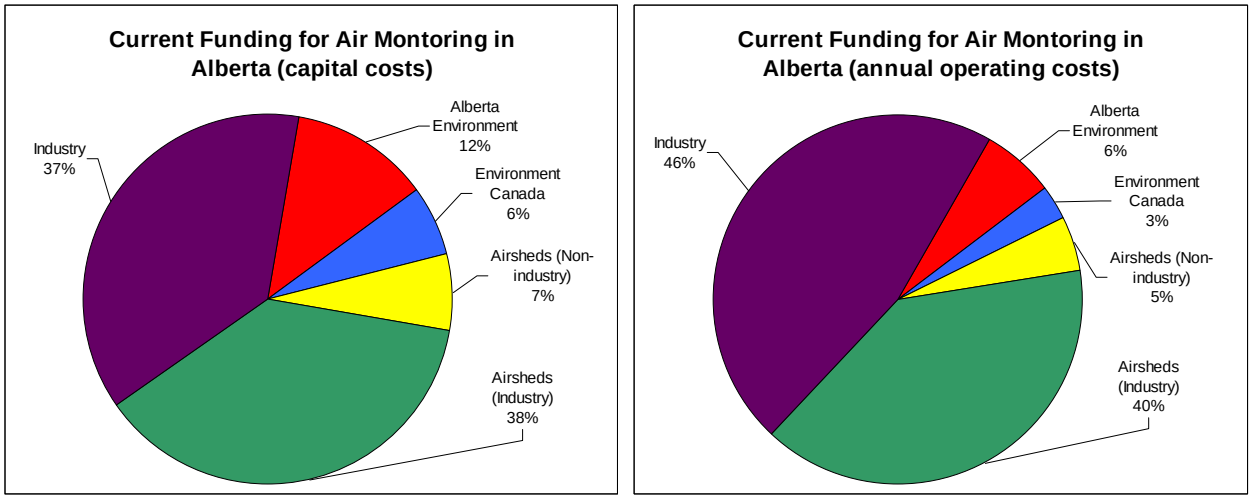


Figure 11. Current* Funding for Air Monitoring in Alberta
*As of February 2009.

The total increase in monitoring costs associated with new monitoring being proposed in this strategic plan is over $4-million for capital equipment and over $4-million for annual operations. These costs are summarized by sub-program in Table 10.

Table 10. Cost of New Monitoring Proposed in the AMSP

Monitoring Program Component	Total Network		Existing Portion		New Portion	
	Capital Equipment ($x1000)	Annual Operations ($x1000)*	Capital Equipment ($x1000)	Annual Operations ($x1000)*	Capital Equipment ($x1000)	Annual Operations ($x1000)*
Population-based Sub-program	5,496	2,050	3,134	1,215	2,362	835
Ecosystem-based Sub-program	618	620	113	126	505	494
Ozone Sub-program	1,120	640	565	150	555	490
Background and Transboundary Sub-program	1,650	900	730	300	920	600
Pattern Recognition Sub-program	137	802	36	138	101	664
Instrument Replacement Costs (10% of Capital)	-	902	-	458	-	444
Data Management	15	150	10	100	5	50
Information Dissemination	-	50	-	0	-	50
Data QA/QC (20% of Operating)	-	662	-	300	-	362
Contractor Overhead (25% of Operating)	-	827	-	375	-	452
Total	**9,036**	**7,603**	**4,588**	**3,162**	**4,448**	**4,441**

* includes supplies, services and laboratory analysis

7.1 Funding System for the New Air Monitoring System

Appropriate funding of the new air monitoring proposed in the AMSP is fundamental to its success. In essence, funding will be based on the cost of the monitoring system. Costs will be apportioned in a fair and equitable manner, which means that all significant regulated and unregulated pollution sources must be identified and emissions must be quantified. The following principles will guide the approach to funding the new system:

1. Costs will be apportioned to emitters relative to their emissions and the costs associated with the air quality and deposition monitoring.
2. Costs will be apportioned to emitters in a fair and equitable manner.
3. For small industrial and diffuse emitters who are not currently paying their share of the monitoring costs, the provincial government will develop a mechanism to ensure that those costs are paid into the system in proportion to the emissions generated.
4. Data and information from this monitoring system will be publicly available. However, data users whose specific needs require additional system resources will pay the costs associated with meeting those needs.
5. Provisions will be included to ensure long-term funding.
6. Those who reduce their emissions should be recognized.
7. There will be flexibility for airsheds to meet their own unique needs and acknowledge previously negotiated funding agreements.

The AMSP team is proposing a funding formula that is simple, fair, objective, open, transparent, and understandable. The formula uses a consistent charge per tonne on emissions throughout the province. The formula is based on the emitter-pay principle, with the understanding that a sustainable and long term funding mechanism will be developed by the Government of Alberta to pay for ambient air quality monitoring.

Two funding scenarios are being considered by the AMSP team. Scenario "A" will apply to all monitors in the provincial system (that is, all seven subprograms), and includes all existing airshed monitors and all existing facility specific (commonly called fenceline) industry monitors. Scenario "B" will apply to all monitors in the provincial system, and includes all airshed monitors and the proportion of the facility specific industry monitors that is estimated to be rolled into the provincial network in the future. The project team proposes that the new Multi-Stakeholder Implementation Committee take on the responsibility of reviewing existing facility specific compliance monitoring to determine which monitors should be upgraded and included in the *provincial monitoring network.*

The funding formula calculation procedure is shown in detail in Appendix F.

Figure 12 shows the changes in the funding requirements from the current system to the new emitter-pay system. The funding for the total network represented in this figure includes the following monitoring programs: provincial subprograms, mobile and emergency, airsheds, and industrial compliance (facility specific industry monitoring). Once the new network is in place, the increase to annual operating costs will be about $4.8 million. Under the proposed emitter-pay system, about 70% of these costs are attributed to non-industrial sources ($3.4 million) and 30% are attributed to industrial sources ($1.4 million). This represents a substantial increase in monitoring costs to government, with a doubling of annual operating costs. The increase in costs to industry would be less than 10% for annual operations.

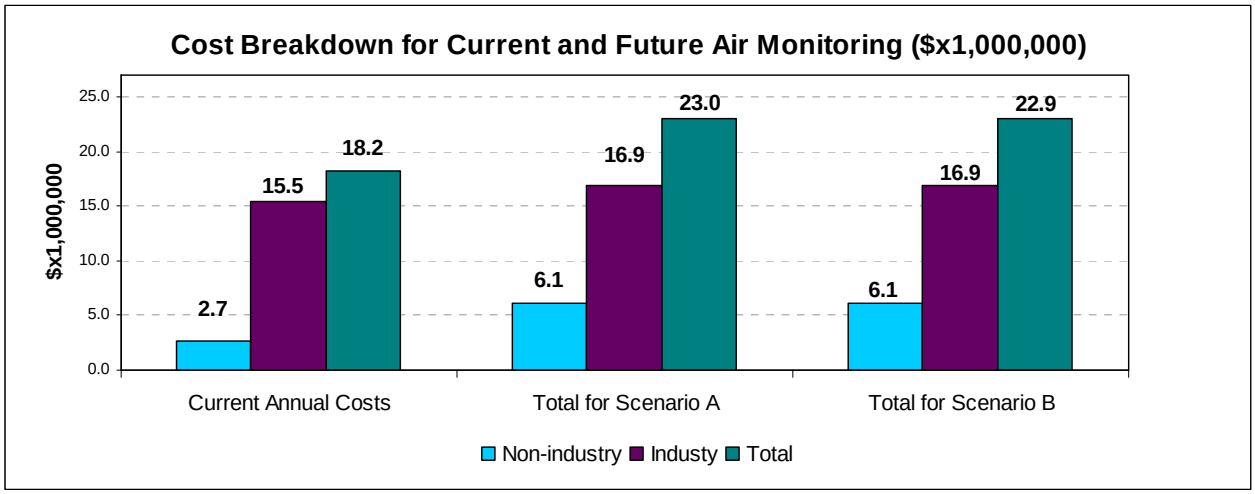


Figure 12. Annual Cost Breakdown for the Proposed Air Monitoring System

The cost per tonne of emissions is calculated using air emissions information for the province and the cost of monitoring each individual pollutant. These costs need to be assigned and weighted according to each criteria air contaminant (CAC). CACs include fine particulate matter ($PM_{2.5}$), sulphur oxides

(SOx), oxides of nitrogen (NOx), volatile organic compounds (VOCs), carbon monoxide (CO) and ammonia (NH_3). The resulting cost per tonne estimates for the entire provincial network, once the new network is fully operational (Year 5), are presented for Scenarios "A" and Scenarios "B" in Figure 13. These values are calculated using the 2005 Environment Canada CAC inventory[13] (Appendix G).

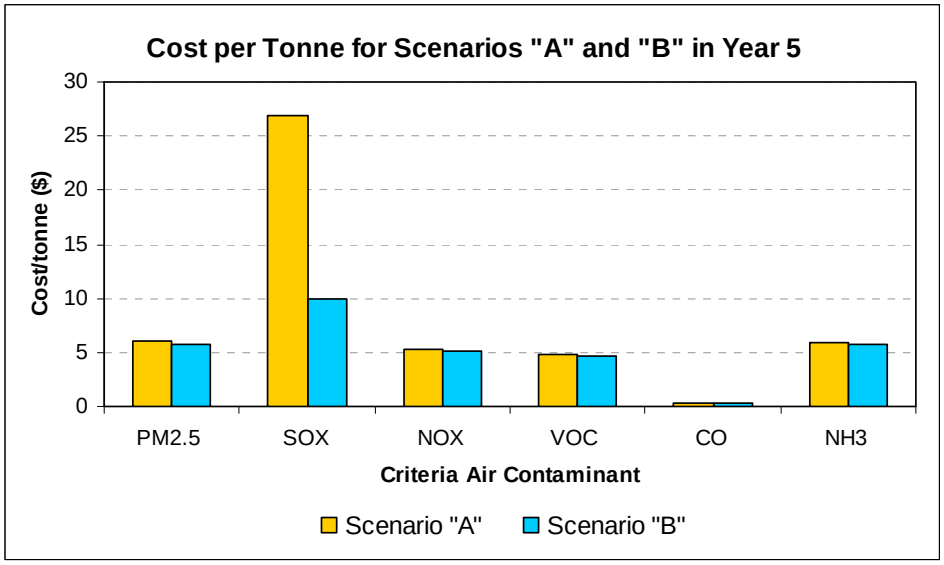


Figure 13. Cost Per Tonne for New Monitoring Network Under Scenarios "A" and "B"

Using the proposed funding formula, the funding changes for specific industry sectors for Scenario "A" and Scenario "B" are shown in Figure 14 and Figure 15, respectively. A List of all industrial sources from the 2005 Environment Canada CAC inventory can be found in Appendix G. As mentioned above, the net increase in annual operating cost for industry will be approximately $1.4 million. However, the changes in cost for specific sectors will be larger because of the current disproportionate distribution of monitoring and monitoring costs based on air emission quantities.

[13] http://www.ec.gc.ca/pdb/cac/Emissions1990-2015/2005/2005_AB_e.cfm

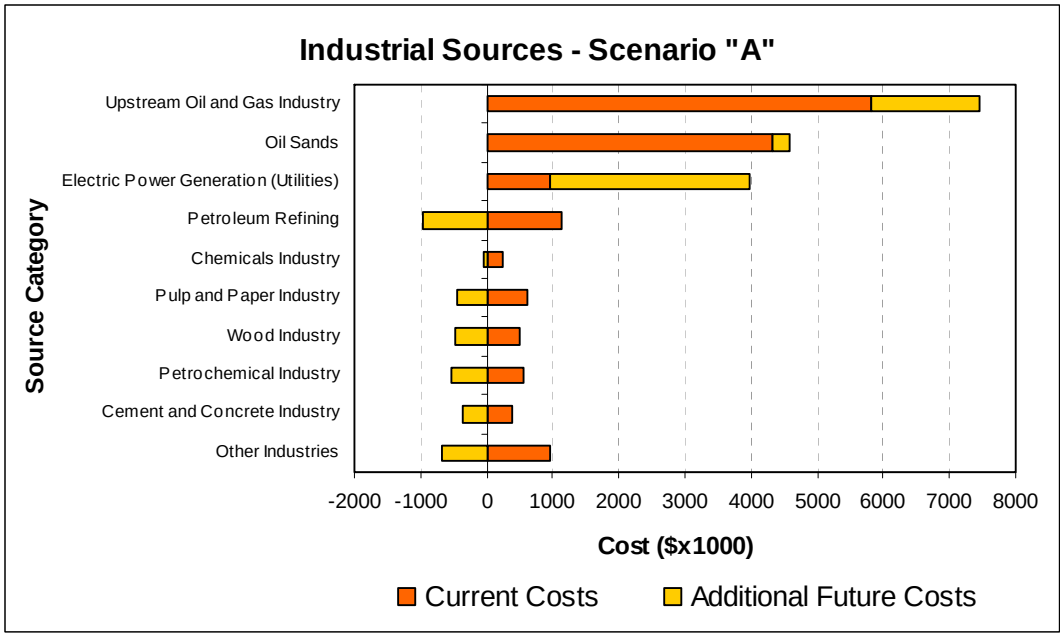


Figure 14. Change in Monitoring Cost by Industry Sector for Scenario "A"

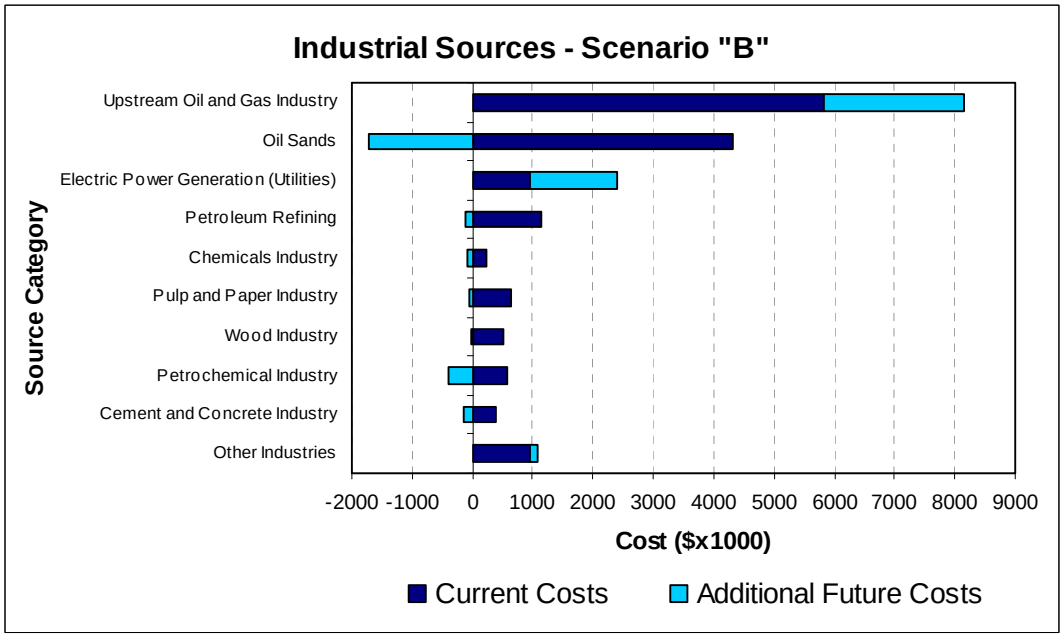


Figure 15. Change in Monitoring Cost by Industry Sector for Scenario "B"

During the first four years of implementation, Alberta Environment and industry will be expected to contribute to funding the new monitoring network implementation in accordance with the funding formula. The team is proposing that the funding formula be phased in, as described in the recommendations below, to provide certainty for the first four years. More information on funding implementation is given in section 9.

***Recommendation 20: Funding to implement the enhanced ambient air monitoring system* (non-consensus recommendation)**

The AMSP Project Team recommends that:

a) *Alberta Environment commit to annual funding through the Government of Alberta's budgeting process to cover the cost of monitoring emissions attributed to diffuse emitters.*
b) *Large and small industrial emitters fund their portion of the enhanced provincial network according to the funding formula.*
c) *For large industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees industry's funding contribution to the enhanced network by committing to pursue payment through regulatory mechanisms.*
d) *For small industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees small industry's contribution to the network by either pursuing payment through regulatory mechanisms or covering their contribution and then retroactively applying the long-term funding mechanism when it is implemented.*

***Recommendation 21: Ensuring long-term sustainable funding* (non-consensus recommendation)**

The AMSP Project Team recommends that:

1. *To ensure long-term sustainable funding for the Ambient Monitoring Strategic Plan (i.e., after the first four years), Alberta Environment develop within two years, a sustainable long-term funding mechanism that ensures equitable contributions from large industrial, small industrial and diffuse emitters.*
2. *Alberta Environment implement this funding mechanism in the subsequent two years.*

Alberta Environment has blocked consensus on recommendations #20 and #21. The Government of Alberta cannot provide the funding certainty implied by these recommendations. Alternative wording for recommendations #20 and #21 provided by Alberta Environment is given in Appendix H.

8 Data and Information Management System

Managing air monitoring data and information is more than just working with numbers. To be most useful and provide the greatest value to the most people, data and information management should be viewed in the larger context of knowledge systems. Knowledge systems provide data, information and learning opportunities to support the operation of the air quality management system. There are three aspects of a knowledge system, all of which should be considered and addressed as part of the new ambient monitoring strategic plan:

- Acquiring and interpreting new information,
- Conducting research and keeping abreast of scientific developments (see Box 2), and
- Education and outreach for sharing knowledge.

Alberta needs to ensure that its knowledge systems are robust and complete enough to support the proposed air quality management system. A successful centralized air quality data and information management system should:

- Include all air quality data collected in the province and provide the appropriate caveats regarding the uncertainties and limitations of this data;
- Provide data in a form that can be used by technical and non-technical users, along with tools and guidance to correctly interpret the data; and
- Provide the public with the information they need to take the appropriate actions to reduce their impact on air quality and take precautions to protect their health.

Box 2. Alberta Environment's Role in Research

Alberta Environment plans, funds and conducts research in direct support of Ministry activities, and will work with partners towards shared objectives. Current research is focused on four themes; assessing emission reduction technologies, assessing ambient air quality, improving monitoring methodologies, and improving air quality management systems. Partnering with other departments, governments and industry on research is part of the overall research management strategy to avoid duplication and maximize the benefit received from research dollars. Other types of information are obtained from strategic intelligence, contract scientific assessments, staff training and development, journals, industry, websites, consultants (world knowledge pool), and other governments (federal and provincial). A corporate research fund is used to obtain more fundamental scientific research results to help the department address emerging issues.

As part of the network review (section 5.4), the centralized data management and information system will be assessed to ensure that it is meeting user data and operational needs, as well as regulatory requirements for data input. Recommendations, if appropriate, to improve the system would be the result of this assessment by the multi-stakeholder group.

8.1 Alberta's Existing Data Management System

Currently, ambient monitoring data collected by Alberta Environment and airsheds in Alberta is managed through the CASA Data Warehouse and is readily available to the public. Alberta's existing data management system is described in more detail in Appendix I. Industry is required to submit air monitoring reports to Alberta Environment. Reporting requirements are specified in approvals and in the *Air Monitoring Directive* and vary depending on the substance(s) in question and the size and nature of the facility. The industry monitoring reports summarize ambient and source monitoring data and provide information on the quality assurance and quality control measures taken to ensure

the data are accurate. These reports also outline problems that may have arisen and any corrective actions taken. Submission of industry monitoring information is being switched to electronic methods.

In recent years, there has been increasing demand for readily available and accessible real-time and historical air quality data. Stakeholders have also expressed a need for the conversion of data to information for technical and non-technical users, who need this information to develop tools and take actions that will improve air quality and protect human and environmental health.

Stakeholders that need real-time access to air quality monitoring data can now access that data (for most sites) from the Alberta Environment real-time air quality website. In this context, real-time access to observations means receiving access to the observations no more than 30 minutes, and ideally within 10 minutes, after each hour for continuously monitored parameters such as ozone and nitrogen dioxide.

8.2 The New Data Management System

The AMSP team has identified several areas in which the existing data management system could be improved:

- The current centralized data management system should integrate data from all scales of monitoring and serve as a province-wide archive for air quality data.
- Data collected by industries, airsheds and governments should be provided to the system in a standard electronic format in a timely and consistent manner.
- Raw and summarized data should be available to technical and non-technical users.
- The system should move towards integrating real-time and historical archived air quality data.

At its broadest, the new data management system could include:

- Archived and real-time ambient air quality data,
- Special monitoring studies,
- Links to health and ecological effects monitoring studies and data related to air quality,
- Links to emissions inventory databases,
- Industrial approval data – ambient monitoring and emissions,
- Mechanisms or tools for consistent data reporting,
- Reports on air quality data and trends,
- Education and advocacy tools and messages, and
- Outreach and communications components.

The new data management system is based on the following principles:

(1) Data from all air monitoring activities in the province are retained within a centralized data management system.
(2) All data contained in the centralized data management system are available over the Internet.
(3) Data are presented in standardized formats that serve both technical and non-technical users.
(4) Data access is intuitive and simple.
(5) Those who monitor air quality in Alberta provide data electronically to the centralized system in a timely and consistent manner.

(6) The centralized data management system will contain one-window access for real-time and archived data.

(7) Meta data, or data about the data, are provided to the data management system. Meta data includes information such as site documentation, data responsibilities, and quality assurance / quality control protocols.

Recommendation 22: Data management principles

The AMSP Project Team recommends that:

CASA accept the principles of the new data management system.

Alberta Environment will have the lead role in ensuring that the data and information management systems are meeting the needs of stakeholders. Alberta Environment's responsibilities will include:

- Providing annual funding for the routine operation, expansion and enhancement of the data and information management system.
- Seeking stakeholder input on the operation of the system through annual presentations to the Multi-stakeholder Implementation Committee.
- Developing an annual work plan for the data management system and communicating this work plan to stakeholders through the multi Multi-stakeholder Implementation Committee.
- Establishing a mandatory mechanism to ensure that ambient air quality data is provided routinely, in electronic format, by those undertaking this monitoring.
- Working with data providers to develop protocols and procedures to assist data providers in providing data efficiently and effectively.
- Following up with enforcement actions if the data are not provided in accordance with established protocols.
- Assuring that ambient air quality data are available in formats and through access channels that are user friendly to the public and stakeholders.

A fundamental advancement to the existing data management system involves the conversion of data into information that is meaningful and useful to the general public, environment consultants, government agencies, academic institutions, the media and others; for example, notifying the public when air quality is poor and may have immediate health impacts on susceptible or at risk individuals. Informing the public about actions they can take to reduce health risks is a practical and proactive mechanism for using and communicating air quality information.

Airshed zones operate websites on which they post their monitoring data along with other information about the airshed and its operations. Airshed zones also voluntarily submit their ambient air quality monitoring data to the CASA Data Warehouse to be housed along with data coming from ambient air monitoring sites operated by Alberta Environment. At present, *facility specific compliance* data from industry are not housed in the CASA Data Warehouse.

Recommendation 23: Mandatory submission of data to a central data management system (currently, the CASA Data Warehouse.)

The AMSP Project Team recommends that:

Alberta Environment develop a mechanism within one year following board approval to facilitate mandatory submission of all ambient air quality monitoring data in Alberta to a central data management system within a prescribed time period.

Data in the CASA Data Warehouse and some supplementary information can be viewed and downloaded in reports, which can be generated by anyone with Internet access. Alberta Environment and industry presently fund the operation of the CASA Data Warehouse. This funding arrangement will need to be reviewed as the Data Warehouse is expanded and more products are made available, thereby increasing operating costs.

Recommendation 24: Funding the central data management system
The AMSP Project Team recommends that:

The Multi-Stakeholder Implementation Committee consider funding for the central data management system as part of the overall air monitoring system costs.

8.3 Turning Data into Information

A fundamental component of the data management system is the conversion of data to information that is intuitive and useful to the general public, environment consultants, government agencies, academic institutions, the media and others. One example of how air quality information can be use is by notifying the public when air quality is poor so that they can take the appropriate actions.

The AMSP team discussed the following data and information items that should be investigated as part of the data and information management system:

- An information dissemination system that would provide interpreted air quality information to public and technical audiences.
- A central archive for published reports related to air quality and its effects on the environment.
- Links to human, ecological and animal health information.
- Links to emissions information (National Pollutant Release Inventory, Alberta Environment information, greenhouse gas information)
- Website links to data and reports from both portable monitoring and bio-receptor monitoring so they are available to the public but not on the website.
- Links to summary information available at the Alberta Environment State of the Environment web page.
- A need for more user-friendly information for the general public.

Ensuring that data are communicated in a user-friendly format means evolving from a data management system to an information communication system. To achieve this goal, the needs of users must be understood. A survey of data users could be used to gain this understanding. The survey should be contracted to a marketing consultant and could be undertaken in partnership with similar activities by airshed zones. The target audience should include regulators, general public, schools (junior and senior high schools), post secondary institutions, academics (scientists and researchers), industry, environmental consultants, special interest groups, media (local and provincial), hospitals (health care delivery), health regions and environmentally sensitive populations.

Recommendation 25: Determining the needs of data users
The AMSP recommends that:

Within one year of board approval Alberta Environment conduct a survey to determine the needs of data users and what information would be most useful to users and provide the report to the Multi-Stakeholder Implementation Committee.

8.4 Emissions Inventory

A comprehensive emissions inventory is necessary for defining the magnitude, type and spatial pattern of emissions sources in the province. Monitoring networks, and in particular monitoring network sub-programs, need to reflect the location and nature of the factors influencing and affecting air quality at the local, regional and provincial scale. Factors affecting air quality typically include meteorology, terrain, and the extent and type of industrial, commercial, agricultural and/or residential development. The most important of these are generally the location and type, qualities, quantities and variability of larger point and/or area emission sources; primarily industrial sources and/or concentrated transportation/urban sources.

A number of provincial emission inventories of common air contaminants (*SO_2, NOx, PM, VOC, CO* and *NH_3*) have been compiled (see Appendix G for one example). Airsheds may also have regional emissions inventory or source data that is used to site monitoring stations and allocate monitoring costs among airshed members. Source emission inventories are an essential input into regional, provincial and national air quality and deposition models and used in the evaluation of cumulative effects for Environmental Impact Assessments. In the context of the AMSP, a comprehensive emissions inventory is required to properly allocate funding responsibilities to significant emitters.

In reviewing ambient air monitoring needs from a spatial, temporal and parameter type/frequency standpoint, one of the challenges that the project team encountered was finding a comprehensive and user friendly inventory of provincial emission sources. Stakeholders wanted a clear picture of emission types, their location and what and how much they were emitting. Such a user-friendly inventory can be used in the implementation of the new air monitoring network being proposed in this strategy. It can further validate and optimize ambient air quality monitoring in the province as well as assist in the review and update of the Plan in the future.

Ideally, the inventory and related report generation capability should be able to:

1. generate an overview of the general categories of emission sources in the province, including the specific types and sub-types of emission sources within each category, and also provide a listing of the types of emissions associated with each source;
2. describe emission characteristics of the specific source types/sub-types and the major factors affecting each emission source (e.g., fuel type/quality, process type, pollution control equipment);
3. provide details on individual sources, such as location, type (e.g., point, area, mobile, controlled, fugitive), relevant release details (e.g., stack height, emission release temperature), emission quantity and quality, variability, how monitored and/or estimated, level of uncertainty in emission estimates, etc., including any/all detailed characterization that has been conducted on the source (e.g., trace element and organic analysis).

Recommendation 26: A comprehensive emissions inventory

The AMSP Project Team recommends that:

Alberta Environment develop and maintain a comprehensive GIS-based provincial inventory of all relevant emission sources that influence provincial air quality commencing within one year following board approval.

9 Implementing the Strategic Plan

This Implementation Plan contains the details to make the 2009 Ambient Monitoring Strategic Plan a reality. It is consistent with the Ambient Monitoring Framework for Alberta and like the Strategic Plan, is intended to be reviewed and updated every three to five years. Ongoing tasks will include implementing the network plans, implementing other ambient air monitoring projects and managing the overall system. Implementation responsibilities rest with various agencies, including Alberta's airshed zones, industries, Alberta Environment, and Environment Canada. However, the Plan is sufficiently flexible that airsheds can make adjustments to optimize monitoring for their zone as needed.

9.1 Implementation Principles

In addition to the principles presented in section 2.1, specific implementation principles are presented below and are offered as guidance to the Multi-stakeholder Implementation Committee. This guidance will help the MIC prepare an annual work plan for implementation.

Two principles are considered most important:

1. Commitment to implementing monitoring obligations external to this process, specifically the particulate matter and ozone management plans.
2. Filling in the largest monitoring gaps according to the seven sub-programs. The largest gaps are where the greatest uncertainties exist. Stations must be strategically located so that when data is collected, there is certainty that the specific monitoring objectives of the monitoring subprogram will be addressed.

The remaining principles are things to keep in mind while preparing an annual work plan:

3. Gaining efficiencies in existing monitoring by combining efforts and reducing duplication. This is aimed at existing monitoring; e.g., adding or upgrading *facility-specific compliance monitoring* and rolling it into the provincial system rather than setting up a new station.
4. Balancing workload over time to ensure the work is manageable economically.
5. Setting a reasonable implementation timeframe for the monitoring itself (not necessarily over the short term).
6. Giving monitoring priority to areas with increasing emissions, based on available emissions forecasts.
7. Creating efficiencies by implementing monitoring that will address more than one program and/or objective. This principle is more focused on new monitoring; if a station will address more than one objective, it should be a higher priority.
8. Emphasize practicality in implementation; that is, implement those things in the short term that are relatively quick and inexpensive to implement.

9.2 Implementing The Enhanced System

The AMSP team is proposing that all funds and equipment be allocated over the first four years following the CASA board's approval of the AMSP, and that the entire system be fully implemented and operating within five years. Total cost for implementing the new infrastructure will be close to $11-million over four years including new capital equipment and annual operations (see section 7 for

more details on funding). After year four, the annual costs for the provincial network are projected to be $4.4 million per year. Figure 16 illustrates the funding needed to implement new monitoring proposed by the strategic plan over five years. The seven monitoring subprograms proposed by the 2009 AMSP are displayed in Figure 17.

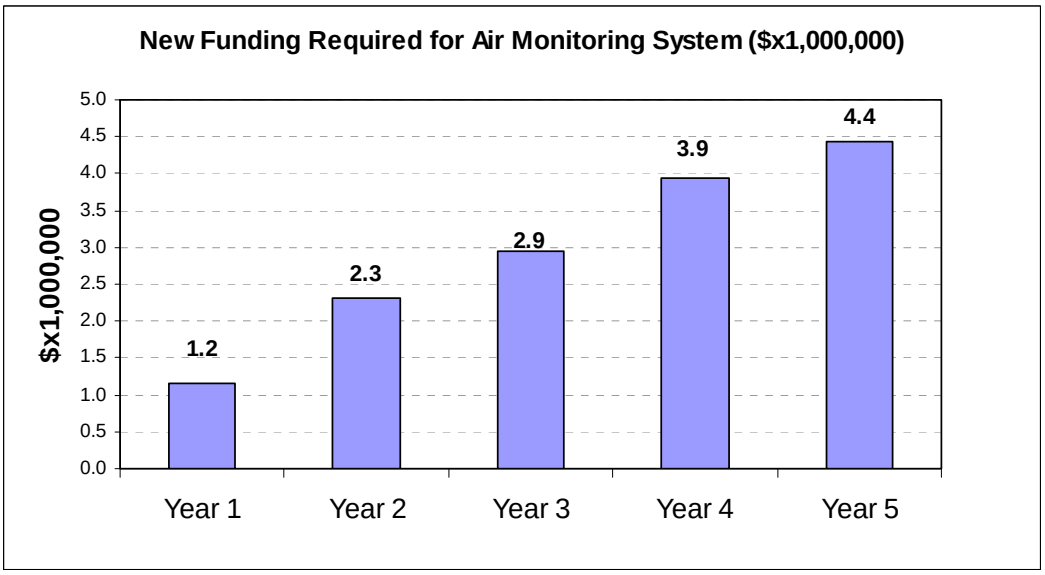


Figure 16. Annual funding required for new air monitoring system proposed by the AMSP.

Table 11 outlines the proposed timeline, cost and responsible agencies for implementing each of the seven sub-programs. This timeline recommends the order and priority for implementation. The highest implementation priority is the ozone monitoring required to address gaps upwind and downwind of major urban areas. It is proposed that this program will be implemented in Year 1. The next priority is improving the deposition monitoring program in Alberta. It is recommended that this program be implemented in Year 1, Year 3 and Year 4. Improvements to population-based monitoring are scheduled in each of Year 1 to Year 4 with the entire program operational in Year 5. Background, pattern recognition and boundary transport monitoring will begin later in the implementation schedule. The incorporation of facility specific compliance monitoring into the provincial network will be ongoing throughout the implementation of the other subprograms. The appropriates improvements to the data and information system will also need to be made in Years 1 to 4 as the seven subprograms are implemented. Data Quality Objectives will be developed prior to the implementation of each monitoring subprogram

Recommendation 27: Priority and timelines for implementation
The AMSP project team recommends that:

- *The Ambient Monitoring Strategic Plan be implemented according to the 5-year timeline suggested by the AMSP Implementation Subgroup, as outlined in Table 11 of the Implementation Plan. Where specific timelines are not mentioned in the recommendations, they are captured in the seven sub-programs discussed in the AMSP.*
- *The MIC have flexibility to modify the implementation timeline according to any new priorities.*

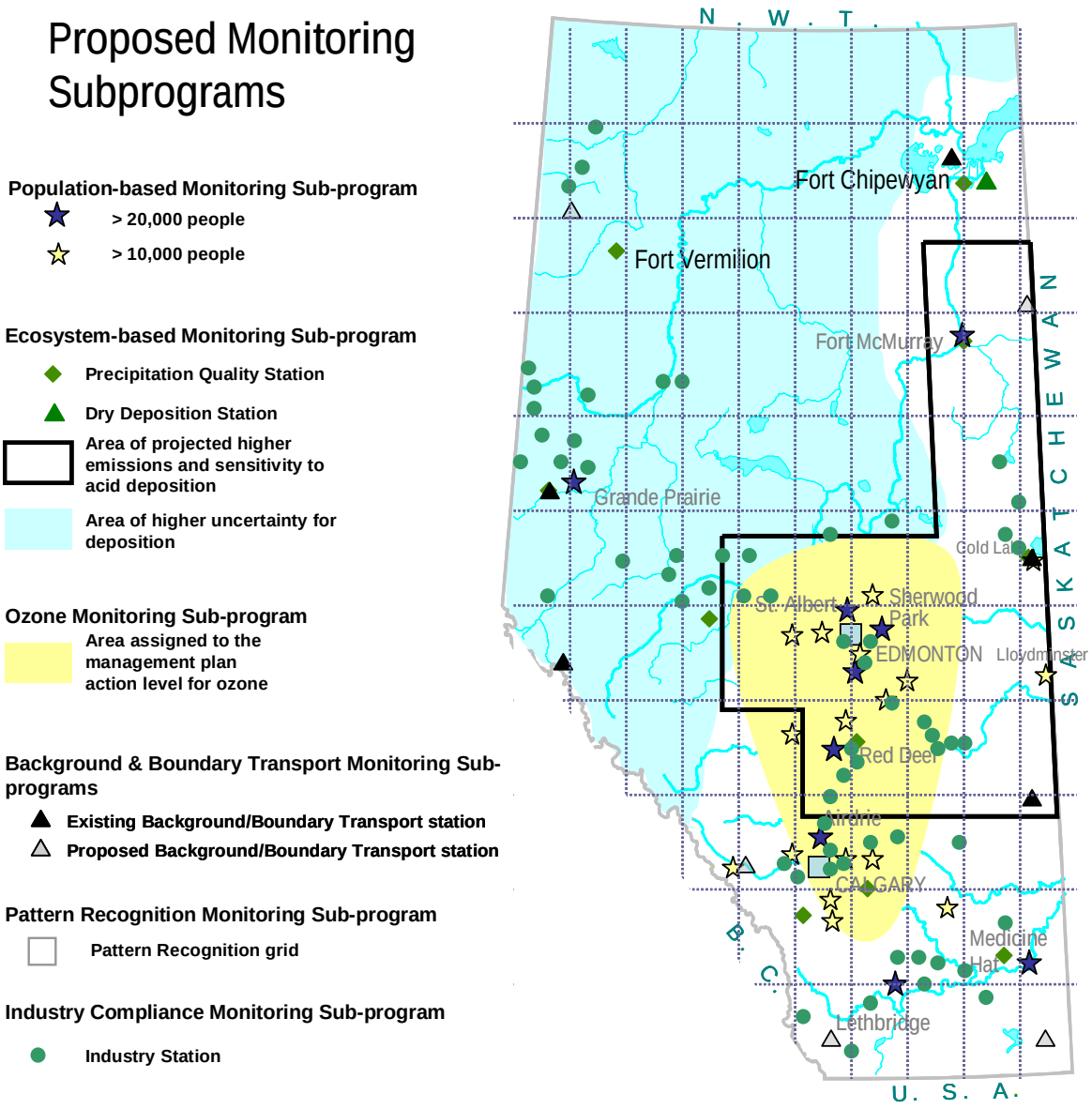


Figure 17. Existing and proposed monitoring recommended by the 2009 AMSP.

Table 11. AMSP Implementation Timeline

Task	Start (months post start)	Duration	Finish (months post start)	Program	Capital cost ($x1000)	Ongoing Operation Cost (/year) *	Who Implements	Who Should Pay? **
Board Approval of AMSP	0	0	0	Admin				
Add CRAZ upwind and downwind stations	3	3	6	Ozone	170	130	Airshed	AENV/Airshed
Add FAP/ACAA upwind and downwind stations	3	3	6	Ozone	200	130	Airshed	AENV/Airshed
Add WCAS/ACAA upwind and downwind stations	6	3	9	Ozone	50	100	Airshed	AENV/Airshed
Add PAMZ upwind and downwind stations	6	3	9	Ozone	135	130	Airshed	AENV/Airshed
Optimize existing fenceline stations for additional applicatior	6	9	15	Facility Specific Compliance			AENV/Industry	
Addition of wet and dry deposition stations (1 and 2 of 5)	11	3	14	Ecosystem	151	134	AENV/Airshed	AENV/Airshed
Addition of wet and dry deposition stations (3 and 4 of 5)	23	3	26	Ecosystem	151	134	AENV/Airshed	AENV/Airshed
Upgrade Edmonton stations	18	3	21	Population	70	0	AENV/Airshed	AENV/Airshed
Addition of smaller community stations (1 of 5)	18	3	21	Population	188	60	AENV/Airshed	AENV/Airshed
Upgrade Calgary stations	21	3	24	Population	35	0	AENV/Airshed	AENV/Airshed
Develop DQO generalize approach	12	6	18	Admin			AENV	AENV
Develop Data to Information tools (web based)	12	6	18	Admin			AENV	AENV
Implement DQO approach on airshed and program basis	12	12	24	Admin			AENV	AENV
Additional Data Management	Ongoing			Admin	5	50	AENV	AENV
Year 1 Total					**1155**	**Operating costs will begin in Year 2**		
Addition of smaller community stations (2 of 5)	21	3	24	Population	223	60	AENV/Airshed	AENV/Airshed
Addition of smaller community stations (3 of 5)	25	3	28	Population	223	60	AENV/Airshed	AENV/Airshed
Addtion of smaller community stations (4 of 5)	37	3	40	Population	223	60	AENV/Airshed	AENV/Airshed
Deployment of additional portable stations (1 of 3)	29	3	32	Population	278	75	AENV/Airshed	AENV/Airshed
Establish Boundary/bkgnd station: Kananaskis	18	3	21	Background/ Transbndry	170	120	AENV/Airshed	AENV/Airshed
Information Dissemination	Ongoing			Admin	0	50	AENV/Airshed	AENV
Year 2 Total					**1117**	**1198**		
Development of "hot spot" monitoring stations (1 of 2)	42	3	45	Population	100	50	AENV/Airshed	AENV/Airshed
Deployment of additional portable stations (2 of 3)	42	3	45	Population	278	75	AENV/Airshed	AENV/Airshed
Deployment of additional portable stations (3 of 3)	40	3	43	Population	278	75	AENV/Airshed	AENV/Airshed
Establish Boundary/bknd station: North Peace area	30	6	36	Background/ Transbndry	170	120	AENV/Airshed	AENV/Airshed
Establish Boundary/bkgnd station: Pincher Creek	32	3	35	Background/ Transbndry	170	120	AENV/Airshed	AENV/Airshed
Addition of wet and dry deposition stations (5 of 5)	30	3	33	Ecosystem	75	67	AENV/Airshed	AENV/Airshed
Implement Passive Network (1 of 3)	32	12	44	Spatial	34	221	AENV/Airshed	AENV/Airshed
Year 3 Total					**1105**	**1834**		
Development of "hot spot" monitoring stations (2 of 2)	45	3	48	Population	100	50	AENV/Airshed	AENV/Airshed
Upgrade smaller community stations	45	3	48	Population	143	210	AENV/Airshed	AENV/Airshed
Addtion of smaller community stations (5 of 5)	45	3	48	Population	223	60	AENV/Airshed	AENV/Airshed
Establish East boundary station... NERN AB	37	6	43	Background/ Transbndry	160	60	AENV/Airshed	AENV/Airshed
Upgrade Boundary/bknd station: Beaverlodge	40	6	46	Background/ Transbndry	10	60	AENV/Airshed	AENV/Airshed
Upgrade Boundary/bknd station: Hightower Ridge	42	6	48	Background/ Transbndry	10	60	AENV/Airshed	AENV/Airshed
Establish Boundary/bknd station: Southeast Alberta	42	6	48	Background/ Transbndry	160	60	AENV/Airshed	AENV/Airshed
Upgrade Boundary/bknd station: Esther	42	6	48	Background/ Transbndry	70	0	AENV/Airshed	AENV/Airshed
Addition of temporary wet deposition monitoring program	42	6	48	Ecosystem	128	160	AENV/Airshed	AENV/Airshed
Implement Passive Network (2 of 3)	42	12	54	Spatial	34	221	AENV/Airshed	AENV/Airshed
Implement Passive Network (3 of 3)	42	12	54	Spatial	34	221	AENV/Airshed	AENV/Airshed
Year 4 Total					**1071**	**2865**		
Year 5 Total					**0**	**4441**		
Overall Total					**4448**	**10337**		

* Operating costs include 10% of capital for instument replacement, 45% of operations for data QA/QC (20%) and contractor overhead (25%).
** The proportion attributed for each sector/stakeholder group will be calculated based on the funding formula.

Legend

Ozone Sub-program | Ecosystem | Admin | Spatial
Facility Specific Compliance | Population | Background Transboundary

Since the project team began their work five years ago, the Government of Alberta has changed its direction and way of doing business. In the last year, as the AMSP team was wrapping up and completing this report, the Government of Alberta released the Land-use Framework and the Alberta Land Stewardship Act that create seven regions with seven regional plans. The 2009 Ambient Air Monitoring Strategic Plan does not address this regional focus or suggest how monitoring will address and support regional outcomes, targets and indicators. Alberta Environment is leading a new Integrated Monitoring, Evaluation and Reporting Framework that will provide the strategy to implement this regional approach for monitoring and support regional outcomes and cumulative effects management. The Cumulative Effects Management concept being developed by the Government of Alberta will increase the emphasis on coordinating air, land, water and biodiversity monitoring.

The AMSP project team acknowledges the on going development of new strategic initiatives by the Government of Alberta to manage the environment on a regional, cumulative-effects basis; the Land-

use Framework and the Integrated Monitoring, Evaluation and Reporting Framework. These initiatives have been unfolding over the past year are still in the process of development as the AMSP team concludes their development of the ambient air monitoring plan for Alberta. The AMSP team recommends that the Air Monitoring Strategic Plan be considered and used as input into the development and implementation of regional plans or regional monitoring strategies. In light of the land-use regional plans and Integrated Monitoring, Evaluation and Reporting Framework still being in the early stages of development, there is uncertainty in how these programs will function and when or how they will be implemented. The AMSP team agrees that a provincial monitoring plan is still required to fulfill the monitoring objectives stated in this report, and that the 2009 Ambient Air Monitoring Strategic Plan is the best air monitoring plan for the province and residents of Alberta at this time. The team also recognizes that actual monitoring priorities, station locations and timelines may be restructured as the environment (physical, economic, social and political) changes over time. However, the fundamental principles presented in this report are still comprehensive, scientifically-based and peer reviewed.

Recommendation 28: Alignment of AMSP with Government of Alberta Direction
The AMSP project team recommends that:

- *AENV consider the 2009 AMSP report, associated recommendations and the ambient air monitoring network design in the development and implementation of new regional environmental plans and regional monitoring through the renewed Clean Air Strategy, Alberta Land-use Framework and Integrated Monitoring, Evaluation and Reporting Framework. The team recognizes that the technical portion of the AMSP report will need to be responsive to changes in the environment (physical, economic, social and political) and that actual monitor locations may change accordingly.*
- *AENV report back to the CASA Board annually on the implementation status of the 2009 AMSP.*

Glossary

AAQMN (Ambient Air Quality Monitoring Network)
The network of Ambient Air Quality monitoring sites and associated technologies and methodologies that currently exists in Alberta. This network comprises monitoring that occurs at the local, regional, provincial and national levels.

AAQMS (Ambient Air Quality Monitoring System)
The overall system (strategic plan, including the CASA Data Warehouse) put in place to ensure that the ambient air in Alberta is monitored appropriately, and that the data generated is shared with stakeholders and the public.

ACAA Alberta Capital Airshed Alliance

ADAG Acid Deposition Assessment Group

Acid Deposition Monitoring
Monitoring acid deposition means measuring the emissions that can acidify soil and/or water. The main acidifying emissions are SOx and NOx, although NH_3 is also in this category. Acidifying emissions can be deposited in wet or dry form. The proposed AMSP will address acid deposition monitoring under the Ecosystem-based sub-program.

Active Integrated (Intermittent) Monitoring
This method involves collecting an air sample using a filter, vessel or other sampling media by actively pulling air through the sampling media using a pump system. The pollutant concentration in the sample media is determined using laboratory analysis. Pollutants monitored using this method include particulate matter, volatile organic compounds, polycyclic aromatic hydrocarbons (PAHs), metals and some sulphur compounds. Active integrated monitoring is the same as intermittent monitoring (or sampling).

AENV Alberta Environment

AHW Alberta Health and Wellness

Air Quality Index
The Air Quality Index (AQI) is a measure of Alberta's outdoor air quality. Alberta Environment continuously measures the concentrations of five major air pollutants – carbon monoxide, fine particulate matter, nitrogen dioxide, ozone and sulphur dioxide – and converts those readings to an AQI number every hour.

Airshed Monitoring
Airsheds operate stations as part of their monitoring programs, although the stations may be owned by the airshed, the province or industry. Airshed monitoring stations are intended to:

- Address regional and local air quality issues,
- Measure air quality representative of the region,
- Fill a geographic or technical data gap, and
- Provide an indication of the cumulative effects of various point and non-point emissions sources.

Airshed monitoring does not include facility-specific compliance monitoring conducted by the airshed.

Airshed Zones
Regional partnership associations that include government, industry, environmental organizations and the general public. These partnerships are responsible for air quality monitoring and in some cases air quality management for a specific region of Alberta. There are presently nine CASA-endorsed airshed zones in Alberta.

AMD Air Monitoring Directive
The Air Monitoring Directive (AMD 1989) and its amendments (AMD 2006) represent Part I of the Monitoring and Reporting Directive series, which specifies environmental monitoring and reporting requirements and guidelines in Alberta.

See Appendix B for more information.

AMSP **Ambient Monitoring Strategic Plan**

AQI see **Air Quality Index**

Background Monitoring Sub-program

Background air quality can be monitored a) in a pristine environment not significantly affected by human activities, b) at a location remote from local or regional air pollution sources, and c) upwind of an area that contains significant emission sources (note: upwind monitoring sites become emission source integration sites during downwind periods and can therefore serve dual purposes).

Background (level)

The ever-present environmental conditions (baseline) against which changes can be measured.

Boundary Transport (Transboundary) Monitoring Sub-program

In Alberta, several existing monitoring stations near the borders measure the quality of air as it enters and leaves the province. Some of these stations also monitor background air quality representative of specific parts of the province.

Buffering Capacity

Ability of soil or water to neutralize the acidity of wet and dry deposition with minimal effect.

CAPMon **Canadian Air and Precipitation Monitoring Network**

CASA **Clean Air Strategic Alliance**

CO **Carbon monoxide**

Continuous Monitoring (Permanent and Temporary)

Continuous monitoring involves monitoring the quality of the ambient air on a continuous basis. This can provide the greatest resolution but may be costly due to capital and operating expenses. Data from continuous monitoring can be stored in different time blocks, such as one-hour averages or five-minute averages. Typically, particulate matter (PM) and gases such as ozone and SO_2 are continuously monitored. Continuous monitoring can be carried out on a permanent (long-term) or temporary basis.

Compliance Monitoring

Air monitoring near an industrial operation that is required as part of an Alberta *Environmental Protection and Enhancement Act (EPEA)* approval.

Also see Industry Compliance Monitoring Sub-program

CRAZ **Calgary Region Airshed Zone**

CWS **Canada Wide Standards**

Data Quality Objectives (DQOs)

DQOs are qualitative and quantitative statements that: clarify the study objective, define the most appropriate type of data to collect, determine the most appropriate conditions from which to collect the data, and specify tolerable limits on decision errors which will be used as the basis for establishing the quantity and quality of data needed to support the decision. DQOs are used to develop a scientific and resource-effective data collection design.

Ecosystem-based Monitoring Sub-program

Ecological Effects Monitoring is done to determine long-term impacts on the environment from air pollution. Ecological effects monitoring is usually done by establishing baseline conditions and comparing the changes after long-term exposure; it involves assessing all aspects of the environment (soil, vegetation, wildlife, etc.)

This program will monitor parameters that can be used to determine impacts or potential impacts of air pollution on land, water and vegetation. The proposed sub-program will focus on air parameters that can be used to estimate wet and dry deposition in Alberta.

EPEA Environmental Protection and Enhancement Act

Facility-Specific Compliance Monitoring Station

Facility-specific compliance monitoring is done to ensure compliance with Alberta's Ambient Air Quality Objectives, and is required as part of the facility approval under the Alberta Environmental Protection and Enhancement Act.

A facility-specific compliance monitoring station is typically located where maximum concentrations from a facility are predicted to occur, or where the greatest frequency of higher concentrations is expected, based on modeling results. Additional data may be collected from such monitors for the provincial monitoring network. This additional monitoring comprises the province's industry compliance sub-program (see below). Except for monitoring associated with the industry compliance subprogram, facility-specific compliance monitoring is currently paid for by the facility. All facility-specific compliance monitoring is operated by the facility or by an airshed for the facility.

FAP Fort Air Partnership

HNO_2 Nitrous Acid

HNO_3 Nitric Acid

Industry Compliance Monitoring Sub-program

Air monitoring near an industrial operation, that is required as part of an Alberta *Environmental Protection and Enhancement Act (EPEA)* approval. It typically includes fenceline monitoring for the facility.

Industries with approvals to operate in Alberta are required to control their emissions so that ambient levels of air pollution downwind of their industry are below the air quality objectives established by Alberta Environment. Where there is an industrial complex, monitoring stations may be located where the predicted maximum concentration is expected to occur from the combined emissions of all facilities. Further effort is needed by Alberta Environment, airsheds and industry to rationalize industry monitoring station locations, look for duplication and identify gaps. Where applicable, facility-specific compliance monitors that are also being used to collect data for provincial purposes may be integrated into the provincial monitoring network through this sub-program.

Intermittent Monitoring

See Active Integrated Monitoring

Kriging

Kriging is a geostatistical interpolation method that uses weighted average algorithms to produce contour plots, measure the magnitude of missing values or express trends that are suggested in the data. Kriging interpolates missing grid values based on the apparent spatial distribution of the available data.

LICA Lakeland Industry Community Association

PAMZ Parkland Airshed Management Zone

PAS Palliser Airshed Society

PASZA Peace Airshed Zone Association

MAML Mobile Air Monitoring Laboratory

A specially equipped vehicle can provide immediate air quality "snapshots" on location. The 8.2 metre-long unit carries air sampling equipment and a Global Positioning System, allowing it to sample at specified time or distance intervals, and analyze samples immediately.

NAAQO National Ambient Air Quality Objectives

National Air Pollution Surveillance (NAPS)

The National Air Pollution Surveillance (NAPS) is a joint program of the federal and provincial governments to monitor and assess the quality of the ambient air in Canadian urban centres.

NH_3 Ammonia

NO_2 Nitrogen dioxide

NO_X Oxides of Nitrogen

OSC Operations Steering Committee

O_3 Ozone

Passive Monitoring

Passive monitoring (sometimes referred to as diffusive monitoring) involves the exposure of a reactive surface to the air, which results in transfer of the pollutant by diffusion from the air to the monitor surface. The exposed surfaces are analysed to determine the pollutant concentration. Unlike static monitoring, the sampling rate for some passive monitors is adjusted based on wind speed, temperature, and humidity.

PM Particulate Matter

Particulate Matter and Ozone Monitoring Sub-program

A large part of central Alberta has been assigned to the management plan action level for ozone under the CASA PM and Ozone Management Framework. To better understand the chemistry of ozone production in Alberta, improved monitoring for ozone and its associated precursors and products is needed in the Edmonton and Calgary areas.

Additional monitoring for ozone, ozone precursors and ozone products may be needed in affected rural areas and small urban centres in central Alberta, such as Airdrie, Red Deer, Caroline, Tomahawk or Elk Island and in the Wood Buffalo region based on the emissions of ozone precursors from existing and planned oil sands development in the region. Additional monitoring upwind and downwind of Calgary and Edmonton for precursors and products of ozone should increase the reliability of assessments for keeping clean areas clean and continuous improvement.

Pattern Recognition (Provincial Spatial Scale) Monitoring Sub-program

To get a comprehensive picture of ambient air quality levels, a grid of less expensive passive samplers should be established province-wide. Data gathered by this network would be used to create a monthly and annual spatial map of air pollutant levels for the entire province. These data could also be used to resolve long-term trends in air quality. Pollutants monitored using passive techniques would include ozone, sulphur dioxide and nitrogen dioxide and on a site specific basis nitric oxide, nitric acid, ammonia, hydrogen sulphide and/or organic vapours.

Population-based Monitoring Sub-program

Population-based monitoring refers to ambient monitoring done in communities to determine if ambient air quality could pose a danger to human health. In general, the larger the population, the more monitoring stations the community will have.

The monitoring stations are intended to provide data that can support human health risk assessments but are not intended to measure human exposure to air pollution. One of the primary uses of data collected by human health monitoring stations is to inform the public of air quality episodes associated with large scale events such as smog or transport of forest fire smoke to urban locations

Provincial (Backbone) Monitoring Station

A permanent air quality station that is intended to collect air quality data that may be used to assess human health effects, ecological health effects, general regional air quality or trans-boundary transport and visibility. The difference between a provincial station and an airshed station is that a provincial station is intended to be permanent while an airshed station may be re-located or removed when the need for monitoring no longer exists.

Provincial Monitoring Station

Provincial monitoring stations are currently owned and operated by the province or airsheds. They are paid for by the province, airsheds and the federal government. These stations:

- Address provincial-scale issues
- Are components of the NAPS network to address national issues

QA/QC Quality Assurance/Quality Control

Rationalize (Industry Compliance Monitoring)

In some cases where an industry station has a history of compliance with regulations and there are no local issues with its associated facilities, monitoring can be "rationalized" (i.e., discontinued and replaced with support and participation in the local airshed zone).

Remote Sensing

The use of instruments that take measurements at a distance from the instrument. Remote sensing can be done in a passive or active form. See Appendix D for more details.

SO_2 Sulphur dioxide

Static Monitoring

Static monitoring is done to measure total accumulated loadings of pollutants using a cylinder or plate containing a filter coated with a reactive surface to absorb the pollutant of interest. The filter is then analysed in the laboratory to determine the pollutant loading. Static monitors have no moving parts and are usually placed in the field for one to three months. This technique is used to monitor substances such as hydrogen sulphide, fluorides, dustfall, and total sulphation. Alberta Environment is phasing out static techniques and moving towards passive monitoring.

Transboundary Transport

The long-range movement of emissions and pollutants across political or pre-determined spatial borders.

TSP Total suspended particulates

VOCs Volatile Organic Compounds

WBEA Wood Buffalo Environmental Association

WCAS West Central Airshed Society

Appendix A: Alberta's Air Quality Management System

The environmental assessment process provides a formalized mechanism for reviewing the potential impacts of proposed projects on the environment, including air quality. The process includes public participation and is intended to ensure that environmental management and economic development decisions are based on good environmental impact information.

Approvals issued under the *Alberta Environmental Protection and Enhancement Act* for designated activities are the principal regulatory instrument for applying the air quality management system to industry. Approvals have a number of components. They: specify source emission limits; indicate the required pollution control equipment and technologies; identify allowable emission sources and may specify operational procedures required to minimize emissions; outline stack design criteria based on plume dispersion modeling to ensure acceptable ambient levels are met; and specify environmental monitoring and reporting requirements, including emission inventory data.

Enforcement is an important deterrent component of the air quality management system. Alberta Environment's approach is to undertake enforcement firmly and fairly, in a timely and consistent manner. The department has a wide range of enforcement tools available, from warning letters and tickets to prosecutions, court orders and cancellation of approvals. The enforcement action depends on the circumstances surrounding the particular incident and the past history of the operation.

Inspections and abatement are undertaken to ensure that all air quality management requirements are being met. Inspections and abatement activities also help Alberta Environment develop and maintain expertise and experience as well as ensure a strong regulatory presence, thus demonstrating that Alberta Environment is committed to ensuring proper operation of emission control systems.

Source emissions monitoring is done to assess compliance with a source emission limit. Source emissions monitoring is done using in-stack continuous monitors (CEMS) and integrated stack tests. In addition, some of the fugitive emissions from facilities are assessed to estimate industrial emissions from non-point sources.

Source emission standards minimize air emissions and protect ambient air quality. Source emissions from industrial facilities and other activities are regulated through legislation or approvals. Source standards are based on best available pollution control technologies economically achievable.

Product standards are typically used to manage emissions from area or mobile sources. Area or mobile sources are generally numerous, widespread and the issue is they are currently not in our jurisdiction; they include vehicles, home furnaces and various consumer products. Normally emissions are controlled through the application of standards during the product manufacturing stage.

Emission inventories are used to determine provincial, regional and/or sector emissions and emission trends as well as to: perform sector-specific emission evaluations; provide benchmarks for reference to national and international protocols and trends; identify emission reduction priorities and/or opportunities; and assist in developing airshed management programs and in land use planning.

Emission dispersion and transformation models attempt to link emissions to resultant ambient air concentrations. Once an emission limit is proposed for a source, models predict the impact on air

quality. If the impact is unacceptable then modeling is used to determine the required stack height or further emission reduction to meet acceptable ambient air quality objectives. Modeling is also used to help site ambient air monitoring stations in the vicinity of industrial facilities, and can take into account the cumulative impact of all other sources emitting similar substances in the area.

Research activity is currently focused on four themes: i) assessing emission reduction technologies, ii) assessing ambient air quality, iii) improving monitoring methodologies, and iv) improving air quality management systems. Alberta Environment's overall research management strategy includes partnering with other departments, other governments, universities and industry, which helps address multiple but linked information interests and needs, avoids duplication, and maximizes the benefit received from research dollars.

Ambient air quality objectives provide benchmarks for assessing air quality and air quality changes. These objectives are intended to provide protection of the environment and human health to an extent technically and economically feasible, as well as socially and politically acceptable. They are used to a) report on the state of Alberta's atmospheric environment; b) to inform Albertans on air quality through an air quality index; c) to establish approval conditions for regulated industrial facilities; d) to evaluate proposals for constructing facilities; e) to guide special ambient air quality surveys; and f) to assess compliance near major industrial air emission sources.

Ambient air monitoring is used to assess air quality. Some industries, through conditions in their approvals, are required to conduct ambient air quality monitoring for specific substances. The number of monitoring stations, frequency and duration of monitoring or sampling, measurement or sampling techniques, and analytical methods, if necessary, depend on the substance to be monitored and its emission rate. Air monitoring in Alberta is described in more detail in the Implementation Plan (section 9).

Environmental reporting requirements for industry are specified through regulation, the Air Monitoring Directive, approvals and Codes of Practice. They vary depending on the substance emitted and on the size and nature of the facility. These reports generally require summaries of ambient and source monitoring data (as applicable), information on the quality assurance and quality control measures performed to ensure that the data are accurate and reliable, and outlines of any problems that may have arisen and corrective actions taken. Since April 2007, CEMS data are also reported electronically on a monthly basis. All reports are submitted to Alberta Environment and are available to the public on request.

Environmental Education is a process or approach for engaging Albertans (citizens, communities and industry) by raising awareness, increasing understanding, shifting attitudes, changing behaviour and growing support networks.

Alberta's industrial air quality management system is illustrated in the figure below. The 2009 Ambient Monitoring Strategic Plan applies to the ambient air monitoring component of this overall air quality management system, and a successful air quality monitoring system will also include an urban planning component.

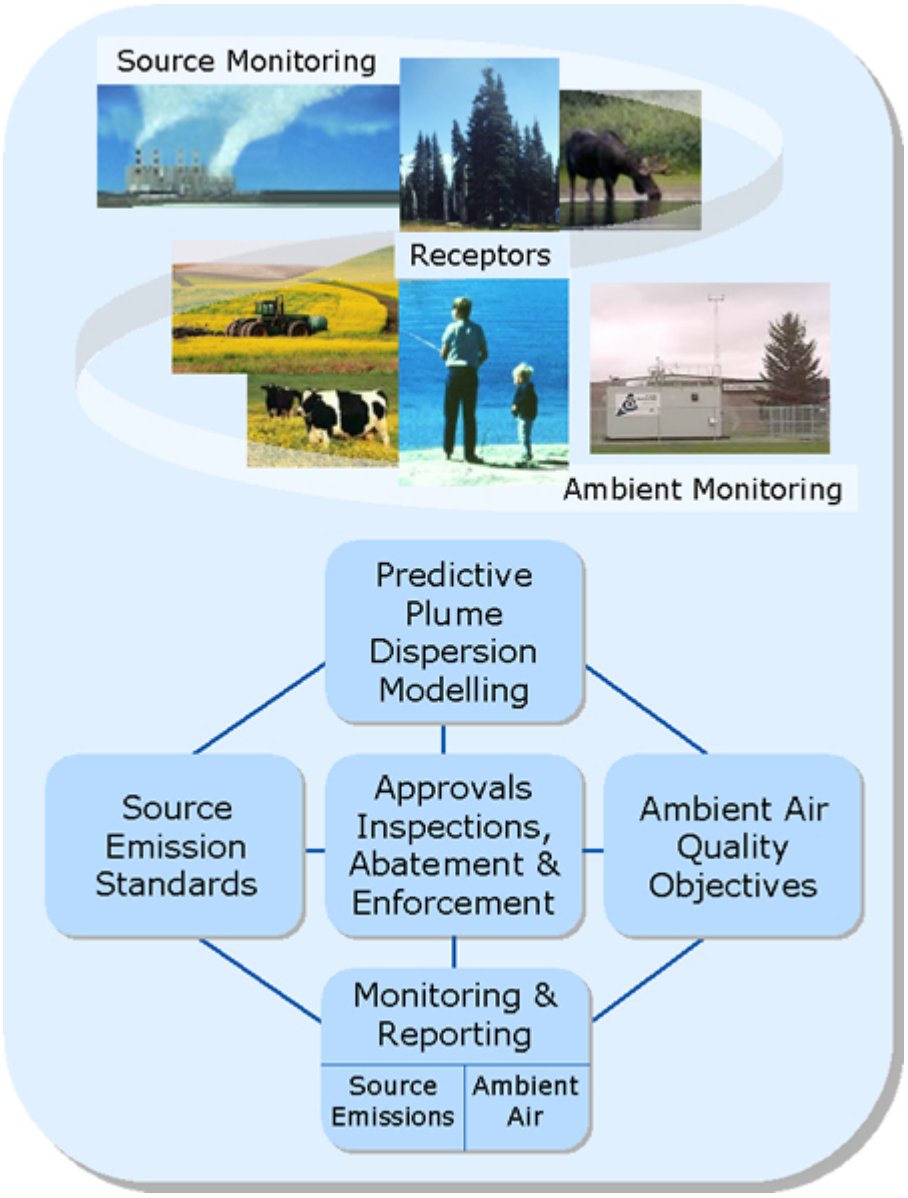


Figure A1. Alberta's Industrial Air Quality Management System

Appendix B: Ambient Air Monitoring in Alberta

In Alberta, ambient air quality is monitored by industry, airshed zones, Alberta Environment and Environment Canada. Monitoring activities are structured more or less into networks designed to address provincial, compliance and regional issues.

The table below shows the number and type of air monitoring stations operated by industry, airshed zones, and government. Alberta's Air Monitoring Directive provides overall guidance and specifies air monitoring and reporting requirements. Figures B1, B2 and B3 show the locations of continuous, passive and deposition monitoring, respectively, across the province.

Table B1. Number and Type of Permanent Ambient Air Monitoring Stations in Alberta*

Operator	Continuous	Active Integrated (Intermittent)	Passive	Static	Wet Deposition	Dry Deposition
Airsheds	48	2	217	0	3	2
Industry	57	27	530	393	0	0
Alberta Environment	5	2	10**	0	9	1
Environment Canada	1	1	0	0	0	0
Total	**111**	**32**	**757**	**393**	**12**	**3**

* As of December, 2008. Includes monitoring stations that are operated twelve months a year.
** Part of a temporaryhttp://environment.alberta.ca/933.html monitoring program that will be discontinued March, 2009.

An important product of the air monitoring system is Alberta's Air Quality Index, described in Box 3 below.

BOX 3. Alberta's Air Quality Index

The Air Quality Index (AQI) is a way of describing Alberta's outdoor air quality. Alberta Environment continuously measures the concentrations of five major air pollutants – carbon monoxide, fine particulate matter ($PM_{2.5}$), nitrogen dioxide, ozone and sulphur dioxide – and converts those readings to an AQI number every hour. The highest AQI value for any of the substances becomes the AQI value for that hour for that station. The higher the AQI number, the greater the level of pollution. A rating of 0-25 indicates Good air quality, 26-50 is Fair, 51-100 is Poor, and more than 100 is Very Poor air quality. These categories relate directly to guidelines under Alberta's *Environmental Protection and Enhancement Act* (EPEA). They reflect the maximum desirable, acceptable and tolerable levels specified by the National Ambient Air Quality Objectives (NAAQO). An AQI rating of 25 for a specific air pollutant corresponds to the federal maximum desirable level; a rating of 50 corresponds to the federal maximum acceptable level; and a rating of 100 corresponds to the federal maximum tolerable level. The index is calculated at a number of air monitoring stations throughout the province. The AQI is available to the public in real time through Alberta Environment's website (http://environment.alberta.ca/933.html) as well as websites operated by some of the airshed zones. The AQI can also be accessed through an automated phone system at 1-877-247-7333.

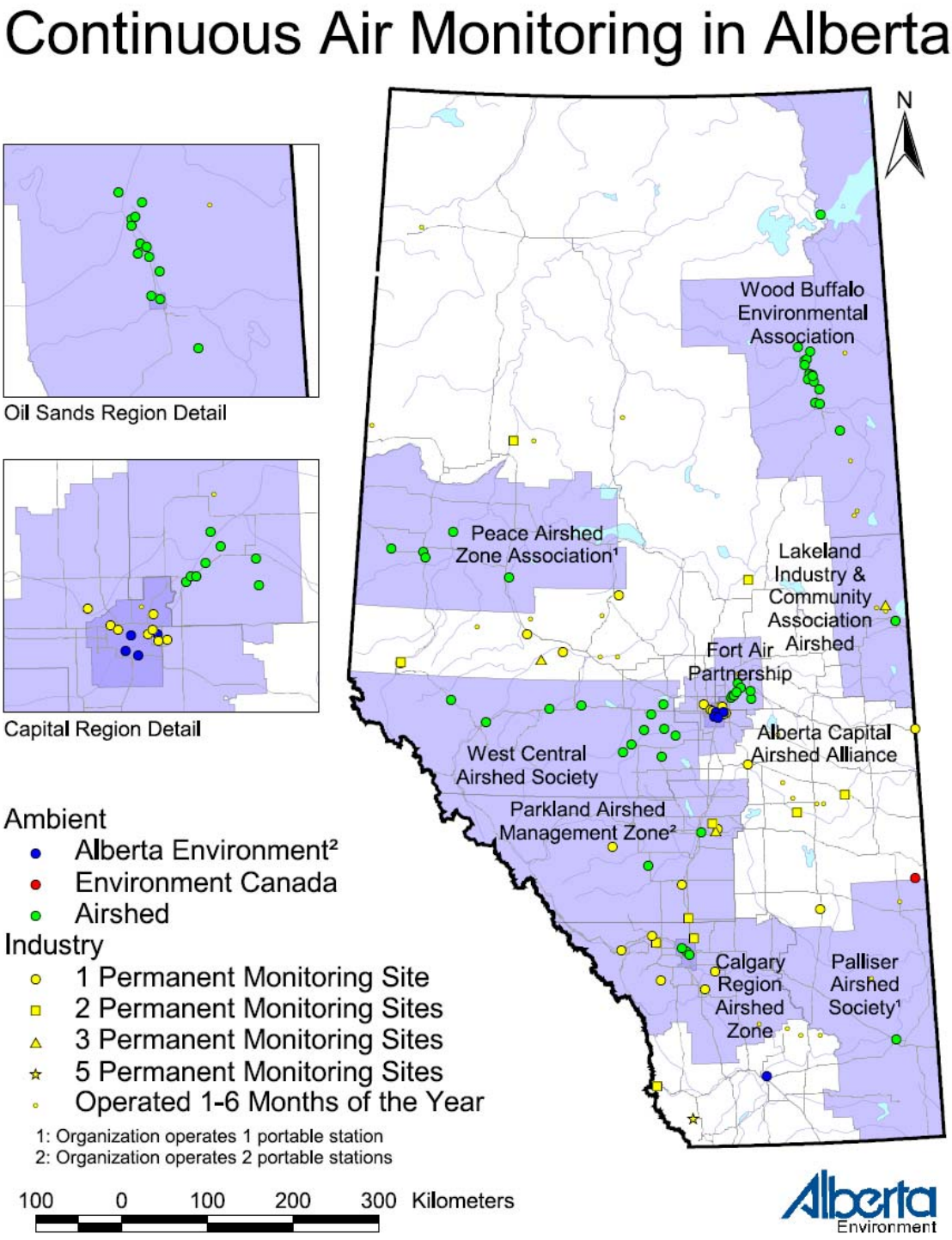


Figure B1. Continuous Air Monitoring in Alberta

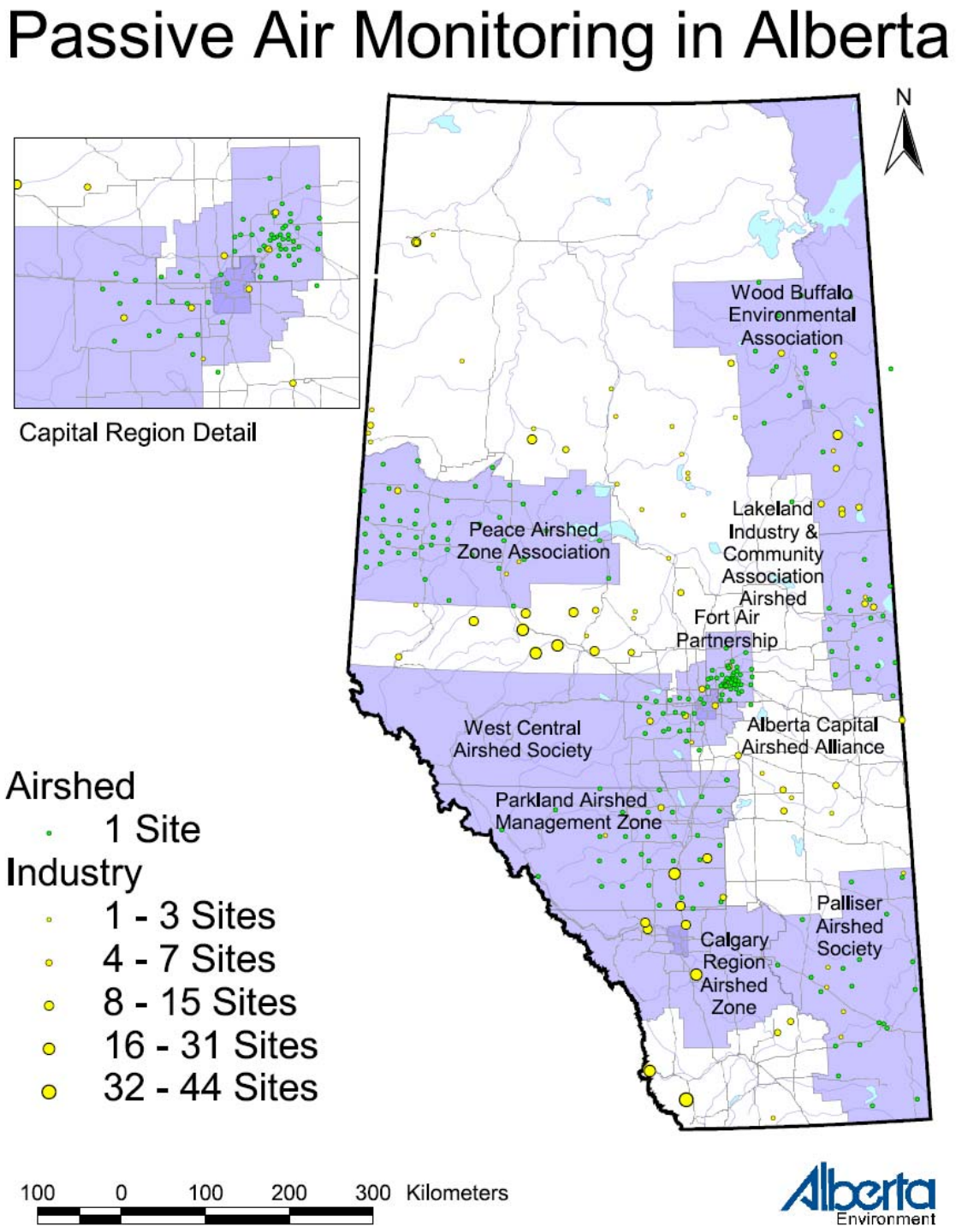


Figure B2. Passive Air Monitoring Network in Alberta

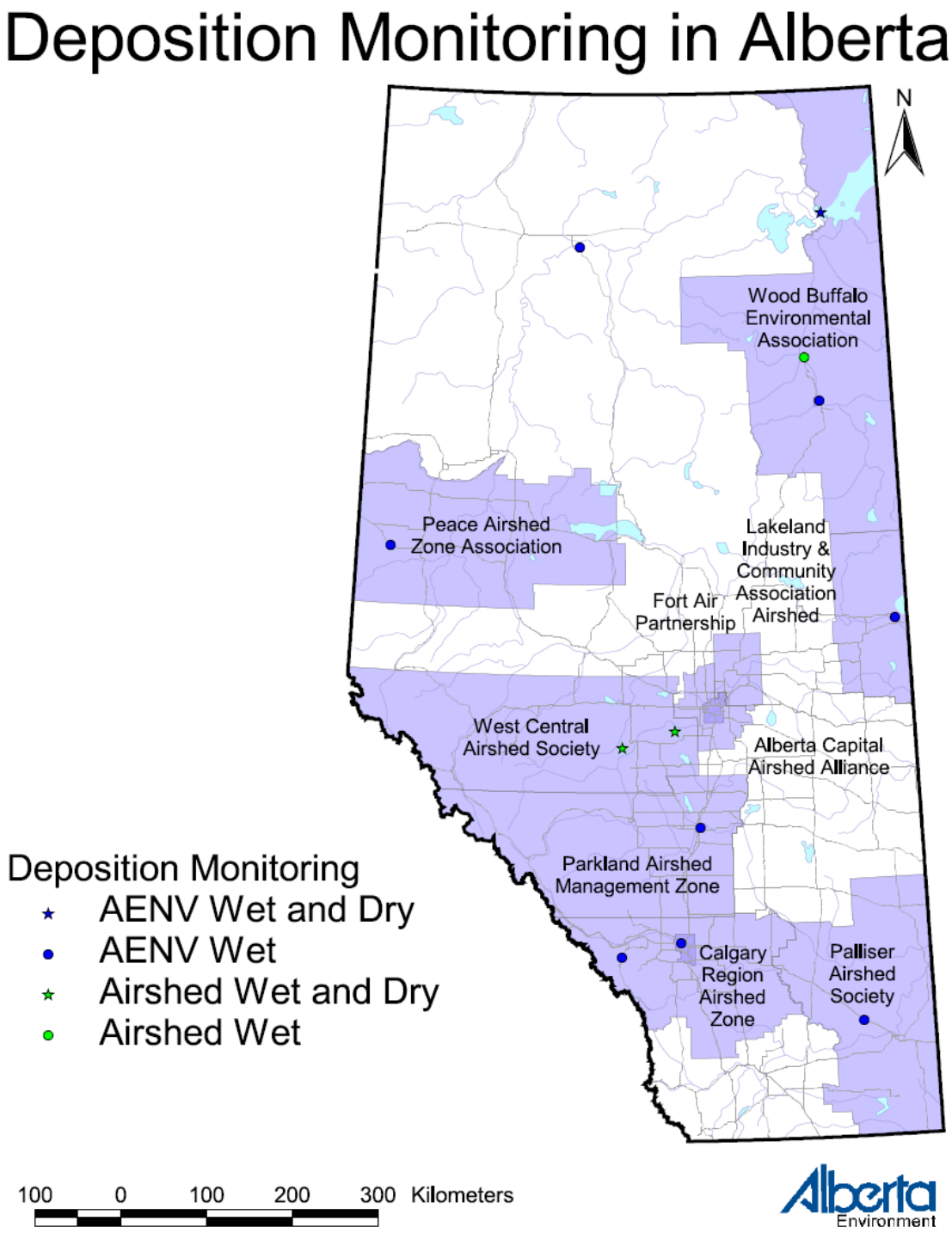


Figure B3. Deposition Monitoring in Alberta

B.1 The Air Monitoring Directive

Air monitoring data collected in Alberta and submitted to Alberta Environment must be consistent, of high quality, and defensible. The Air Monitoring Directive (AMD) outlines the methods acceptable to Alberta Environment for air monitoring and reporting, as required by an Alberta *Environmental Protection and Enhancement Act* (EPEA) approval, Code of Practice, Registration, or any other air monitoring and reporting activities for which data are submitted to Alberta Environment, or any other organization acting on its behalf. The purpose of the AMD is to:

- Outline the minimum requirements for the collection and reporting of environmental monitoring data to Alberta Environment;
- Establish a set of consistent requirements for Quality Assurance practices that ensure, and allow for verification of, the quality of the environmental data collected in Alberta, and ensure data comparability among monitoring sites; and
- Provide guidance and criteria to operators of monitoring equipment, auditors, and other Alberta Environment staff on minimum Quality Assurance requirements and air monitoring and reporting requirements.

B.2 Existing Monitoring by Alberta Environment

Continuous Monitoring

Alberta Environment operates a number of continuous air monitoring stations in larger population centres, as well as a mobile air monitoring laboratory for emergency response and field surveys. Alberta Environment is responsible for ensuring that all monitoring done for compliance purposes by industry and airsheds meets requirements set forth in the Air Monitoring Directive through regular review of data and by auditing monitoring stations and support equipment used for these stations. Using data from their stations and those operated by airsheds, Alberta Environment also reports on the state of the environment and provides reporting in support of provincial and national management frameworks. Alberta Environment encourages and facilitates the development of airsheds in the province by providing staff and resources to work with local organizations and individuals in areas interested in establishing an airshed.

Alberta Environment operates five permanent air quality monitoring stations located in Edmonton and Lethbridge, and owns an additional seven continuous stations that are operated by airshed zones. Air parameters monitored at these stations are shown in Table B2. The overall objective of Alberta Environment's monitoring program is to *determine the status, changes and trends in selected measures of air quality in the province*. Specific objectives of the program are to:

- Provide data for the assessment of existing air quality relative to air quality guidelines;
- Inform the public on the status of air quality;
- Monitor air quality representative of urban environments;
- Report long-term trends in air quality; and
- Undertake special monitoring surveys.

Table B2. Air Parameters Monitored at Provincial Monitoring Stations in 2006*

Provincial Station	Station Type	Ozone	Oxides of Nitrogen	Sulphur Dioxide	Hydrogen Sulphide	Ammonia	Hydrocarbons	Carbon Monoxide	Total Reduced Sulphur	Continuous Particulates	Wet Deposition	Dry Deposition	Intermittent Particulates	Volatile Organic Compounds	Semi Volatile Organic Compounds	Passive (SO2, NO2, O3 or VOCs)	Wind Direction and Speed	Temperature and/or Humidity	Intensive Meteorology	Visibility (nephelometer)	Data Logger	Data System	Shelter
Edmonton East	HE(>20K)	X	X	X	X		X	X		X			X	X	X	X	X	X			X	X	X
Edmonton Northwest	HE(>20K)	X	X				X	X		X			X	X	X	X	X	O			X		X
Edmonton Central	HE(>20K)	X	X				X	X		O			X	X	X	X					X		X
Calgary East	HE(>20K)	X	X	X	X		X	X		X			X	X	X	X	X	X			X	X	X
Calgary Northwest	HE(>20K)	X	X				X	X		X			X	X	X	X	X	O			X		X
Calgary Central	HE(>20K)	X	X				X	X		O			X	X	X	X					X		X
Calgary No 4	HE(>20K)	X	X				X	X					X	X	X	X	X				X		X
St. Albert	HE(>20K)	X	X	X			X	X					X	X	X	X	X				X		X
Sherwood Park	HE(>20K)	X	X	X	X		X	X					X	X	X	X	X				X	X	X
Fort McMurray	HE(>20K)	X	X	X			X	X	X	X			X	X	X	X	X				X		X
Grande Prairie	HE(>20K)	X	X	X			X	X	X	O			X	X	X	X	X	O			X		X
Medicine Hat	HE(>20K)	X	X				X	X		O			X	X	X	X	X				X		X
Lethbridge	HE(>20K)	X	X			O	X	X		O			X	X	X	X	X				X		X
Red Deer	HE(>20K)	X	X	X	X		X	X					X	X	X	X	X				X		X
Fort Saskatchewan	HE(10-20K)	X	X	X	X	X	X	X		X			X	X	X	X	X	X			X		X
Whitecourt Area	HE(gaps)	X	X	X	X		X	X					X	X	X	X	X	X			X		X
Sundre/Caroline Area	HE(gaps)	X	X	X	X		X	X					X	X	X	X	X	X			X		X
Waterton Area	HE(gaps)	X	X	X	X		X	X					X	X	X	X	X	X			X		X
Airdrie	HE(10-20K)												X			X							
Leduc	HE(10-20K)												X			X							
Spruce Grove	HE(10-20K)												X			X							
Wetaskiwin	HE(10-20K)												X			X							
Camrose	HE(10-20K)												X			X							
Lloydminster	HE(10-20K)												X			X							
Bow Valley Corridor	HE(10-20K)												X			X							
10 Representatives	HE (<5K)															X							
Hinton (Hightower Ridge)	EE,TTV	X	X	X			X			O	X	X	X	X	X	X	X		X		X		X
Beaverlodge	EE,TTV	X	X	O			X				X	X	X	X		X	X		X		X		X
Esther	EE,TTV	X	X				X				X	X	X	X	X	X	X		X	X	X		X
Pincher Creek/Waterton Area	TTV	X	X	X	X		X				X	X	X	X	X	X	X		X	X	X		X
WCAS	Airshed	X	X	X	X		X			O	X	X	X	X		X	X		X		X	X	X
PAMZ	Airshed	X	X	X	X		X		X	O	X	X	X	X		X	X		X		X	X	X
WBEA	Airshed	X	X	X			X		X	O	X	X	X	X	O	X	X		X		X	X	X
Mobile Monitoring Unit #1	HE	X	X	X	X	O	X	X	O	X							X	O			X		X
Mobile Monitoring Unit #2	HE	X	X	X	X		X	X									X				X		X

HE(>20K) - health effects station (population > 20,000). HE(10-20K) - health effects station (population from 10,000 to 20,000).
HE(gaps) - health effects station (to fill existing gaps). HE(<5K) - health effects station (population < 5,000).
TTV - Transboundary transport and visibility station. EE - Ecological effects station.
X - indicates a condition or parameter that is expected to be measured once the provincial network is in place.
O - indicates a condition or parameter that is measured that was not part of the original strategic plan.
Shading indicates that the system is in place as of April 2006.

* The text in this table is the system that was proposed in the 1995 plan. Shaded areas indicate those components that had been put in place as of April 2006. In other words, the cells that are not shaded indicate the elements of the 1995 plan that have not been implemented. Since the 1995 plan, the name “health effects” station has been changed to “population based” station.

Mobile Air Monitoring Laboratory

The Mobile Air Monitoring Laboratory (MAML) is a specially modified vehicle designed to measure air quality. The MAML allows Alberta Environment to monitor air quality anywhere in the province. The onboard instruments can take air samples at specified time or distance intervals, and analyze them quickly and reliably. The MAML is winterized for year-round use. The MAML spends at least 100 days a year on the road, allowing Alberta Environment to provide the public with accurate air quality "snapshots." The MAML is used to:

- Obtain province-wide air quality data;
- Explore potential sites for Alberta's permanent monitoring network;
- Identify potential problem areas; and
- Respond to community air quality concerns.

The MAML is also used in research projects to provide a better understanding of air quality processes. Pollutants measured by the MAML include ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide.

Emergency Air Monitoring Vehicles

In 2003, the City of Calgary and Alberta Environment built a mobile emergency air monitoring vehicle designed to monitor the air quality impacts from emergencies in central and southern Alberta. In 2005, a similar vehicle was built in Edmonton to cover central and northern Alberta. These vehicles allow Calgary and Edmonton firefighters to monitor air quality during emergencies in all areas of Alberta.

B.3 Compliance Monitoring by Industry

Industries with ambient monitoring requirements conduct fenceline monitoring in the immediate vicinity of their facilities' operations to ensure that their local impacts are within acceptable objectives. They are responsible for submitting that information regularly for review by Alberta Environment to ensure their compliance.

In some instances, groups of similar industries or industries within the same geographic area have banded together to form monitoring networks that monitor individual facilities as well as their cumulative effect. Industries have also turned over the operation of some monitoring stations to airsheds (see section B.4 below). In some cases where an industry station has a history of compliance with regulations and there are no local issues with its associated facilities, monitoring can be "rationalized" (i.e., discontinued and replaced with support and participation in the local airshed zone).

Compliance monitoring by industry is an integral part of Alberta Environment's regulatory program to determine the environmental performance of industrial operations and assess their impacts on the environment. Most industrial approval holders under the *Environmental Protection and Enhancement Act* are required to monitor source emissions as well as ambient air. Specific monitoring requirements are determined on a case-by-case basis. The collected data submitted to Alberta Environment is compared to established limits, standards or guidelines to assess a facility's performance. The same data is crucial in assessing the impact of an environmental release.

Industry is required to monitor air quality on a permanent and temporary basis. Permanent stations are operated year round while temporary stations are operated from two to six months per year. In Alberta, industry operates 57 permanent continuous ambient monitoring stations and 28 temporary continuous stations, as of December 2008. Industries are also required to monitor air parameters on an intermittent (active integrated), passive and static basis. Data from these monitoring stations is provided to Alberta Environment in hard copy reports on a monthly and annual basis. Within their boundaries, airshed zones carry out most of the compliance monitoring that is required of industry. Air monitoring by industry is summarized in Table B3.

Table B3. Ambient Air Monitoring Conducted by Industry

Continuous Monitoring	**Intermittent**	**Passive Monitoring**
Parameter	*Parameter*	*Parameter*
Ammonia	Acetaldehyde	Hydrogen sulphide
Chlorine	Acetic acid	Nitrogen dioxide
Ethylene	Acetone	Ozone
Hydrogen fluoride	Benzene	Sulphur dioxide
Hydrogen sulphide	Ethylbenzene	
Non-methane hydrocarbons	Fluorides	**Static Monitoring**
Oxides of Nitrogen	Heavy metals	*Parameter*
Ozone	Ozone	Ammonia
PM_{10}	Phenol	Dustfall
$PM_{2.5}$	PM_{10}	Fluoride
Sulphur dioxide	$PM_{2.5}$	Hydrogen fluoride
Total hydrocarbons	Styrene	Hydrogen sulphide
Total reduced sulphur	Toluene	Nitrogen dioxide
Vinyl chloride	Total hydrocarbons	Non-methane hydrocarbons
VOC	Total suspended particulates	Particulate fluoride
Wind	Vinyl chloride	Sodium chloride
	Volatile organic compounds	Total hydrocarbons
		Total sulphation

B.4 Monitoring by Airshed Zones

Many of Alberta's air quality issues are local or regional, both in their cause and the solutions required. For example, some contaminants such as hydrogen fluoride are not transported very far. In these cases, province-wide approaches may not be appropriate or efficient. Airshed zones provide an opportunity for local stakeholders to design local solutions to their concerns. The primary responsibility of a multi-stakeholder airshed zone is to oversee ambient air quality monitoring, although some zones have also developed management plans to deal with air quality concerns in the region. The issues addressed by airshed zones are defined broadly, reflecting the vision and principles of the Clean Air Strategic Alliance.

Each airshed zone defines its own areas of responsibility. Zones typically focus on assessing regional air quality based on comparison to objectives or other airshed-defined criteria and longer-term trends. Some of this data will provide an indication of the cumulative effects of various point and non-point sources. Zones may also develop air monitoring programs to better understand and address local issues or to fill technical data gaps.

Some airsheds operate industry compliance monitoring stations where the data can be used to better understand regional air quality and provide more public credibility. Airsheds have also taken over operation of a number of stations that were operated by Alberta Environment.

The success of a zone depends largely on the co-operation and dedication of all stakeholders including governments, industries, environmental organizations and the public. Stakeholders drive the establishment of an airshed in their region. CASA provides the framework within which airshed zones function but each operates independently as a non-profit society or association.

Regional airshed zones have a number of benefits. Among other things, zones:

- Improve existing monitoring in the region;
- Make local and regional monitoring systems more efficient;
- Collect data to address regional air quality concerns;
- Obtain information about regional air quality;
- Improve access to air quality data and information; and
- Identify regional air quality issues and adjust monitoring objectives accordingly.

Zones also offer flexibility in the way air quality issues are addressed, and this approach tends to make the monitoring and management of air quality more efficient and more cost-effective. Airshed zones have become an important mechanism for addressing air quality issues in many regions of the province.

Alberta presently has nine airshed zones:

- Alberta Capital Airshed Alliance
- Calgary Region Airshed Zone
- Fort Air Partnership
- Lakeland Industry and Community Association
- Palliser Airshed Society
- Parkland Airshed Management Zone
- Peace Airshed Zone Association
- West Central Airshed Society
- Wood Buffalo Environmental Association

A major advantage of an airshed zone is that, in most cases, the local community has immediate access to the air quality data. Airshed zones generally share their data freely and openly in real time with the public and other users through their own websites or the CASA Data Warehouse. Airshed zones are beginning to focus more on informing and educating the public about air quality by interpreting their data to create more useful information. This leads to improved public confidence and understanding in air quality data and in the monitoring system.

As of the end of 2008, seven airshed zones were fully operational and have been endorsed by CASA.[14] They operate 48 continuous monitoring stations and 217 passive monitors throughout the province. Air monitoring conducted by zones is summarized in Table B4.

[14] The Calgary Region Airshed Zone and the Alberta Capital Airshed Alliance have been incorporated as not-for-profit societies and are now developing their monitoring plans. They will likely request CASA endorsement in 2009.

Table B4. Continuous and Passive Monitoring Stations* Operated by Airshed Zones

Airshed	Continuous Stations	Passive Stations
West Central Airshed Society	13	21
Wood Buffalo Environmental Association	15	20
Fort Air Partnership	8	56
Parkland Airshed Management Zone**	4	32
Peace Airshed Zone Association**	6	48
Palliser Airshed Society**	2	20
Lakeland Industry and Community Association	1	20
Calgary Region Airshed Zone	3	0
Total Airshed Monitoring Stations	**52**	**217**

* As of December, 2008
** Includes portable continuous monitors (1 each for PAS and PASZA, 2 for PAMZ)

B.5 Other Monitoring

B.5.1 Monitoring by Environment Canada

Environment Canada operates one air quality station near Esther, Alberta.

B.5.2 The National Air Pollution Surveillance Program

The National Air Pollution Surveillance Program (NAPS) is a joint program of the federal and provincial governments to monitor and assess the quality of the ambient air in Canadian urban centres. Alberta has 13 NAPS stations; eight are run by Alberta Environment and five by airshed zones. Environment Canada supplies much of the air monitoring equipment for the NAPS-designated parameters for these stations.

Air quality data for sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and total suspended particulates (TSP) are measured at over 152 stations in 55 cities in the ten provinces and two territories, including those stations in Alberta. The NAPS database has been expanded to include ozone observations from Canadian and U.S. rural monitoring locations in order to allow analysis of regional ozone episodes. Data from the National Air Pollution Surveillance (NAPS) network monitoring stations are available at the Environment Canada Environmental Technology Centre website at www.etcentre.org/NAPS/index_e.html. A password is needed to access data from the NAPS website.

B.5.3 Acid Deposition Monitoring

Acidic substances contained in the atmosphere are eventually deposited on the earth's surface in the form of precipitation (wet deposition, or acid precipitation) or particulate matter and gases (dry deposition). The effects of acid deposition depend on the relative amounts of acidic and basic pollutants being deposited and the *buffering capacity* of the receptor (ability of soil or water to neutralize the acidity). Alberta developed, and CASA endorsed, an acid deposition management framework in 1999 to ensure that acid deposition is effectively managed in the province. The

framework establishes three levels of management that are contingent on the actual levels of acid deposition, relative to critical and target loads.

Alberta Environment operates nine precipitation quality monitoring stations (wet deposition), located at Beaverlodge, Calgary, Cold Lake, Fort Chipewyan, Fort McMurray, Fort Vermilion, Kananaskis, Red Deer, and Suffield.

The West Central Airshed Society monitors wet and dry deposition at its Genesee and Violet Grove air monitoring stations and the Wood Buffalo Environmental Association monitors for parameters necessary to calculate dry deposition at its Fort McKay air monitoring station. Environment Canada monitors wet and dry deposition at Bratt's Lake in southwestern Saskatchewan. Data collected at the Bratt's Lake station can be used as an indicator of deposition for southeastern Alberta. Alberta Environment monitored the parameters necessary to calculate dry deposition at Royal Park northwest of Vegreville from 1992 to 1997, at Beaverlodge from 1997 to 2003, and presently at Fort Chipewyan.

Appendix C: Other System Management Options Considered by the AMSP Project Team

The Ambient Monitoring Strategic Plan Project Team considered other options for managing the ambient air quality monitoring system as described in this strategic plan and its companion documents. Members agreed to recommend the so-called hybrid option, which establishes a single responsible agency. Two other options were also considered and rejected.

Status Quo Option:
The Status Quo option describes the current CASA Operations Steering Committee (OSC) process where Alberta Environment acts as the Systems Manager and manager of the CASA Data Warehouse, with the process managed through a CASA team. While this model is well established, the AMSP Team felt that the OSC should evaluate its terms of reference and consider how to improve its effectiveness and enhance its functionality to meet the demands of the 2009 *AAQMS*. Key performance measures for the OSC and AAQMS also needed to be defined.

Multi-Stakeholder Option:
The Multi-Stakeholder Option would be based on the CASA collaborative, consensus model where those with an interest in the outcome of the *AAQMN* would be represented on the committee (including government, industry, non-governmental organizations and airshed zones). As with the status quo option, a CASA team would manage the process. With this option, a statement of opportunity would need to be prepared by government for a CASA implementation team. This would allow for a re-invention of the current management process. This model would have limitations contingent on how the organization is funded. This model would also require more active involvement from the multi-stakeholder membership.

	Pros	**Cons**
1. Status Quo Option:	The system, people and process is already well established.	While the process has been in place for a number of years, the effectiveness of this option needs to be evaluated.
2. Multi-Stakeholder Option	A statement of opportunity may allow for a re-imagining of the roles and responsibilities of this process**.**	This option is very similar to option 1.
3. Hybrid (Single Agency) Option	Multi-stakeholder consensus based process where there is clear responsibility and accountability.	A decision making process would have to be established that recognizes the authority of the various jurisdictions at the table (for instance, government vs. airshed zones).

Appendix D: Ambient Air Quality Monitoring Techniques

A number of monitoring techniques can be used to provide timely and accurate ambient air quality data. Such data is generally collected via continuous and non-continuous techniques. Continuous measurements result in data generated by real-time air analysis using automated instruments. Non-continuous measurements are collected using a method that integrates measurements over a pre-defined time period, usually varying from one day to one month. Non-continuous, integrated samples are collected using either active (using a pump system) or passive (sampled by diffusion) methods. Mobile and portable monitoring units can also be used to collect data using various continuous and non-continuous monitoring methods. A number of pollutants can be measured using more than one technique, and the final choice depends on a variety of factors, including cost.

D.1 Existing Monitoring Technologies

1. Continuous Monitoring equipment provides nearly instantaneous measurements of ambient air pollutant concentrations. Continuous monitoring involves drawing air through a commercial analyzer calibrated to produce an output that is proportional to the ambient pollutant concentration. This provides the greatest resolution, but is costly, due largely to the capital and operating costs involved. Data from continuous monitoring is stored in one-hour average time blocks.

Air pollutants monitored on a continuous basis include carbon monoxide (CO), oxides of nitrogen (NO_2, NO and NO_X), ozone (O_3), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), total reduced sulphur (TRS), particulate matter ($PM_{2.5}$ and PM_{10}), hydrocarbons (THC, NMHC and CH_4) and ammonia (NH_3). This technology can now monitor VOCs continuously, such as BTEX (benzene, toluene, ethylbenzene, xylene) and ethylene. Meteorological parameters such as temperature, wind speed and direction, and relative humidity are also monitored at continuous monitoring stations.

2. Active Integrated Monitoring is carried out with samplers that run for a predetermined length of time, and are reset to take samples in a regular schedule or interval. The sampled air is actively pulled through the sampler by a pump. It is then captured on a sample media or in a vessel and sent to an analytical lab.

This method is used to sample several compounds and chemicals including particulate matter, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), metals and some sulphur compounds. A typical and widely used cycle is one 24-hour sample every six days in accordance with the National Air Pollution Surveillance (NAPS) network schedule. Integrated monitoring is often used to determine the concentration of compounds or a group of compounds that cannot be monitored and identified by conventional continuous analyzers.

Integrated samplers, or networks of samplers, can be deployed at a lower cost than continuous monitoring. Often, integrated monitors require little support equipment and shelters and can sometimes be operated using alternative power systems such as battery power and solar power.

3. Passive (Diffusive) Monitoring involves the exposure of a reactive surface to the air, which results in transfer of the pollutant by diffusion from the air to the sampler surface. The sampler surface consists of a solid chemical compound or a filter that is impregnated with a reactive solution.

Samplers are typically exposed for periods of one month, and analysis is then performed in a laboratory.

Diffusive or passive monitoring methods provide a cost-effective solution for monitoring air quality at locations where continuous monitoring is not practical. Diffusive monitoring devices can monitor air pollutants, such as SO_2, H_2S, O_3, VOCs, and nitrogen dioxide (NO_2), without the need for electricity, data loggers or pumps. Diffusive monitoring devices are lightweight, portable and relatively simple to operate. No active movement of air through the sampler is necessary.

A major advantage of using a diffusive monitoring system is a network of multiple samplers can be used over a large area to determine the spatial variation of pollutant levels. Diffusive samplers are also useful for looking at long-term trends of air pollutants at specific locations. However, since monitoring is conducted over a period of about one month, events that last for a short time period, such as one hour, will be averaged out.

D.2 New Technologies

While many new technologies to monitor ambient air quality parameters are being developed, few are now ready to be used in a cost effective and reliable manner. Several technologies that are both in use and undergoing further development are worth watching, and are noted below. The world of ambient monitoring is not static. While we currently have a well-defined network of ambient monitoring stations, as new technologies and monitoring techniques are developed, the Integrated Ambient Air Quality Monitoring Network will consider and adopt those technologies that make sense and fit within the system.

Remote Sensing

Remote sensing refers to the use of instruments that take measurements at a distance from the instrument. Remote sensing can be operated from the ground, on aircraft or on satellites. There are two broad categories of remote sensing:

1. Passive remote sensing relies on existing energy sources such as light or other radiation sources. This includes sunlight, terrestrial infrared emissions or reflected radiation from the sun. Passive sensors receive naturally transmitted electromagnetic waves from the viewed object. The types of emitted energy may be visible light (light that our eyes detect), or other invisible energy (such as shortwave and thermal infrared). The human eye is an example of a passive remote sensing device that detects visible light. Remote sensing infers what is in the atmosphere by the colors (wavelength) of radiation that it can detect or the absence of others.
2. Active remote sensing relies on the generation of a pulse of energy that is released and the reflected or returned signal that is detected. This pulse of energy can be sound or electromagnetic energy (radio waves or light). For instance, radar is an active form of remote sensing. The Canadian satellite RADARSAT is an example of a satellite-borne platform that sends a pulse of microwave energy downward and maps the surface of the earth from the reflected signal.

An example of the application of a mix of passive and active remote sensing is the series of five satellites known as the “A-Train” that are in orbit so that they pass over a given point within 15 minutes of each other. By examining a variety of wavelengths with passive and active sensing they can infer vertical structure and total amounts of atmospheric moisture and a variety of pollutants.

Modeling Tools
A computer model is a data driven system that uses a set of defined rules to simulate real world situations. The goal of computer models is to simplify complex natural processes to better understand, manipulate and predict outcomes. Computer models can be used in many applications from predicting the weather to understanding the behavior of a substance as it moves down wind from an industrial stack.

Open-Path Monitoring
Open-path monitors provide continuous and nearly instantaneous data on concentrations of air pollutants. They are commonly used for monitoring fugitive emissions, or leaks, from industrial facilities or providing early warning for non-compliance or emergency release events. Existing open-path monitors are expensive to purchase and operate and therefore are generally used for short-term studies by industrial facilities. Open-path monitoring can be used for substances such as ozone, particulate matter, sulphur dioxide, nitrogen dioxide, ammonia, carbon monoxide, methane, nitrous oxide and lead.

Emergency Air Monitoring Vehicle
In 2003, the City of Calgary and Alberta Environment built a mobile Emergency Air Monitoring Vehicle designed to monitor the emissions from emergencies in Central and Southern Alberta. In 2005, a similar vehicle was built in Edmonton to cover Central and Northern Alberta. These new vehicles allow Calgary and Edmonton firefighters to monitor air quality during emergencies in all areas of Alberta.

Appendix E: Air Monitoring Guidance Tool and Decision-Making Process

The guidance tools described in this section were developed to help the multi-stakeholder group in their review of the monitoring network. It is designed to help determine where air monitors should be located to maximize effectiveness. Groups involved in air monitoring, such as governments, airshed zones and industry can use the tools to ensure that air monitors are placed in optimal locations.

E.1 Tools for Guiding the Assessment and Selection of Monitoring Sites

Two possible structures for a guidance tool have been developed: a "two-tier" approach and a "20 questions" approach. When a potential monitoring site has been identified, the tool can be used to determine the applicability of the site for air monitor placement. Both tools incorporate "yes-no" questions for factors that must be considered for an air monitor to be deemed useful at the site. The "20 questions" tool also includes a third column in situations where there is not enough information to choose a yes or no response. Both tools help the user to consider all factors to ensure all potential uses of the monitor or monitoring system have been assessed. For example, a monitor that is being installed for human health concerns may also be able to provide useful data for understanding ecological effects of certain emissions in the area.

While using the guidance tool, if the answer to any of the questions is "yes", the user notes this "trigger" and continues to work through all the factors. After the user has examined all factors, the triggers are accounted for and analyzed by the multi-stakeholder review team to help the team decide if the site would be a suitable location for an air monitor. The review team will also determine which type of monitor (ambient, passive, active integrated, etc.) and frequency (continuous, monthly, rotating yearly, etc.) will satisfy the objectives, both on a scientific and economic basis. A number of monitoring techniques can be used to provide timely and accurate ambient air quality data, and new technologies emerge regularly. A number of pollutants can be measured using more than one technique, and the final choice depends on a variety of factors, including cost. The review team will need to remain abreast of these technologies to ensure that it is recommending the most appropriate approach. Current monitoring technologies are described in more detail in Appendix D.

When there are potential monitoring sites, this tool could be used to prioritize installation. For example, if a given site produces fifteen triggers that are closely related to the primary objective and a different site produces only five triggers of limited importance, the first site should be given priority for installation of a monitor. However, a decision should not be based solely on the number of triggers. The review team should also consider the quality of the triggers and other associated factors such as security at the site, capital costs, logistics, and others, some of which might be unique to a site. Each case will be different so judgment of the review team must be used to make the final decisions.

E.1.1 The Two-Tier Guidance Tool

Structure

The first tier of the two-tier approach is used to consider the user's objectives for air monitoring, as shown in Figure E1. Four main objectives have been identified for monitoring air: human health, ecological health, boundary transport, and data gaps. The first tier ensures that the user considers all four objectives in order to identify potential multiple uses of a monitor or monitoring system.

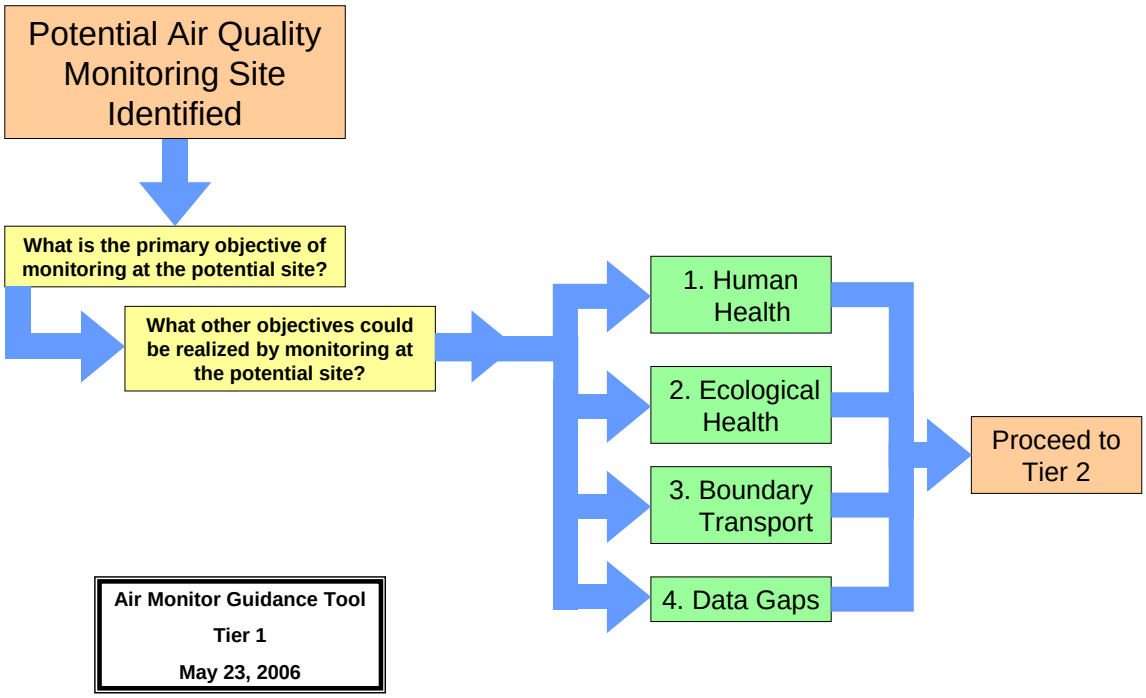


Figure E1. Tier 1 of the Two-Tier Approach

The second tier includes all factors or "triggers" that should be considered under each of the objectives introduced in tier 1. As stated earlier, each trigger is noted and used by the multi-stakeholder review team to make decisions. The following sections contain the overall Tier 2 structure as well as the corresponding criteria guidance for each factor.

Objective 1: Human Health

Figure E2 contains the relevant factors to be considered for siting a monitor used to measure air quality for human health concerns.

The following text expands on the ideas presented in the Human Health tool as criteria guidance.

1a: Is the population greater than 20,000?

When considering human health, an obvious factor is the number of people near the potential site. When answering this question, populations less than 20,000 may also cause a trigger if a given monitor or monitor system would better serve a smaller population. For example, an area with a population of 10,000 to 20,000 may be well served by continuous rotational monitors and an area with a population of 5,000 to 10,000 may be adequately assessed with a network of passive monitors.

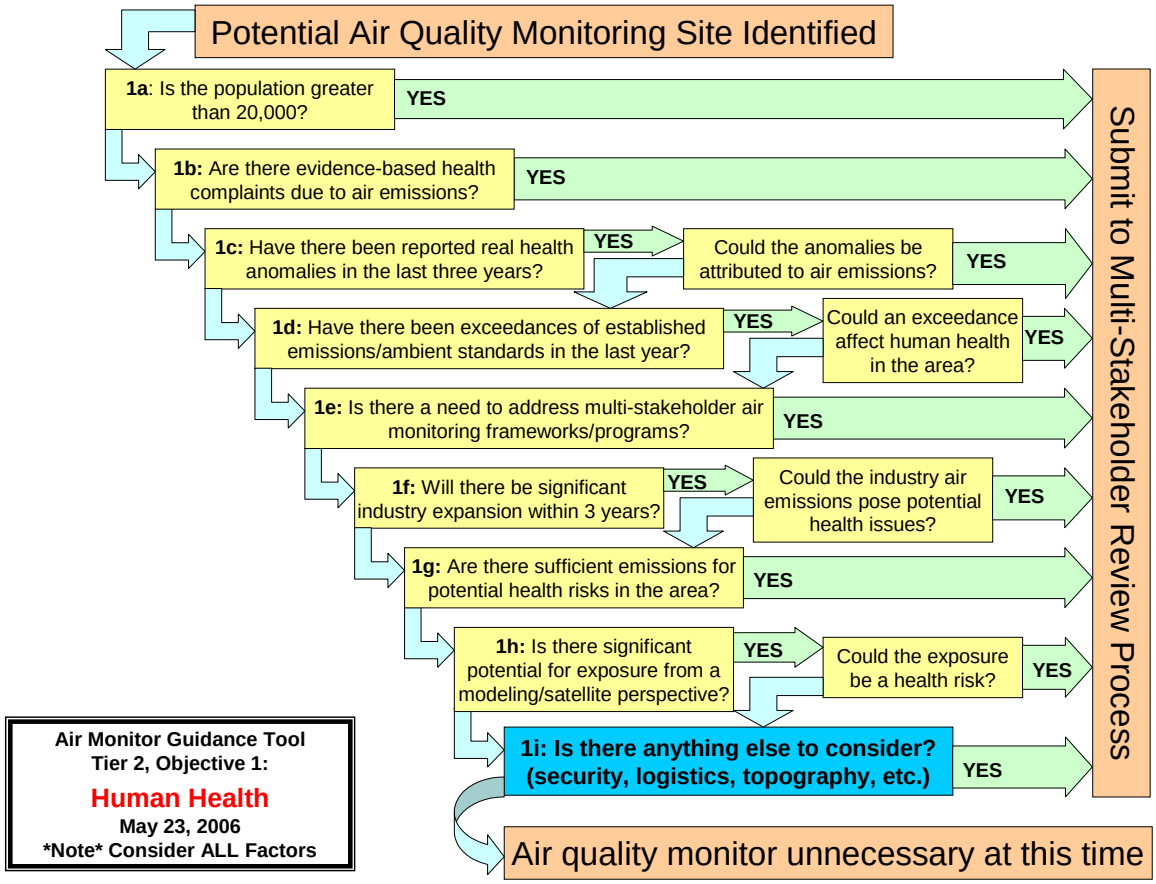


Figure E2. Tier 2, Objective 1: Human Health

1b: Are there evidence-based health complaints due to air emissions?

Regional health authorities may collect human health complaints, and the complaints may be attributed to air quality issues. "Evidence-based" means true health issues based on scientific evidence, not simply the occurrence or reporting of complaints from patients or the public.

1c: Have there been reported real health anomalies in the last three years?

Can the anomalies be attributed to air emissions?

These questions are related to 1b, although they pertain to real diagnosed health conditions that may occur in areas with abnormally high pollutant concentrations. If the abnormality can be attributed to air emissions, this could cause a trigger.

1d: Have there been exceedances of established emissions/ambient standards in the last year?

Could an exceedance affect human health in the area?

These questions relate to standards that have been established in the area. For example, if the Canada-Wide Standards for particulate matter and ozone have been exceeded in the area in the past year, and it could potentially affect human health in the area, this would cause a trigger.

Other standards include Ambient Air Quality Objectives or emissions limits in industrial approvals.

1e: Is there a need to address multi-stakeholder air monitoring frameworks/programs?

Multi-stakeholder frameworks or programs, such as CASA frameworks developed to address air quality issues, often outline air monitoring priorities. The recommendations of these frameworks should be considered when assessing where air monitors should be located.

1f: Will there be significant industry expansion within 3 years?

Could the industry air emissions pose potential health issues?

In this question, "significant" means new types of industry, expansion of existing industry or the addition of emissions that could harm human health.

1g: Are there sufficient emissions for potential health risks in the area?

Could the exposure be a health risk?

This question relates not only to the levels of potentially hazardous emissions but also to the nature of the emission. For example, a sour gas plant emitting hydrogen sulphide (H_2S) could cause a trigger because of the highly poisonous nature of H_2S.

1h: Is there significant potential for exposure from a modeling/satellite perspective?

If computer simulations predict that a location may be exposed to potentially harmful emissions (e.g., downwind of a point source or in a valley), or if satellite imagery has shown potential exposure, this would cause a trigger.

1i: Is there anything else to consider? (security, logistics, topography, etc.)

This question is used to raise any other concerns that might identify the need for monitoring in a particular location. For example, a site may need security from vandalism, it may need a power source, it may be on top of a hill, etc.

Objective 2: Ecological Health

Figure E3 contains the relevant factors to be considered for siting a monitor used to measure air quality for ecological health concerns.

The following text expands on the ideas presented in the Ecological Health tool as criteria guidance.

2a: Does the ecoregion have less than two ambient air quality monitors?

An ecoregion is defined as one of the six distinct ecoregions in Alberta. They are: Boreal Forest, Rocky Mountain, Foothills, Canadian Shield, Parkland and Grassland. The ecoregions are shown in Figure E4. Ideally, each ecoregion would have at least two ambient air quality monitors.

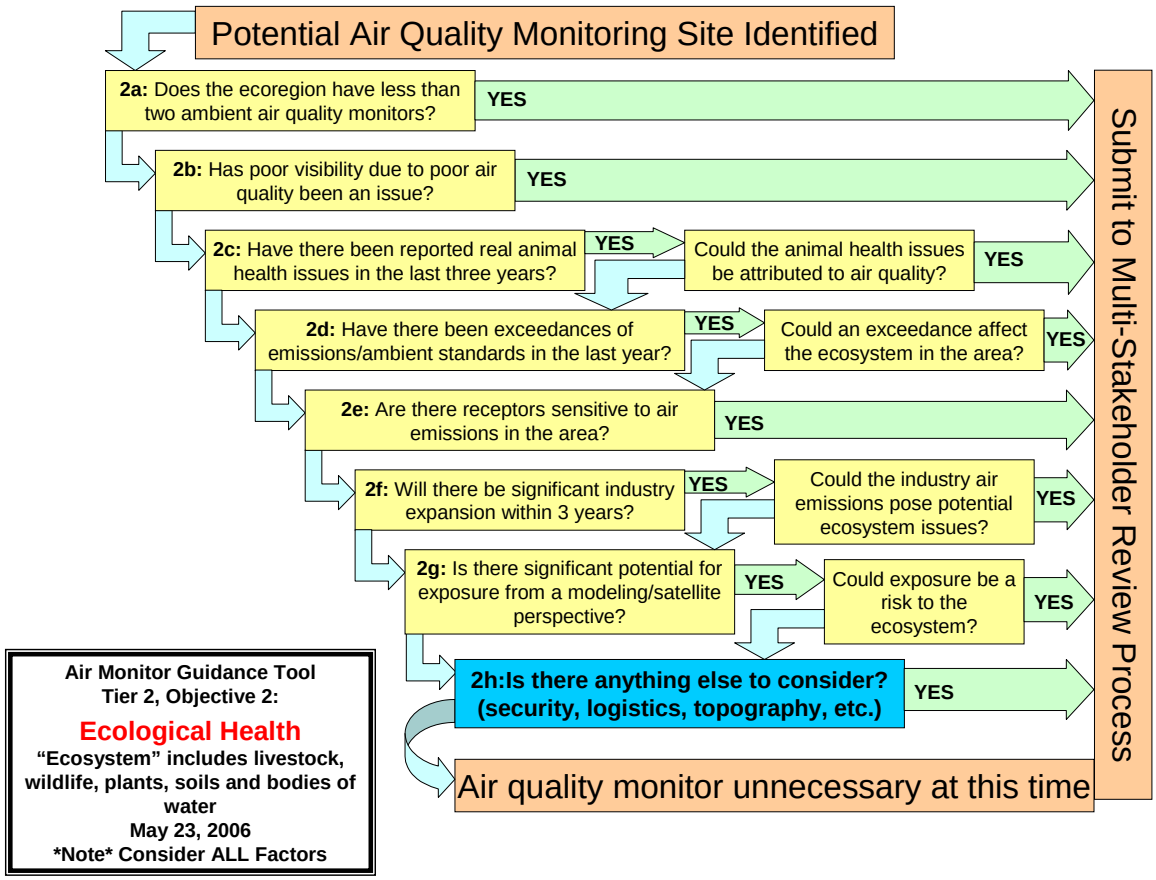


Figure E3. Tier 2, Objective 2: Ecological Health

2b: Has poor visibility due to poor air quality been an issue?

Poor visibility caused, for example, by particulate matter from forest fires, can have a negative impact on health and tourism. If it has been an issue, this would cause a trigger.

2c: Have there been reported real animal health issues in the last three years? | Could the animal health issues be attributed to air quality?

These questions pertain to real diagnosed animal health conditions that may occur in areas with higher than normal pollutant concentrations, whether it is due to natural or anthropogenic causes. If the health problems can be attributed to air emissions, this would cause a trigger.

2d: Have there been exceedances of emissions/ambient standards in the last year? | Could an exceedance affect the ecosystem in the area?

These questions relate to standards that have been established in the area. For example, if the critical loads for acid deposition defined by the Acid Deposition Management Framework have been exceeded in the area in the past year, ecosystem health could potentially be affected and this would cause a trigger. Other standards include emissions limits in industrial approvals and Ambient Air Quality Objectives.

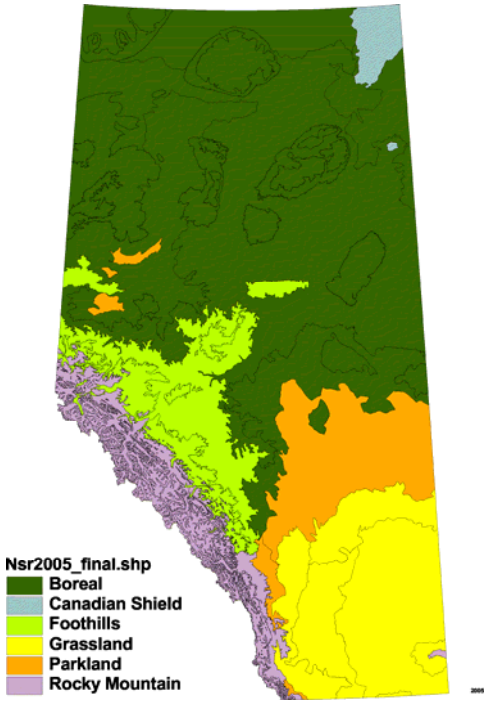


Figure E4. Ecoregions of Alberta

2e: Are there receptors sensitive to air emissions in the area?

Sensitive receptors can include breeding habitat, areas with endangered plant an animal species, wetlands and alpine environments to name a few. Agricultural land and human settlements where the land is the primary resource for living may also be included as a sensitive receptor.

2f: Will there be significant industry expansion within 3 years?

Could the industry air emissions pose potential ecosystem issues?

In this question "significant" means new types of industry, expansion of existing industry or the addition emissions that could harm the ecosystem in the area.

2g: Is there significant potential for exposure from a modeling/satellite perspective?

Could exposure be a risk to the ecosystem?

If computer simulations predict that a location may be exposed to potentially harmful emissions (e.g., downwind of a point source or in a valley), or if satellite imagery has shown potential exposure, this would cause a trigger.

2h:Is there anything else to consider? (security, logistics, topography, etc.)

This question is used to raise any other concerns that might identify the need for monitoring in a particular location. For example, a site may need security from vandalism, it may need a power source, it may be on top of a hill, etc.

Objective 3: Boundary Transport

Figure E5 contains the relevant factors to be considered for siting a monitor used to measure air quality for boundary transport issues.

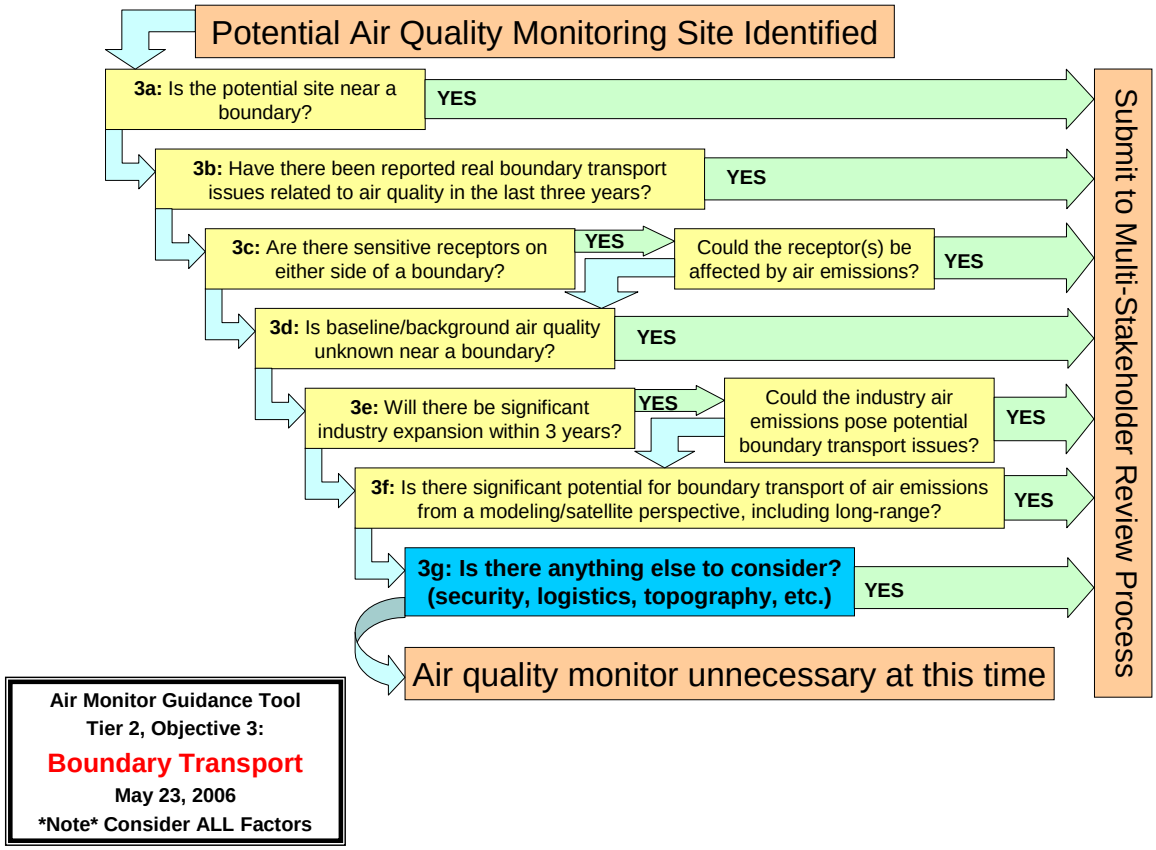


Figure E5. Tier 2, Objective 3: Boundary Transport

The following text expands on the ideas presented in the Boundary Transport tool as criteria guidance.

3a: Is the potential site near a boundary?

For a monitor to adequately measure boundary transport of emissions, it should be located near a boundary, although farther distances may be adequate in remote locations. Boundaries are

usually defined in political terms, such as international, provincial or municipal, but they may also be regional, such as airshed boundaries.

3b: Have there been reported real boundary transport issues related to air quality in the last three years?

If, in the previous three years, there have been incidents where air quality has been affected by transboundary emissions, and it has been proven, then this would cause a trigger.

3c: Are there sensitive receptors on either side of a boundary?

Could the receptor(s) be affected by air emissions?

Sensitive receptors can include breeding habitat, areas with endangered plant an animal species, wetlands and alpine environments to name a few. Agricultural land and human settlements where the land is the primary resource for living may also be included as a sensitive receptor. Receptors on either side of the boundary should be considered in case of outward emissions.

3d: Is baseline/background air quality unknown near a boundary?

To determine if air quality is being affected by transboundary emissions, it is necessary to understand what the baseline/background air quality is. If it is unknown, this would cause a trigger.

3e: Will there be significant industry expansion within 3 years?

Could the industry air emissions pose potential boundary transport issues?

In this question "significant" means new types of industry, expansion of existing industry or the addition of emissions that could cross boundaries.

3f: Is there significant potential for boundary transport of air emissions from a modeling/satellite perspective, including long-range?

If computer simulations calculate that a location may be exposed to potentially harmful emissions (e.g., downwind of a point source or in a valley), or if satellite imagery has shown potential exposure from a source across a boundary, this would cause a trigger. Long-range emissions exposure should also be considered, as large-scale events such as forest fires can cross boundaries and affect a large area downwind of the fire.

3g: Is there anything else to consider? (security, logistics, topography, etc.)

This question is used to raise any other concerns that might identify the need for monitoring in a particular location. For example, a site may need security from vandalism, it may need a power source, it may be on top of a hill, etc.

Objective 4: Data Gaps

Figure E6 contains the relevant factors to be considered for siting a monitor used to measure air quality to close data gaps.

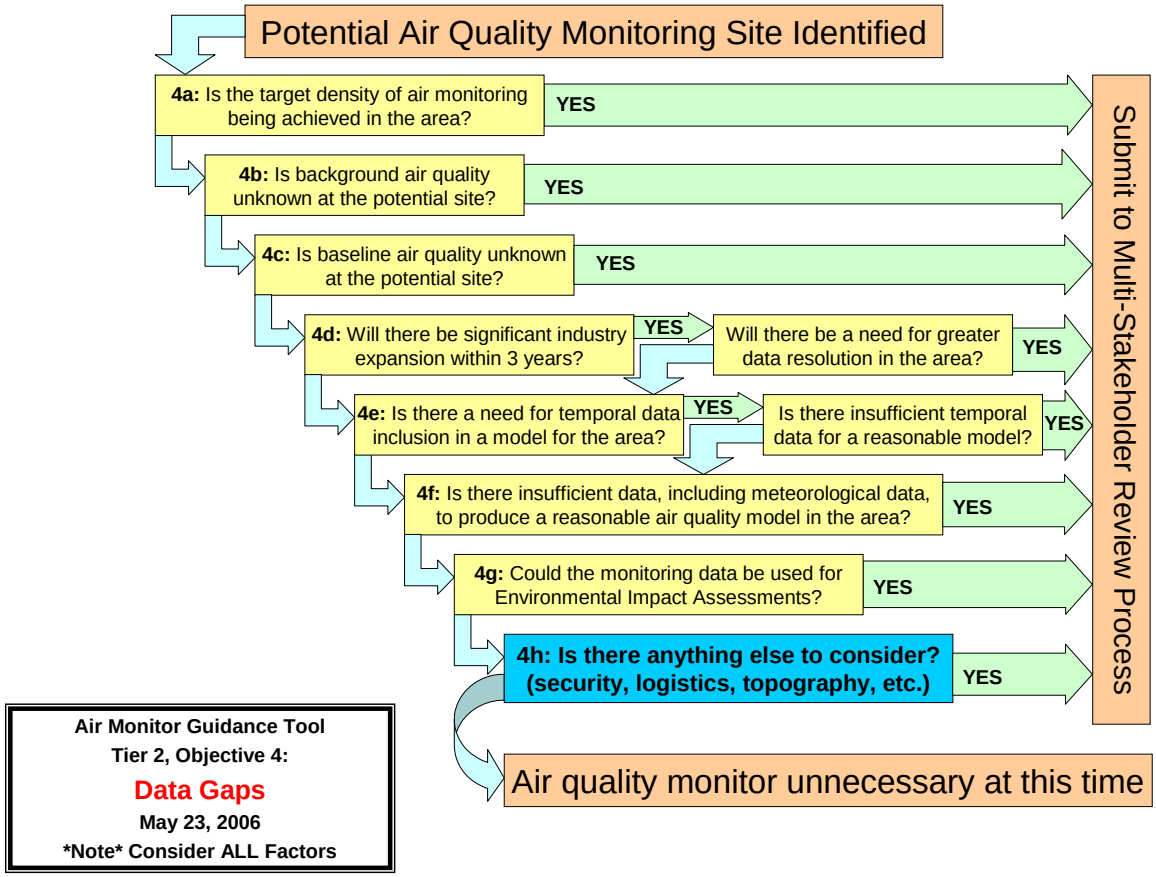


Figure E6. Tier 2, Objective 4: Data Gaps

The following text expands on the ideas presented in the Data Gaps tool as criteria guidance.

4a: Is the target density of air monitoring being achieved in the area?

Target density refers to the desired number of air monitors or monitored parameters in a given area. A populated area with industrial development will usually have a higher target density than a remote area with no industry.

4b: Is background air quality unknown at the potential site?

Background air quality is defined as the ambient concentrations of selected pollutants that do not originate from sources within the prescribed area, but rather reflect natural concentrations and/or influences from transboundary emissions.

4c: Is baseline air quality unknown at the potential site?

Baseline air quality is defined as the ambient concentrations of selected parameters that are measured at the earliest point in time possible to determine subsequent trends from industry expansion, increased development, etc.

4d: Will there be significant industry expansion within 3 years?

Will there be a need for greater data resolution in the area?

In this question "significant" means new types of industry, expansion of existing industry or the a greater concentration of emissions sources. In areas where industry is becoming more concentrated, it may be necessary to install more monitors to aid in environmental impact assessments and source detection.

4e: Is there a need for temporal data inclusion in a model for the area?

Is there insufficient temporal data for a reasonable model?

In areas with seasonal variability and/or industrial process variability of air emissions over time, it may be necessary to increase air monitoring capacity to gain a better understanding of the temporal nature of air quality in the area.

4f: Is there insufficient data, including meteorological data, to produce a reasonable air quality model in the area?

To create a reasonable model of air quality in an area, a significant amount of data is required. If there is not sufficient data, including meteorological data, to produce a reasonable model, a monitor should be installed, thus causing a trigger.

4g: Could the monitoring data be used for Environmental Impact Assessments?

Installing a monitor may be useful for completing and enhancing the accuracy of Environmental Impact Assessments.

4h: Is there anything else to consider? (security, logistics, topography, etc.)

This question is used to raise any other concerns that might identify the need for monitoring in a particular location. For example, a site may need security from vandalism, it may need a power source, it may be on top of a hill, etc.

E.1.2 The "Twenty Questions" Checklist

This section includes a more general approach to evaluating whether or not to site an air monitor in a given location. The questions cover the same topics as the two-tier approach but in more general terms. As stated earlier, the user should consider each question to ensure that all potential uses of an air monitor at a given location are taken into account.

A multi-stakeholder review team will analyze the results of the checklist to determine if the site would be a suitable location for an air monitor. The review team will also determine which type of monitor (e.g., ambient, passive, active integrated, etc.) and frequency (e.g., continuous, monthly, rotating yearly, etc.) will satisfy the objectives, both on a scientific and economic basis. This will ensure that all involved parties will be able to provide input and take an active role in the decision-making process.

Ambient Monitoring Strategic Plan Guidance Tool Checklist

Use this checklist to consider factors that may be important for monitoring ambient air at a selected site.

		YES	NO	Not enough information
1.	Is the population greater than 20,000 people?			
2.	Is the target density of air monitoring being achieved in the area?			
3.	Could the monitoring data be used for Environmental Impact Assessments?			
4.	Are historical trends showing increasing air pollutant levels?			
5.	Are there evidence-based human or animal health complaints due to air emissions?			
6.	Have there been reported real human or animal health anomalies due to air emissions in the last three years?			
7.	Are there sufficient emissions (e.g., point, non-point, transportation) for potential human or animal health risks in the area?			
8.	Have there been exceedances of emissions/ambient standards in the last year?			
9.	Will there be significant industry expansion within three years?			
10.	Is vegetation being affected by air quality?			
11.	Is there potential for significant exposure from a modeling/satellite perspective?			
12.	Is there insufficient data, including temporal or meteorological data, to produce a reasonable air quality model in the area?			
13.	Does the ecoregion have fewer than two ambient air quality monitors?			
14.	Are there sensitive receptors in the area?			
15.	Is the potential site near a boundary?			
16.	Have there been reported real boundary transport issues related to air quality in the last three years?			
17.	Is background air quality unknown?			
18.	Is baseline air quality unknown?			
19.	Has visibility been an issue?			
20.	Is there anything else to consider? (security, logistics, topography, etc.)			
	TOTAL			

Ambient Monitoring Strategic Plan Decision Tool Checklist
Criteria Guidance

This section expands on the ideas presented in the checklist above.

1. Is the population greater than 20,000 people?

When considering human health, an obvious factor is the number of people near the potential site. When answering this question, populations less than 20,000 may also cause a trigger if a given monitor or monitor system would better serve a smaller population. For example, an area with a population of 10,000 may be well served by a network of passive monitors instead of a fixed continuous ambient monitor.

2. Is the target density of air monitoring being achieved in the area?

Target density refers to the desired number of air monitors or monitored parameters in a given area. A populated area with industrial development will usually have a higher target density than a remote area with no industry.

3. Could the monitoring data be used for Environmental Impact Assessments?

The site may be useful for reporting as part of industrial approvals and Environmental Impact Assessments (EIAs).

4. Are historical trends showing increasing air pollutant levels?

In cases where historical data is available, a monitor may be desired in a location where the air quality has been deteriorating (i.e., increasing pollutant levels) over time.

5. Are there evidence-based human or animal health complaints due to air emissions?

Regional health authorities and veterinarians may catalogue human and animal health complaints, and the complaints may be contributed to air quality issues. “Evidence-based” means true health issues based on scientific evidence, not simply the occurrence of complaints from patients or livestock operations.

6. Have there been reported real human or animal health anomalies due to air emissions in the last three years?

This question is related to Number 5, although it pertains to real diagnosed health conditions that may occur in areas with higher than normal pollutant concentrations, such as high asthma rates in a municipality or abnormally high rates of birth defects in livestock.

7. Are there sufficient emissions (e.g., point, non-point, transportation) for potential human or animal health risks in the area?

This question relates not only to the concentrations of potentially hazardous emissions but also to the nature of the emissions. For example, a potential source of hydrogen sulphide (H_2S) should be considered because it is highly poisonous, even in low concentrations.

8. Have there been exceedances of emissions/ambient standards in the last year?

This question relates to standards that have been established in the area. Examples of standards include: Canada-Wide Standards for particulate matter and ozone, emissions limits in industrial approvals and Ambient Air Quality Objectives.

9. Will there be significant industry expansion within three years?

In this question “significant” means new types of industry, expansion of existing industry or the addition of emissions that could adversely affect air quality in the area.

10. Is vegetation being affected by air quality?

Vegetation can be damaged by particular air emissions and this is often monitored by using wet/dry deposition monitoring.

11. Is there potential for significant exposure from a modeling/satellite perspective?

According to the results of computer simulations or satellite imagery, the site may be exposed to potentially harmful emissions (e.g., commonly if a site is downwind of a point source or in a valley).

12. Is there insufficient data, including temporal or meteorological data, to produce a reasonable air quality model in the area?

To create a reasonable model of air quality in an area, a significant amount of data, including temporal and meteorological data, is required. Installation of an air monitor would ensure that the required data is available for modeling of the area.

13. Does the ecoregion have fewer than two ambient air quality monitors?

An ecoregion is defined as one of the six distinct ecoregions in Alberta. They are: Boreal Forest, Rocky Mountain, Foothills, Canadian Shield, Parkland and Grassland. The ecoregions of Alberta are shown in Figure E4 (above). Ideally, each ecoregion would have at least two ambient air quality monitors.

14. Are there sensitive receptors in the area?

Sensitive receptors can include sensitive human settlements (e.g., hospitals and schools), animal breeding habitat, areas with endangered plant and animal species, lichen rich areas, wetlands and alpine environments, to name a few. Agricultural land and human settlements where the land is the primary resource for living may also be included as a sensitive receptor.

15. Is the potential site near a boundary?

In order for a monitor to adequately measure boundary transport of emissions, it should be located near a boundary, although farther distances may be adequate in remote locations. Boundaries are usually defined in political terms, such as international, provincial or municipal, but they may also be regional, such as airsheds.

16. Have there been reported real boundary transport issues related to air quality in the last three years?

Real boundary transport issues include instances when air quality has been affected by transboundary emissions and it has been scientifically proven.

17. Is background air quality unknown?

To determine if air quality is being affected by transboundary emissions, it is necessary to understand what the background air quality is. Background air quality is defined as the ambient concentrations of selected pollutants that do not originate from sources within the prescribed area, but rather reflect natural concentrations and/or transboundary emissions.

18. Is baseline air quality unknown?

To determine if air quality is being affected by transboundary emissions, it is necessary to understand what the background air quality is. Baseline air quality is defined as the ambient concentrations of selected pollutants that are measured at the earliest point in time possible to determine subsequent trends from industry expansion, increased development, etc.

19. Has visibility been an issue?

Poor visibility, usually caused by particulate matter from forest fires, can have a negative impact on health and tourism. It may also be an issue as a result of large-scale industry and/or agriculture.

20. Is there anything else to consider? (security, logistics, topography, etc.)

This question is used to raise any other concerns that might identify the need for monitoring in a particular location. For example, a site may need security from vandalism, it may need a power source, it may be on top of a hill, etc.

Appendix F: Funding Formula Calculation Procedure

The purpose of this document is to illustrate the procedure for calculating a funding formula consistent with funding options Scenario A and B as determined by the CASA Ambient Monitoring Strategic Plan (AMSP) Project Team. The calculations that follow are used to demonstrate the procedure and include several assumptions that are indicated throughout. These calculations are based on the best available information but will need to be revised once the funding formula is implemented. As such, the values used in this document should be treated as estimates.

The funding formula for Scenarios A and B will include the annual operating costs for the existing monitoring network (base costs). These costs will include equipment replacement, data management and other cost overhead considerations.

The AMSP proposes that new air monitoring planned for the provincial program be fully implemented and operational within five years of CASA Board acceptance. To achieve this goal, capital equipment will need to be purchased in the first four years (Years 1 to 4) and will be operational in the subsequent year (Years 2 to 5). To calculate future costs on an annual basis, operations will need to be incremented over the implementation period (Years 2 to 5) and new capital equipment will need to be annualized over the first four years (Years 1 to 4).

Step 1: Determine Base Annual Costs for Scenario A

Scenario A includes the following base annual operating costs:

- The existing provincial monitoring network,
- All existing airshed monitoring outside of the provincial network, and
- All facility specific compliance (commonly called fenceline) monitoring not included in airshed monitoring networks.

The operating cost for the existing provincial monitoring network is specified in Table F1 (italicized and bold). The total annual operation costs for this portion of the network is $3,162,000 (3,162K).

Table F1. Annual operating cost for existing provincial air monitoring network.

Monitoring Program Component	Total Network		Existing Portion		New Portion	
	Capital Equipment ($x1000)	Annual Operations ($x1000)*	Capital Equipment ($x1000)	Annual Operations ($x1000)*	Capital Equipment ($x1000)	Annual Operations ($x1000)*
Population-based Sub-program	5,496	2,050	3,134	***1,215***	2,362	835
Ecosystem-based Sub-program	618	620	113	***126***	505	494
Ozone Sub-program	1,120	640	565	***150***	555	490
Background and Transboundary Sub-program	1,650	900	730	***300***	920	600
Pattern Recognition Sub-program	137	802	36	***138***	101	664
Instrument Replacement Costs (10% of Capital)	-	902	-	***458***	-	444
Data Management	15	150	10	***100***	5	50
Information Dissemination	-	50	-	***0***	-	50
Data QA/QC (20% of Operating)	-	662	-	***300***	-	362
Contractor Overhead (25% of Operating)	-	827	-	***375***	-	452
Total	**9,036**	**7,603**	**4,588**	***3,162***	**4,448**	**4,441**

* includes supplies, services and laboratory analysis

Based on information provided by airsheds, Table F2 shows the estimated current operating cost for airsheds that conduct air monitoring. These costs are broken down by government and industry and

by the portions of these networks that are considered part of the provincial monitoring network. The airshed column (italicized and bold) will be included in subsequent steps for Scenario A.

Table F2. Annual operating costs for current airshed monitoring*

Existing Operating Costs (for 2008 in $x1000)						
	Government	Industry	Provincial	***Airshed (Total - Provincial)*** **	Total	Provincial Calculation includes:
CRAZ	225	0	225	***0***	225	3 Calgary stations
FAP	107	680	150	***637***	747	Elk Island and Fort Sask
LICA	60	505	0	***565***	565	None
PAMZ	106	779	150	***735***	885	Red Deer and Caroline
PAS	69	195	75	***189***	264	Medicine Hat
PASZA	149	594	150	***593***	702.5	Grande Prairie and Beaverlodge
WBEA	55	3845	150	***3,750***	3700	Fort McMurray (AV) and Fort Chipewyan
WCAS	90	806	150	***746***	776	Violet Grove and Hightower Ridge
Total	861	7,404	1,050	***7,215***	7,865	

* Calculations include only air and deposition monitoring. Terrestrial monitoring is not included.
** Airshed stations considered to be facility specific compliance stations are included in this calculation.

The total facility specific industry monitoring outside of airsheds includes 57 permanent continuous stations, 28 temporary stations, 49 integrated monitors, 530 passive stations and 393 static stations. The estimated total costs of monitoring by industry are 11,681K for capital equipment and 8,082K for annual operations. The annual operating cost includes capital equipment replacement (10% of capital), QA/QC (20% of operating) and contractor overhead (25% of operating). These costs will be attributed to sulphur dioxide because the vast majority of industry monitoring outside of airsheds is for sulphur compounds (sulphur dioxide and hydrogen sulphide).

Step 2: Determine Base Annual Costs for Scenario B

The base annual operating costs to be included in Scenario B include the following:

- The existing provincial monitoring network,
- All existing airshed monitoring outside of the provincial network and not including facility specific compliance monitoring operated by airsheds, and
- The portion of facility specific compliance monitoring that may be incorporated into the provincial network in the future.

For Scenario B, the existing cost of the provincial network is the same as Scenario A indicated in Table F1 above (3,162K).

Several monitoring stations operated by airsheds are considered facility specific compliance stations. For Scenario B, the cost of operating these stations needs to be removed from calculation. The criteria for removing these stations are as follows:

1. The station is a former facility specific compliance station prior to being incorporated into the airshed, and
2. The station has not been moved or upgraded to monitor air quality representative of the region.

Therefore, the purpose of the station is solely to measure compliance with the requirements of a specific industrial approval. It was approximated that ten of the existing 50 airshed permanent or portable continuous stations are considered facility specific compliance stations. It is assumed that

the average capital cost of one of these stations is 125K (total 1250K) and annual operating cost is 40K (total 400K). The annual operating costs for airsheds without provincial stations and facility specific compliance stations are indicated in the bold and italicized text in Table F3.

Table F3. Annual operating costs for current airshed monitoring (compliance stations removed)*

Existing Operating Costs (for 2008 in $x1000)						
	Government	Industry	Provincial	***Airshed (Total - Provincial)*** **	Total	Provincial Calculation includes:
CRAZ	225	0	225	***0***	225	3 Calgary stations
FAP	107	640	150	***597***	747	Elk Island and Fort Sask
LICA	60	505	0	***565***	565	None
PAMZ	106	779	150	***735***	885	Red Deer and Caroline
PAS	69	195	75	***189***	264	Medicine Hat
PASZA	149	554	150	***553***	702.5	Grande Prairie and Beaverlodge
WBEA	55	3645	150	***3,550***	3700	Fort McMurray (AV) and Fort Chipewyan
WCAS	90	686	150	***626***	776	Violet Grove and Hightower Ridge
Total	861	7,004	1,050	***6,815***	7,865	

* Calculations include only air and deposition monitoring. Terrestrial monitoring is not included.

** Airshed stations considered to be facility specific compliance stations were removed from this calculation.

The next step is to determine the portion of facility specific compliance stations that can be upgraded and rolled into the provincial monitoring network. This requires identifying existing facility specific compliance stations that can be upgraded to address one or more of the objectives of the provincial monitoring network. A couple of examples of this type of station are:

- A facility specific compliance station that is located in an urban centre that can be upgraded to monitor pollutants representative of an urban environment, or
- A facility specific compliance station located near the border of Alberta and another jurisdiction that can be upgraded to monitor air quality entering or leaving the province.

Based on this criteria, the portion of the facility specific compliance network that can be included in the provincial network totals 1253K (12% of facility specific total) for capital cost and 539K (7% of facility specific total) for annual operating cost. These costs will be attributed to sulphur dioxide because the vast majority of industry monitoring outside of airsheds is for sulphur compounds.

Step 3: Breakdown Base Annual Costs by Pollutant

The total existing operational costs, broken down by pollutant, to be included for Scenarios A and B are indicated in Table F4. These are the based on annual operating costs for the existing monitoring to be included in Scenarios A and B.

Table F4. Base annual operating costs to be included for Scenarios A and B.

Scenario	Ozone	Oxides of Nitrogen	Carbon Monoxide	Sulphur Dioxide	Continuous Particulates (PM2.5)	Hydrocarbons	Hydrogen Sulphide	Ammonia	Total Reduced Sulphur	Continuous BTEX	Continuous Particulates (PM10)	Particulate Composition	Volatile Organic Compounds	Semi Volatile Organic Compounds	Peroxyacetyl nitrate (PAN)	Wet Deposition	Dry Deposition	Passive Ozone	Passive Nitrogen Dioxide	Passive Sulphur Dioxide	Passive Ammonia	Passive Hydrogen Sulphide	Total
Scenario A																							
Airshed Annual Operations (non provincial)	568	1097	188	804	1189	719	392	314	784	46	732	59	144	0	0	52	65	17	17	20	0	9	7215
Industry Annual Operations (facility specific)				8082																			8082
Provincial Annual Operations (existing)	415	415	196	265	374	229	114	40	55	0	30	130	340	126	0	103	103	76	76	76	0	0	3162
Total for Scenario A	**983**	**1512**	**385**	**9151**	**1563**	**948**	**506**	**353**	**839**	**46**	**762**	**188**	**484**	**126**	**0**	**156**	**169**	**93**	**93**	**95**	**0**	**9**	**18459**
Scenario B																							
Airshed Annual Operations (non provincial and non facility specific)	537	1037	178	759	1123	679	370	296	740	43	691	56	136	0	0	49	62	16	16	19	0	8	6815
Industry Annual Operations (6% facility specific)				560																			560
Provincial Annual Operations (existing)	415	415	196	265	374	229	114	40	55	0	30	130	340	126	0	103	103	76	76	76	0	0	3162
Total for Scenario B	**952**	**1452**	**374**	**1584**	**1497**	**908**	**484**	**336**	**796**	**43**	**721**	**185**	**476**	**126**	**0**	**153**	**165**	**92**	**92**	**94**	**0**	**8**	**10537**

Step 4: Calculate New Costs for the Provincial Network

The new costs for the provincial network are calculated assuming that the network will be implemented from Year 1 to 4 and fully operational after Year 5. New costs are calculated by dividing the new capital costs by four years (assuming even distribution in the first four years) and incrementing the annual operating cost starting in Year 2 and ending in Year 5. After Year 5, the annual operating cost should remain the same, not accounting for inflation. The annual operating costs for the provincial network include 10% of capital to account for replacement of old equipment. The operating costs for new monitoring are indicated in Table F1 above. The distribution of these costs for the first five years is indicated in Table F5. The total cost of Scenarios A and B are the sum of the annual costs for existing monitoring plus the annual costs for new monitoring proposed by the AMSP. The total costs for Scenarios A and B are shown in Tables F6 and F7.

Table F5. New costs for provincial monitoring network (full implementation over five years - $x1000).

Implementation Year	Ozone	Oxides of Nitrogen	Carbon Monoxide	Sulphur Dioxide	Continuous Particulates (PM2.5)	Hydrocarbons	Hydrogen Sulphide	Ammonia	Total Reduced Sulphur	Continuous BTEX	Continuous Particulates (PM10)	Particulate Composition	Volatile Organic Compounds	Semi Volatile Organic Compounds	Peroxyacetyl nitrate (PAN)	Wet Deposition	Dry Deposition	Passive Ozone	Passive Nitrogen Dioxide	Passive Sulphur Dioxide	Passive Ammonia	Passive Hydrogen Sulphide	Total
Year 1	110	140	63	93	195	71	61	32	29	25	4	4	75	13	46	52	74	9	9	9	0	0	1112
Year 2	169	202	95	145	254	99	89	43	39	32	4	4	318	35	57	147	143	104	104	104	19	19	2222
Year 3	227	265	126	196	313	127	117	53	49	39	4	4	561	57	68	243	212	199	199	199	37	37	3332
Year 4	286	327	158	247	372	155	145	63	60	46	4	4	805	78	79	338	281	294	294	294	56	56	4443
Year 5	235	250	126	205	236	112	112	41	41	28	0	0	973	88	45	381	276	381	381	381	75	75	4441

Table F6. Total costs for provincial monitoring network for first five years (Scenario A - $x1000).

Implementation Year	Ozone	Oxides of Nitrogen	Carbon Monoxide	Sulphur Dioxide	Continuous Particulates (PM2.5)	Hydrocarbons	Hydrogen Sulphide	Ammonia	Total Reduced Sulphur	Continuous BTEX	Continuous Particulates (PM10)	Particulate Composition	Volatile Organic Compounds	Semi Volatile Organic Compounds	Peroxyacetyl nitrate (PAN)	Wet Deposition	Dry Deposition	Passive Ozone	Passive Nitrogen Dioxide	Passive Sulphur Dioxide	Passive Ammonia	Passive Hydrogen Sulphide	Total
Year 1	1093	1652	448	9244	1758	1019	567	385	868	71	765	192	559	138	46	208	243	101	101	104	0	9	19571
Year 2	1152	1714	479	9295	1817	1047	595	396	878	78	765	192	802	160	57	303	312	196	196	199	19	27	20681
Year 3	1211	1777	511	9346	1876	1075	623	406	889	85	765	192	1045	182	68	398	381	291	292	294	37	46	21791
Year 4	1269	1840	543	9398	1935	1103	651	417	899	92	765	192	1288	204	79	494	450	387	387	389	56	65	22901
Year 5	1218	1762	511	9355	1799	1060	618	395	881	73	762	188	1456	213	45	537	445	473	473	476	75	83	22899

Table F7. Total costs for provincial monitoring network for first five years (Scenario B - $x1000)

Implementation Year	Ozone	Oxides of Nitrogen	Carbon Monoxide	Sulphur Dioxide	Continuous Particulates (PM2.5)	Hydrocarbons	Hydrogen Sulphide	Ammonia	Total Reduced Sulphur	Continuous BTEX	Continuous Particulates (PM10)	Particulate Composition	Volatile Organic Compounds	Semi Volatile Organic Compounds	Peroxyacetyl nitrate (PAN)	Wet Deposition	Dry Deposition	Passive Ozone	Passive Nitrogen Dioxide	Passive Sulphur Dioxide	Passive Ammonia	Passive Hydrogen Sulphide	Total
Year 1	1062	1591	438	1656	1692	979	545	368	824	68	725	189	551	138	46	205	239	100	100	103	0	8	11627
Year 2	1120	1654	469	1708	1751	1007	573	378	835	75	725	189	794	160	57	300	308	195	195	198	19	27	12738
Year 3	1179	1716	501	1759	1810	1035	601	389	845	82	725	189	1037	182	68	395	377	290	291	293	37	45	13848
Year 4	1238	1779	532	1810	1869	1063	629	399	856	89	725	189	1280	204	79	491	446	386	386	388	56	64	14958
Year 5	1186	1702	500	1768	1733	1020	597	377	837	71	721	185	1449	213	45	534	441	472	472	475	75	83	14956

Step 5 – Calculate the Cost per Tonne for each Criteria Air Contaminant (CAC)

The cost per tonne for each CAC is calculated for each implementation year (Year 1 to Year 5). First, the approximate cost of monitoring each pollutant proposed in the AMSP needs to be simplified so that they can be assigned to individual CACs. Table F8 shows this calculation only for Year 5 for Scenarios A and B.

Table F8. Simplified cost per pollutant for Year 5 for Scenarios A and B.

Pollutant	Scenario A ($x1000)	Scenario B ($x1000)	
Ozone (PAN)	1736	1703	includes O_3, PAN and passive O_3
Oxides of Nitrogen	2236	2174	includes NOx and passive NO_2
Carbon Monoxide	511	500	includes CO
Sulphur Dioxide	9831	2242	includes SO_2 and passive SO_2
Particulate Matter	2749	2640	includes $PM_{2.5}$, PM_{10} and composition
Hydrocarbons (VOCs, SVOCs)	2803	2753	includes THC, BTEX, VOCs and SVOCs
Hydrogen Sulphide	1582	1517	includes H_2S, TRS and passive H_2S
Ammonia	469	452	includes NH_3 and passive NH_3
Acidic Deposition (wet and dry)	982	975	includes wet and dry deposition
Total	**22899**	**14956**	

To determine a cost per tonne for each CAC, a weighting must be applied to account for the primary and secondary emissions that are associated with ambient pollutant concentrations. As indicated in Table F9, the primary emissions of sulphur dioxide are the major contributor to ambient sulphur dioxide concentrations. However, emissions of sulphur dioxide, nitrogen dioxide and ammonia contribute to the formation of secondary particulate matter measured at ambient monitoring stations. Therefore, factors must be applied to these pollutants to account for this contribution. The red font in the table indicates factors that have been modified since the March 2008 workshop based on scientific literature and discussions with AENV scientists. Also, the attribution of 100% of hydrogen sulphide emissions to sulphur dioxide has been questioned because of the lack of a relationship between emissions of these two pollutants. This issue has not yet been resolved.

Table F9. Assignment of weightings for each CAC as they contribute to the emissions of each pollutant monitored *

Pollutant	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
Ozone (PAN)	0.0	0.0	0.9	0.1	0.0	0.0
Oxides of Nitrogen	0.0	0.0	1.0	0.0	0.0	0.0
Carbon Monoxide	0.0	0.0	0.0	0.0	1.0	0.0
Sulphur Dioxide	0.0	1.0	0.0	0.0	0.0	0.0
Particulate Matter	0.8	0.1	0.05	0.0	0.0	0.05
Hydrocarbons (VOCs, SVOCs)	0.0	0.0	0.0	1.0	0.0	0.0
Hydrogen Sulphide	0.0	*1.0*	0.0	0.0	0.0	0.0
Ammonia	0.0	0.0	0.0	0.0	0.0	1.0
Acidic Deposition (wet and dry)	0.0	0.5	0.25	0.0	0.0	0.25

* Red font indicates coefficients that have been modified since the March 2008 workshop.

Tables F10 and F11 show the weightings for each CAC applied to the monitoring network costs for Year 5 for Scenarios A and B, respectively. Table F12 shows the cost per tonne for each CAC based

on 2005 CAC emissions for Year 5 of implementation. The escalating cost per tonne for individual CACs from Year 1 to Year 5 are shown in Figures F1 and F2.

Table F10. Total cost distributed by CAC for Scenario A in Year 5.

Pollutant	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
Ozone (PAN)	0	0	1562	174	0	0
Oxides of Nitrogen	0	0	2236	0	0	0
Carbon Monoxide	0	0	0	0	511	0
Sulphur Dioxide	0	9831	0	0	0	0
Particulate Matter	2200	275	137	0	0	137
Hydrocarbons (VOCs, SVOCs)	0	0	0	2803	0	0
Hydrogen Sulphide	0	1582	0	0	0	0
Ammonia	0	0	0	0	0	469
Acidic Deposition (wet and dry)	0	491	245	0	0	245
Total	**2200**	**12179**	**4181**	**2977**	**511**	**852**

Table F11. Total cost distributed by CAC for Scenario B in Year 5.

Pollutant	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
Ozone (PAN)	0	0	1533	170	0	0
Oxides of Nitrogen	0	0	2174	0	0	0
Carbon Monoxide	0	0	0	0	500	0
Sulphur Dioxide	0	2242	0	0	0	0
Particulate Matter	2112	264	132	0	0	132
Hydrocarbons (VOCs, SVOCs)	0	0	0	2753	0	0
Hydrogen Sulphide	0	1517	0	0	0	0
Ammonia	0	0	0	0	0	452
Acidic Deposition (wet and dry)	0	488	244	0	0	244
Total	**2112**	**4511**	**4083**	**2923**	**500**	**828**

Table F12. Cost per tonne for each CAC for Scenarios A and B in Year 5.

Criteria Air Contaminant	Total Alberta Emissions (tonnes)*	Monitoring Cost		Monitoring Cost Per Tonne	
		Scenario A ($x1000)	Scenario B ($x1000)	Scenario A ($/tonne)	Scenario B ($/tonne)
$PM_{2.5}$	365397	2200	2112	6	6
SO_X	452515	12179	4511	27	10
NO_X	789688	4181	4083	5	5
VOC	625363	2977	2923	5	5
CO	1656131	511	500	0	0
NH_3	145662	852	828	6	6

* From Environment Canada 2005 Criteria Air Contaminant air emissions inventory.

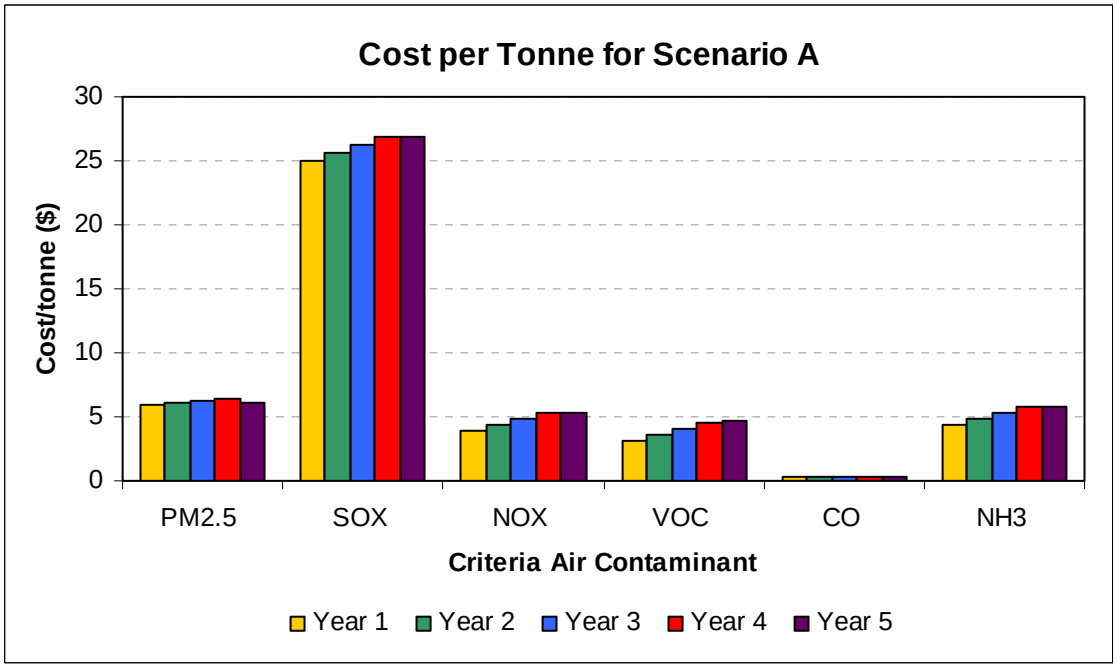


Figure F1. Cost per tonne for each CAC for Scenario A from Year 1 to Year 5.

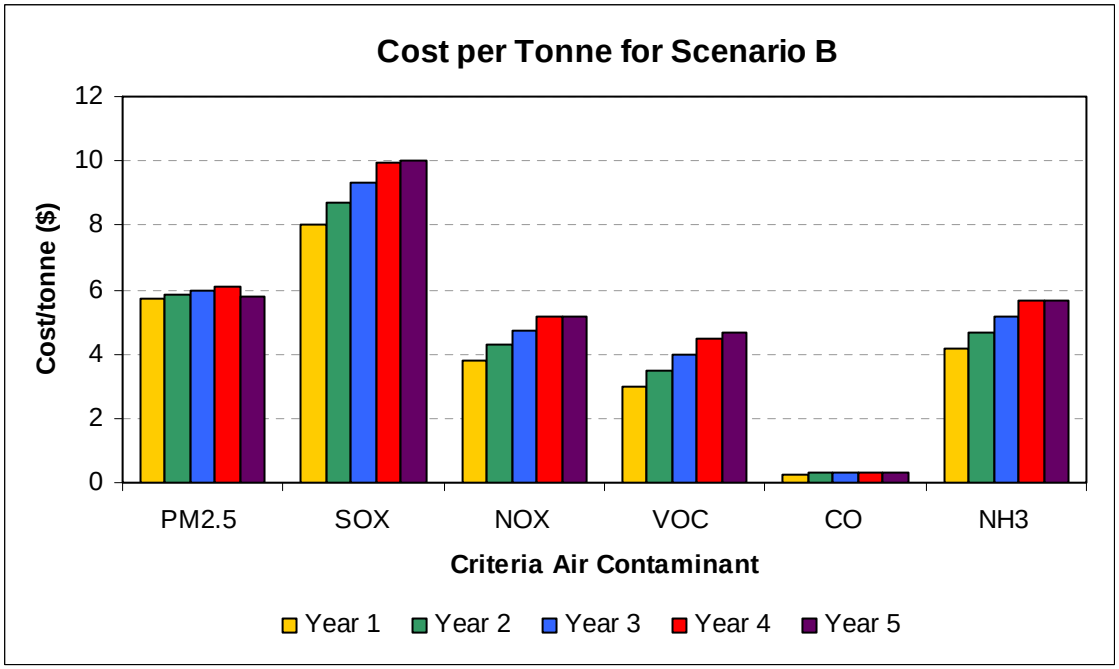


Figure F2. Cost per tonne for each CAC for Scenario B from Year 1 to Year 5.

Step 6 – Determine Emitting Sources and Sectors

From the 2005 Environment Canada CAC emissions inventory, data is broken down by emission source category, air pollutant and province. The above cost per tonne of emissions can be applied to each source category to determine the distribution of monitoring cost applied to each source

category. To apply this funding approach consistently and fairly in Alberta, a comprehensive and up-to-date emissions inventory of all contributing emission sources must be maintained.

Air emissions from the CAC emissions inventory were broken down into major emission source categories for each CAC in Table F13. Source categories that contributed to more than 1% of total emissions are included in this table. Over 97% of total CAC emissions are captured by source categories that emit more than 1% of total emissions. The cost of monitoring is then applied to the emissions for each CAC. In Tables F14 and F15, this has been done for Year 5 for Scenarios A and B, respectively. This information is also presented graphically in Figures F3 to F6.

Table F13. Source categories that emitted more than 1% of specific CACs in 2005

Emission Source Category	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
Non-industrial Sources						
Agriculture (Animals)	3%	-	-	19%	-	56%
Agriculture Tilling and Wind Erosion	2%	-	-	-	-	-
Air Transportation	-	-	1%	-	1%	-
Commercial Fuel Combustion	-	-	1%	-	-	-
Construction Operations	32%	-	-	-	-	-
Dust from Paved Roads	3%	-	-	-	-	-
Dust from Unpaved Roads	47%	-	-	-	-	-
Forest Fires	2%	-	-	2%	4%	-
Fuel Marketing	-	-	-	2%	-	-
General Solvent Use	-	-	-	4%	-	-
Heavy-duty diesel vehicles	-	-	6%	-	1%	-
Heavy-duty gasoline trucks	-	-	1%	-	2%	-
Light-duty gasoline trucks	-	-	3%	4%	26%	1%
Light-duty gasoline vehicles	-	-	2%	3%	15%	1%
Off-road use of diesel	2%	1%	10%	1%	3%	-
Off-road use of gasoline/LPG/CNG	-	-	1%	3%	17%	-
Pesticides and Fertilizer Application	-	-	-	-	-	34%
Rail Transportation	-	-	2%	-	-	-
Residential Fuel Combustion	-	-	1%	-	-	-
Residential Fuel Wood Combustion	1%	-	-	1%	2%	-
Surface Coatings	-	-	-	1%	-	-
Total Non-industrial	**93%**	**1%**	**28%**	**39%**	**70%**	**91%**
Industrial Sources						
Cement and Concrete Industry	-	-	1%	-	-	-
Chemicals Industry	-	1%	2%	-	-	5%
Electric Power Generation (Utilities)	1%	29%	11%	-	1%	-
Oil Sands	1%	32%	9%	9%	3%	1%
Other Industries	1%	2%	1%	1%	-	-
Petrochemical Industry	-	-	1%	-	-	-
Petroleum Refining	-	1%	1%	-	-	-
Pulp and Paper Industry	-	1%	1%	-	1%	-
Upstream Oil and Gas Industry	2%	33%	46%	47%	21%	2%
Wood Industry	-	-	-	1%	2%	-
Total Industrial	**4%**	**98%**	**71%**	**58%**	**28%**	**8%**
Total Non-industrial and Industrial	**97%**	**99%**	**99%**	**97%**	**98%**	**98%**

"-" sector emitted <1% of total in 2005.

Table F14. Cost of monitoring for each source sector and CAC in Year 5 for Scenario A.

Emission Source Category	Scenario A ($x1000)						Total for Source Category ($x1000)
	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3	
Non-industrial Sources							
Agriculture (Animals)	71	-	-	557	-	473	1101
Agriculture Tilling and Wind Erosion	42	-	-	-	-	-	42
Air Transportation	-	-	42	-	3	-	45
Commercial Fuel Combustion	-	-	27	-	-	-	27
Construction Operations	710	-	-	-	-	-	710
Dust from Paved Roads	70	-	-	-	-	-	70
Dust from Unpaved Roads	1037	-	-	-	-	-	1037
Forest Fires	38	-	-	48	23	-	108
Fuel Marketing	-	-	-	61	-	-	61
General Solvent Use	-	-	-	108	-	-	108
Heavy-duty diesel vehicles	-	-	267	-	3	-	271
Heavy-duty gasoline trucks	-	-	35	-	11	-	46
Light-duty gasoline trucks	-	-	110	124	135	7	377
Light-duty gasoline vehicles	-	-	66	79	77	6	227
Off-road use of diesel	48	93	439	41	13	-	634
Off-road use of gasoline/LPG/CNG	-	-	58	94	85	-	237
Pesticides and Fertilizer Application	-	-	-	-	-	287	287
Rail Transportation	-	-	86	-	-	-	86
Residential Fuel Combustion	-	-	35	-	-	-	35
Residential Fuel Wood Combustion	26	-	-	24	8	-	58
Surface Coatings	-	-	-	28	-	-	28
Total Non-industrial	**2041**	**93**	**1165**	**1164**	**359**	**773**	**5595**
Industrial Sources							
Cement and Concrete Industry	-	-	25	-	-	-	25
Chemicals Industry	-	78	71	-	-	39	188
Electric Power Generation (Utilities)	16	3512	450	-	4	-	3981
Oil Sands	14	3875	374	274	18	11	4566
Other Industries	23	183	39	26	-	-	271
Petrochemical Industry	-	-	26	-	-	-	26
Petroleum Refining	-	162	24	-	-	-	186
Pulp and Paper Industry	-	133	27	-	3	-	162
Upstream Oil and Gas Industry	34	3962	1939	1410	108	15	7466
Wood Industry	-	-	-	22	10	-	31
Total Industrial	**87**	**11905**	**2974**	**1731**	**141**	**64**	**16903**
Total Non-industrial and Industrial	**2129**	**11998**	**4139**	**2895**	**501**	**837**	**22498**

"-" sector emitted <1% of total in 2005.

Table F15. Cost of monitoring for each source sector and CAC in Year 5 for Scenario B.

Emission Source Category	Scenario B ($x1000)						Total for Source Category ($x1000)
	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3	
Non-industrial Sources							
Agriculture (Animals)	69	-	-	547	-	459	1075
Agriculture Tilling and Wind Erosion	40	-	-	-	-	-	40
Air Transportation	-	-	41	-	3	-	44
Commercial Fuel Combustion	-	-	26	-	-	-	26
Construction Operations	682	-	-	-	-	-	682
Dust from Paved Roads	67	-	-	-	-	-	67
Dust from Unpaved Roads	995	-	-	-	-	-	995
Forest Fires	36	-	-	47	22	-	105
Fuel Marketing	-	-	-	60	-	-	60
General Solvent Use	-	-	-	106	-	-	106
Heavy-duty diesel vehicles	-	-	261	-	3	-	265
Heavy-duty gasoline trucks	-	-	34	-	11	-	45
Light-duty gasoline trucks	-	-	108	122	133	9	371
Light-duty gasoline vehicles	-	-	64	78	75	7	224
Off-road use of diesel	46	35	428	41	13	-	562
Off-road use of gasoline/LPG/CNG	-	-	57	92	84	-	232
Pesticides and Fertilizer Application	-	-	-	-	-	374	374
Rail Transportation	-	-	84	-	-	-	84
Residential Fuel Combustion	-	-	34	-	-	-	34
Residential Fuel Wood Combustion	25	-	-	24	8	-	57
Surface Coatings	-	-	-	28	-	-	28
Total Non-industrial	**1960**	**35**	**1137**	**1143**	**352**	**850**	**5477**
Industrial Sources							
Cement and Concrete Industry	-	-	24	-	-	-	24
Chemicals Industry	-	29	70	-	-	51	149
Electric Power Generation (Utilities)	15	1301	439	-	3	-	1758
Oil Sands	14	1435	365	270	17	14	2115
Other Industries	22	68	38	25	-	-	154
Petrochemical Industry	-	-	25	-	-	-	25
Petroleum Refining	-	60	23	-	-	-	83
Pulp and Paper Industry	-	49	26	-	3	-	78
Upstream Oil and Gas Industry	33	1467	1893	1384	105	19	4902
Wood Industry	-	-	-	21	9	-	31
Total Industrial	**84**	**4409**	**2904**	**1700**	**138**	**84**	**9319**
Total Non-industrial and Industrial	**2044**	**4443**	**4041**	**2843**	**490**	**934**	**14796**

"-" sector emitted <1% of total in 2005.

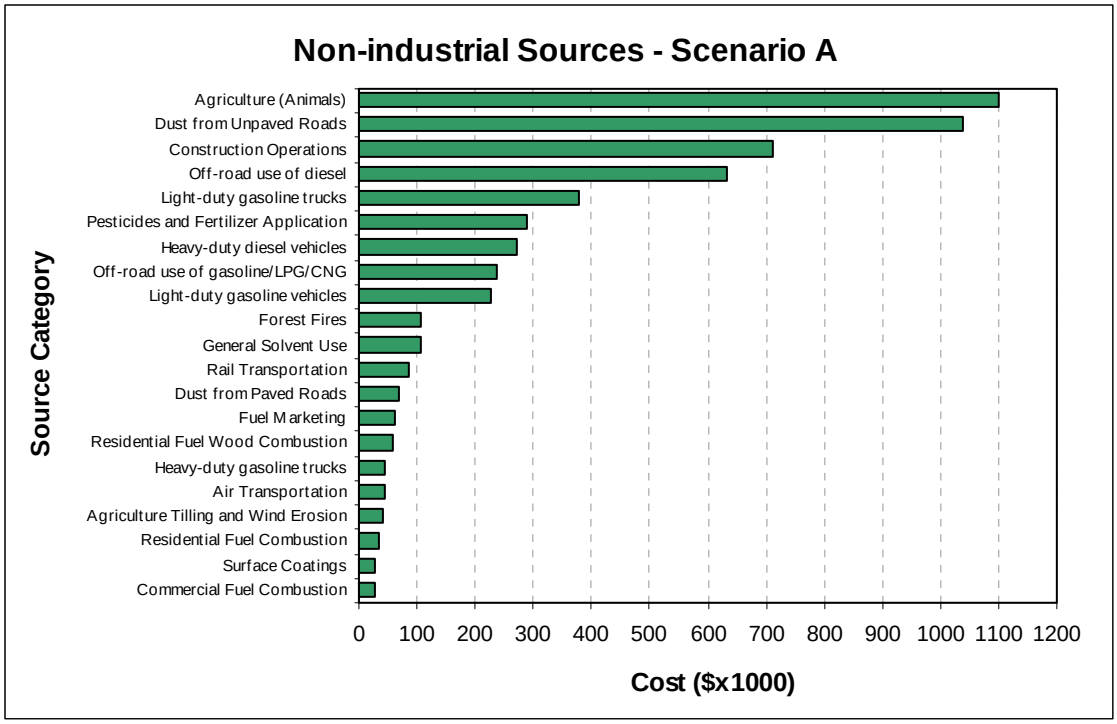


Figure F3. Cost of monitoring for non-industrial sectors in Year 5 for Scenario A.

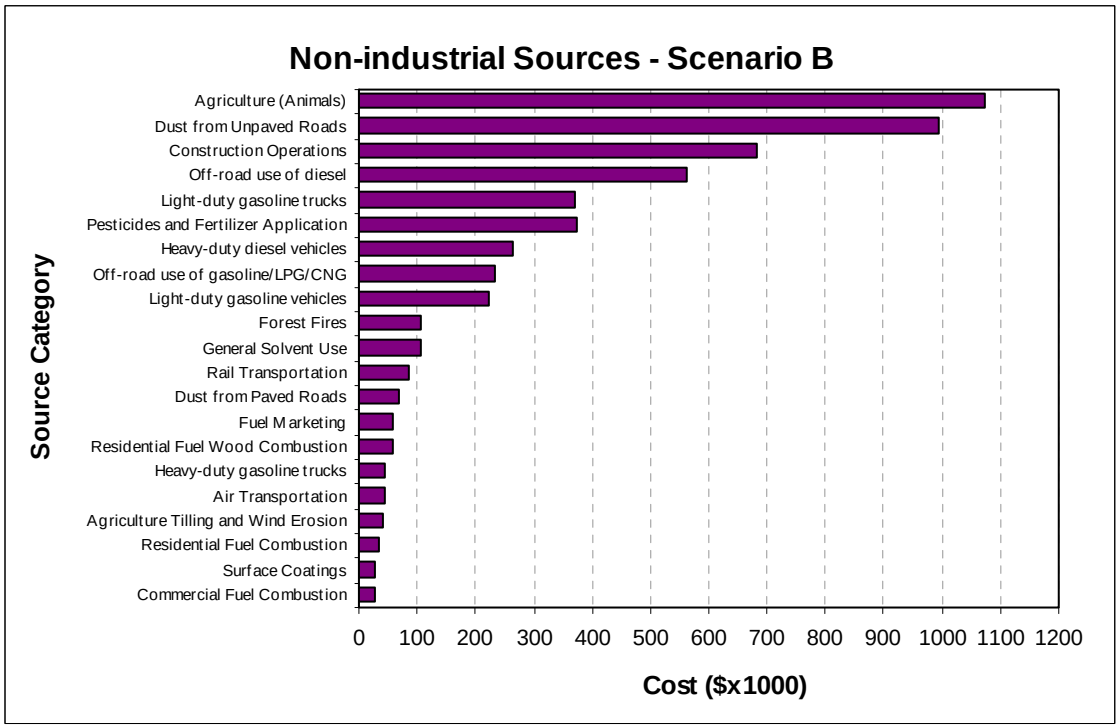


Figure F4. Cost of monitoring for non-industrial sectors in Year 5 for Scenario B.

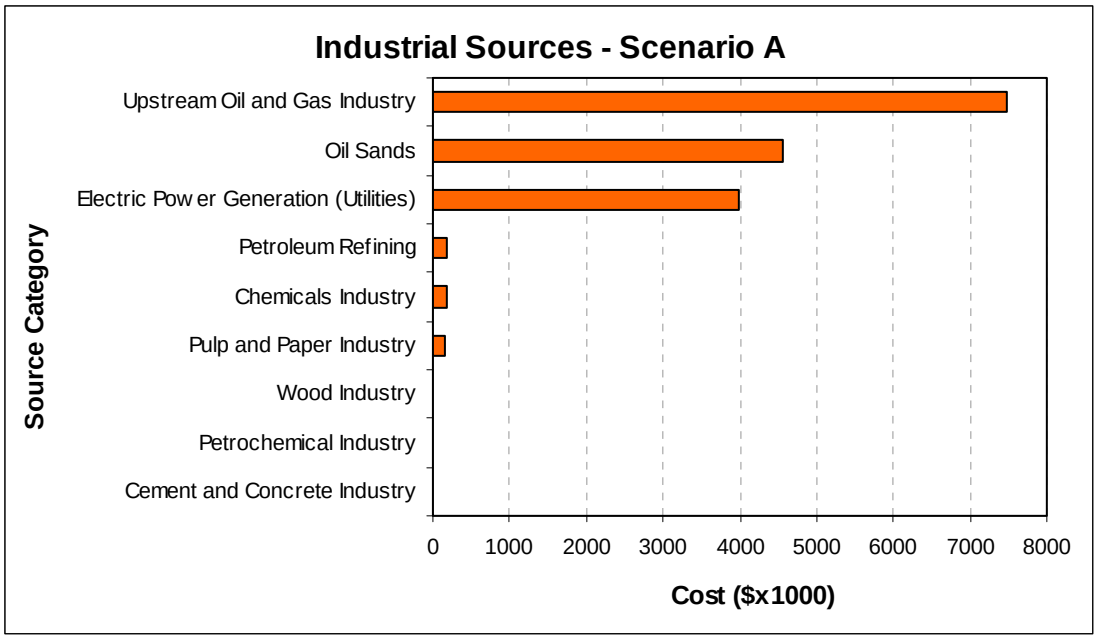


Figure F5. Cost of monitoring for industrial sectors in Year 5 for Scenario A.

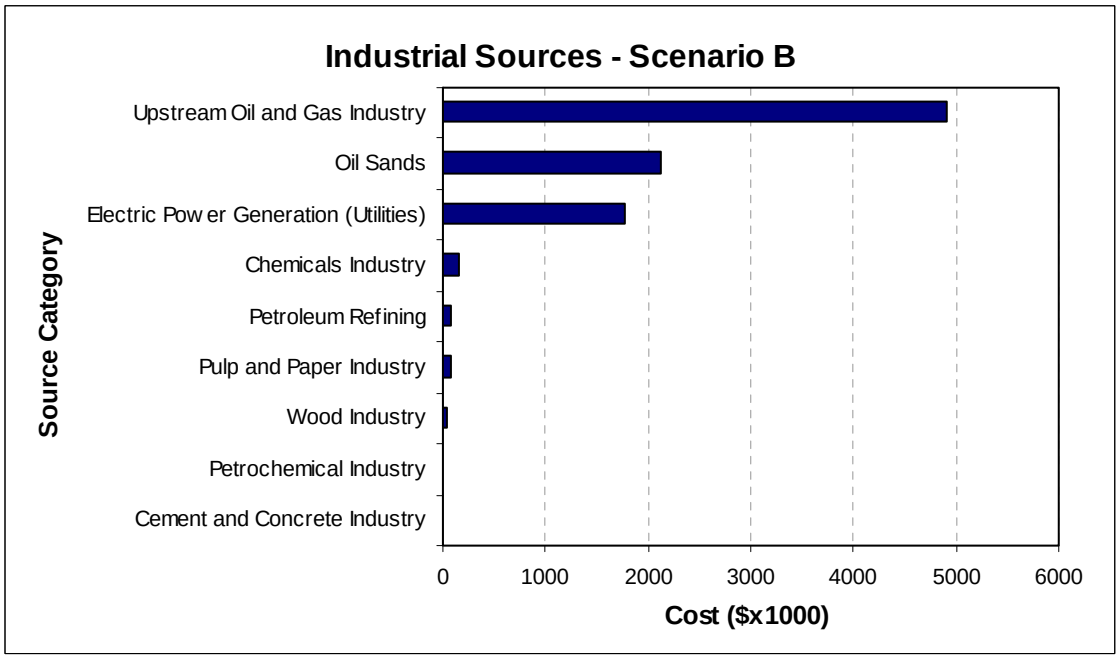


Figure F6. Cost of monitoring for industrial sectors in Year 5 for Scenario B.

Step 7 – Prepare Summary of Total Costs

As shown in Figure F7, the current air monitoring network in Alberta costs $18 million to operate on an annual basis (including 10% capital replacement costs) with approximately 85% of these costs paid for by industry and 15% paid for by government (federal, provincial and municipal). The annual operating costs for the entire network after the provincial monitoring network is completely in place (Year 5) are estimated at $23 million. Based on the funding formula, 74% of these costs should be attributed to industrial sources and 26% should be attributed to non-industrial sources. Figure F8 shows this cost breakdown.

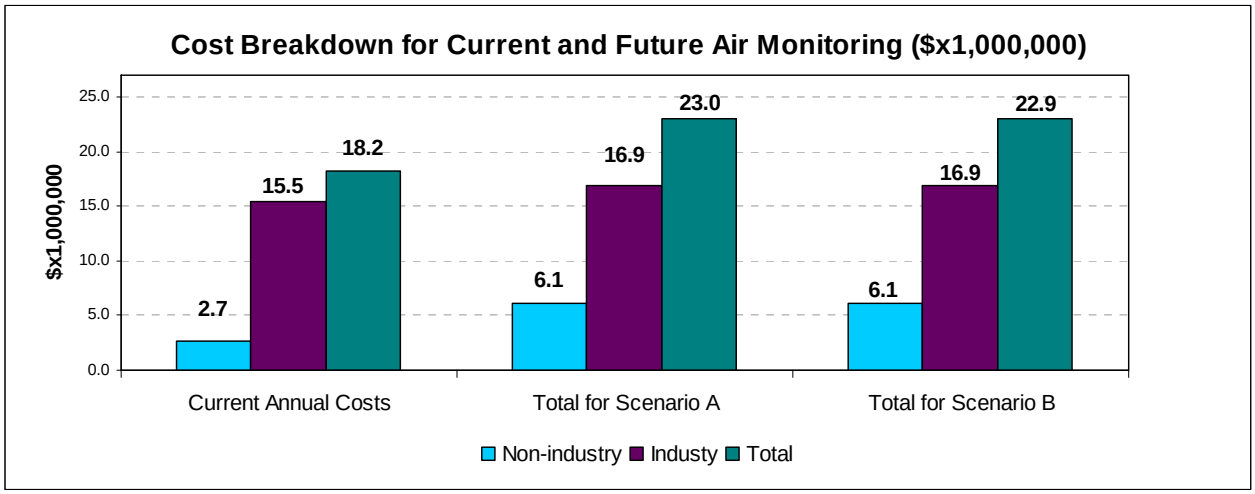


Figure F7. Cost Breakdown for the New Air Monitoring System

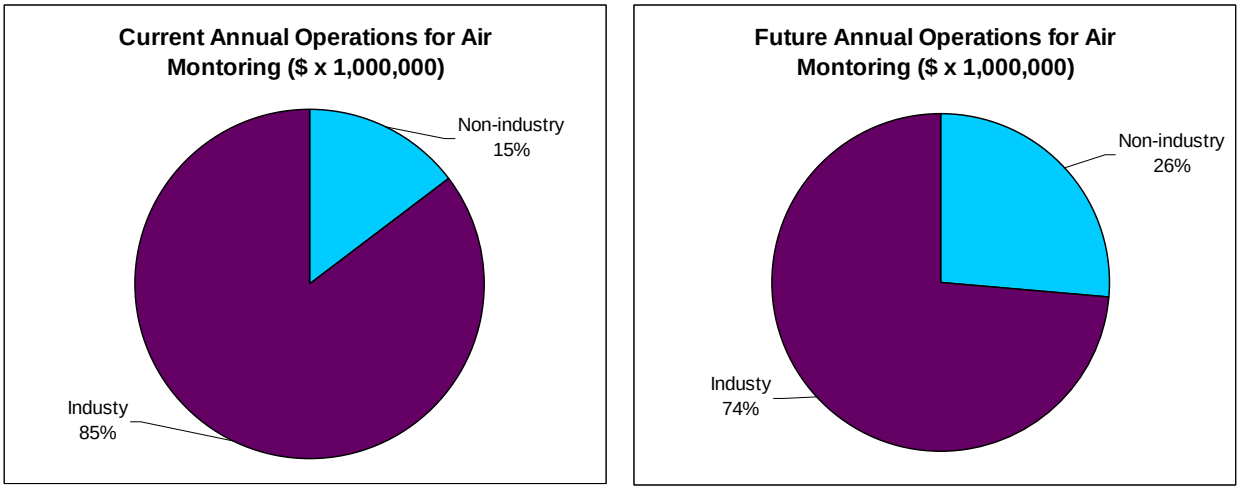


Figure F8. Current and Future Annual Operating Costs for the New Air Monitoring System

Appendix G: Environment Canada 2005 Criteria Air Contaminant Emissions for Alberta

(in tones)

CATEGORY / SECTOR / PROVINCES	TPM	PM_{10}	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
INDUSTRIAL SOURCES								
Abrasives Manufacture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aluminum Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asbestos Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asphalt Paving Industry	12,488.7	1,873.9	624.9	4.5	8.8	6.5	88.6	0.0
Bakeries	0.0	0.0	0.0	0.0	0.0	355.2	0.0	0.0
Cement and Concrete Industry	5,700.7	1,866.3	758.2	1,828.1	4,674.3	0.0	2,031.5	0.0
Chemicals Industry	1,015.6	709.1	504.7	2,899.2	13,479.0	946.9	4,316.2	6,642.9
Clay Products Industry	25.7	7.5	4.7	0.0	0.0	0.0	0.0	0.0
Coal Mining Industry	2,392.3	1,300.0	772.7	652.7	358.1	250.8	0.0	0.0
Ferrous Foundries	86.5	81.9	76.2	0.4	1.5	1.5	817.5	0.0
Grain Industries	5,682.2	1,437.4	240.9	0.0	0.0	0.0	0.0	0.0
Iron and Steel Industries	153.4	92.7	54.2	60.2	215.1	65.5	478.8	0.0
Iron Ore Mining Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mining and Rock Quarrying	7,661.6	794.6	690.2	0.0	0.0	0.0	0.0	300.7
Non-Ferrous Mining and Smelting Industry	26.2	25.8	3.2	0.0	0.0	0.0	0.0	160.0
Oil Sands	5,510.9	3,906.4	2,379.7	143,973.7	70,679.8	57,655.5	57,020.0	1,831.6
Other Petroleum and Coal Products Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paint & Varnish Manufacturing	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0
Petrochemical Industry	674.1	647.5	169.9	96.9	4,885.7	1,942.0	2,046.2	1.2
Petroleum Refining	825.7	589.3	351.1	6,015.9	4,513.0	1,821.0	3,191.6	18.8
Plastics & Synthetic Resins Fabrication	6.9	6.2	6.2	0.0	0.0	143.8	59.9	0.0
Pulp and Paper Industry	1,485.9	1,089.8	849.1	4,927.7	5,025.9	839.0	9,025.8	344.3
Upstream Oil and Gas Industry	5,697.7	5,658.2	5,637.2	147,202.5	366,155.5	296,122.7	349,138.9	2,514.8
Wood Industry	4,151.6	1,842.5	965.2	2.5	2,745.0	4,556.5	31,355.5	38.3
Other Industries	9,451.9	5,905.5	3,863.9	6,814.8	7,387.7	5,367.9	5,592.7	239.4
TOTAL INDUSTRIAL SOURCES	**63,037.6**	**27,834.6**	**17,952.2**	**314,479.1**	**480,129.4**	**370,084.8**	**465,163.2**	**12,092.0**
NON INDUSTRIAL FUEL COMBUSTION								
Commercial Fuel Combustion	548.8	525.9	510.4	1,352.0	5,110.2	268.9	4,019.6	31.4
Electric Power Generation (Utilities)	8,615.2	5,394.0	2,617.8	130,475.9	84,913.0	575.3	11,412.0	157.2
Residential Fuel Combustion	560.2	546.8	534.6	76.8	6,605.4	384.9	2,783.2	36.8
Residential Fuel Wood Combustion	4,525.8	4,308.3	4,294.5	56.9	398.4	5,113.3	26,539.5	35.9
TOTAL NON INDUSTRIAL FUEL COMBUSTION	**14,250.0**	**10,775.0**	**7,957.3**	**131,961.6**	**97,027.0**	**6,342.4**	**44,754.3**	**261.3**
TRANSPORTATION								
Air Transportation	175.0	175.0	170.0	595.4	7,884.0	1,497.6	9,926.1	5.0
Heavy-duty diesel vehicles	1,384.7	1,384.7	1,278.6	822.6	50,515.6	1,912.7	11,309.3	99.4
Heavy-duty gasoline trucks	92.8	90.1	75.0	19.5	6,606.8	2,132.0	36,190.5	58.1
Light-duty diesel trucks	151.5	151.5	139.8	100.0	1,510.7	634.4	1,152.3	7.3
Light-duty diesel vehicles	8.9	8.9	8.2	4.1	90.1	29.8	99.3	0.6

CATEGORY / SECTOR / PROVINCES	TPM	PM_{10}	$PM_{2.5}$	SO_X	NO_X	VOC	CO	NH_3
Light-duty gasoline trucks	170.5	165.5	127.7	102.2	20,831.8	26,046.9	438,842.8	1,189.3
Light-duty gasoline vehicles	45.0	43.7	39.9	54.1	12,398.5	16,583.2	249,763.2	940.7
Marine Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Motor cycles	3.5	3.4	2.3	0.4	220.2	395.0	2,685.3	1.8
Off-road use of diesel	8,175.6	8,175.6	7,930.3	3,464.4	82,827.7	8,676.4	42,476.8	56.9
Off-road use of gasoline/LPG/CNG	582.1	582.1	539.6	9.3	10,939.5	19,737.1	276,648.2	7.3
Rail Transportation	559.2	559.2	514.4	718.9	16,262.8	412.3	2,221.1	13.7
Tire wear & Brake lining	648.8	641.8	221.5	0.0	0.0	0.0	0.0	0.0
TOTAL TRANSPORTATION	**11,997.6**	**11,981.5**	**11,047.3**	**5,890.9**	**210,087.7**	**78,057.4**	**1,071,314.9**	**2,380.1**
INCINERATION								
Crematorium	0.5	0.5	0.5	0.6	3.7	0.2	1.7	0.0
Industrial & Commercial Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Incineration & Utilities	0.4	0.1	0.1	164.8	15.8	146.8	3.5	634.9
TOTAL INCINERATION	**0.9**	**0.6**	**0.6**	**165.4**	**19.5**	**147.0**	**5.2**	**634.9**
MISCELLANEOUS								
Cigarette Smoking	55.2	55.2	55.2	0.0	0.0	0.9	261.1	9.7
Dry Cleaning	0.0	0.0	0.0	0.0	0.0	17.2	0.0	0.0
Fuel Marketing	0.0	0.0	0.0	0.1	0.0	12,828.3	0.0	0.0
General Solvent Use	0.0	0.0	0.0	0.0	0.0	22,644.0	0.0	45.9
Marine Cargo Handling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat Cooking	805.4	805.4	805.4	0.0	0.0	0.0	0.0	0.0
Pesticides and Fertilizer Application	2,989.3	1,464.8	418.5	0.0	0.0	0.0	0.0	49,089.7
Printing	0.0	0.0	0.0	0.0	0.0	946.7	0.0	0.0
Structural Fires	28.8	28.8	26.7	0.0	0.0	29.4	160.2	1.7
Surface Coatings	0.0	0.0	0.0	0.0	0.0	5,919.2	0.0	0.0
Human	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.7
Other Miscellaneous Sources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL MISCELLANEOUS	**3,878.7**	**2,354.2**	**1,305.8**	**0.1**	**0.0**	**42,385.7**	**421.3**	**49,201.7**
OPEN SOURCES								
Agriculture (Animals)	118,543.0	75,867.5	11,854.3	0.0	0.0	116,941.1	0.0	80,865.5
Agriculture Tilling and Wind Erosion	506,777.8	247,436.5	6,915.1	0.0	0.0	0.0	0.0	0.0
Construction Operations	1,966,657.1	590,005.3	118,009.7	0.0	0.0	0.0	0.0	0.0
Dust from Paved Roads	253,861.2	48,656.7	11,635.3	0.0	0.0	0.0	0.0	0.0
Dust from Unpaved Roads	3,754,295.6	1,140,068.6	172,248.1	0.0	0.0	0.0	0.0	0.0
Forest Fires	8,911.5	7,574.8	6,238.1	5.2	2,338.0	10,064.8	73,389.0	157.3
Landfills Sites	411.4	34.2	10.4	0.0	9.3	952.8	0.0	61.0
Mine Tailings	821.8	65.7	16.4	0.0	0.0	0.0	0.0	0.0
Prescribed Burning	206.3	206.3	206.3	12.9	77.4	386.8	1,083.0	8.3
aTOTAL OPEN SOURCES	**6,610,485.7**	**2,109,915.6**	**327,133.7**	**18.1**	**2,424.7**	**128,345.5**	**74,472.0**	**81,092.1**
PROVINCIAL TOTAL								
TOTAL WITH OPEN SOURCES	**6,703,650.5**	**2,162,861.5**	**365,396.9**	**452,515.2**	**789,688.3**	**625,362.8**	**1,656,130.9**	**145,662.1**
TOTAL WITHOUT OPEN SOURCES	**93,164.8**	**52,945.9**	**38,263.2**	**452,497.1**	**787,263.6**	**497,017.3**	**1,581,658.9**	**64,570.0**

Notes:
1. The emissions inventory was compiled in collaboration with the provincial, territorial, and regional environmental agencies using the latest emission estimation methodologies and statistics available as of March 2007. It represents the most comprehensive emissions information available for Canada and may be different from the emission summaries previously published by Environment Canada and other governmental agencies.
2. The numbers may not add to totals, due to rounding.
3. Source: Environment Canada, March 2007. http://www.ec.gc.ca/pdb/cac/Emissions1990-2015/2005/2005_AB_e.cfm

Appendix H: Alternative Wording for Funding of AMSP

Alberta Environment has not agreed to Recommendations 20 and 21 as they are currently stated in the AMSP:

Recommendation 20: Funding to implement the enhanced ambient air monitoring system
The AMSP Project Team recommends that:

a) Alberta Environment commit to annual funding through the Government of Alberta's budgeting process to cover the cost of monitoring emissions attributed to diffuse emitters.
b) Large and small industrial emitters fund their portion of the enhanced provincial network according to the funding formula.
c) For large industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees industry's funding contribution to the enhanced network by committing to pursue payment through regulatory mechanisms.
d) For small industrial emitters that don't provide funding voluntarily, Alberta Environment guarantees small industry's contribution to the network by either pursuing payment through regulatory mechanisms or covering their contribution and then retroactively applying the long-term funding mechanism when it is implemented.

Recommendation 21: Ensuring long-term sustainable funding
The AMSP Project Team recommends that:

1. *To ensure long-term sustainable funding for the Ambient Monitoring Strategic Plan (i.e., after the first four years), Alberta Environment develop within two years, a sustainable long-term funding mechanism that ensures equitable contributions from large industrial, small industrial and diffuse emitters.*
2. *Alberta Environment implement this funding mechanism in the subsequent two years.*

The Government of Alberta cannot provide the funding certainty implied by these recommendations. The following is the recommended implementation strategy proposed by AENV. The funding obtained will honour the funding principles of the AMSP.

Funding to implement the enhanced ambient air monitoring system

- Alberta Environment will place a high priority on using existing resources to implement new air monitoring proposed by the strategic plan and will investigate other potential equitable funding opportunities.
- In the short-term (12 to 24 months after CASA Board acceptance) Alberta Environment will focus on implementing monitoring that supports the immediate priorities indicated in the AMSP, such as monitoring necessary to implement the particulate matter and ozone management plans developed for the Edmonton and Calgary areas.
- Alberta Environment will assure that the implementation strategy for the AMSP is consistent with the priorities of the future Clean Air Strategy and Land-use Regional Plans being developed through the Land-use Framework.

Ensuring long-term sustainable funding

- Within 18 months after CASA Board acceptance, Alberta Environment will develop options for a sustainable long-term funding mechanism that assures equitable contributions from large industrial, small industrial and diffuse emitters. Alberta Environment will champion the

implementation of a sustainable long-term funding mechanism within three years of CASA Board acceptance. The funding mechanism will be coordinated and consistent with the future Clean Air Strategy and Land-use Regional plans.

- Alberta Environment will report to the CASA Board annually on the status of the funding mechanism.

Appendix I: Existing Data Management System

The original principles for the data management system recommended in the 1995 plan were that:

- It provide reliable and flexible information access, retrieval, archiving, and utilization, based on credible data management procedures.
- Data must be secure.
- There would be responsible data ownership and coordination between owners.
- There would be a horizontal flow of information to all stakeholders.
- It could transfer information vertically between various scales of monitoring.

Air monitoring data is currently managed through several different systems operated by Alberta Environment and airshed associations. Alberta Environment manages the operations of the CASA Data Warehouse, the central archive for air quality data in the province. In addition, the need for timely air quality data and information has lead to the development of Alberta Environment's real-time air quality system and several real-time air quality systems developed by airshed zone associations.

I.1 CASA Data Warehouse

The CASA Data Warehouse is the central data management system for air monitoring stations that are part of the provincial ("backbone") monitoring network described in the Introduction of this report. Additional air monitoring stations operated by airshed zones also provide data to the warehouse on a voluntary basis. The Data Warehouse currently contains continuous (hourly) data from over 40 provincial and airshed monitoring stations. Non-continuous data collected by *active integrated* and passive air monitoring methods is also contained in the data warehouse for some Alberta Environment and airshed monitoring stations. The original intent of the CASA Data Warehouse was also to contain data collected by ecological monitoring programs, but this data has not been submitted to the warehouse. Alberta Environment is in the process of loading historical non-continuous particulate, volatile organic compound, polycyclic aromatic hydrocarbon, passive and precipitation quality data into the CASA Data Warehouse. The quality of the data contained in the data warehouse is the responsibility of the data provider.

I.2 Other Air Quality Websites

Current air quality conditions are available to the public through Alberta Environment's real-time air quality reporting system. This system gives Albertans access to air quality data collected at Alberta Environment and airshed monitoring stations. This system allows transparent user access to the Air Quality Index and individual air parameter levels through a: (1) GIS map of Alberta; (2) time series line graph; and (3) tabular output. These features enable the user to view air pollutant levels for a specific portion of the province. The user can also view air pollutant levels over the previous 45 days either on the GIS map or with graphical and tabular displays. This component of the application is useful for looking at changes in air pollutant levels over time and for comparing levels between monitoring locations. Alberta Environment's real-time website is accessible at http://environment.alberta.ca/933.html.

Data collected by most airshed zones is also available in real-time from the specific airshed websites. Most of these websites present the data in graphical and tabular formats. Some websites also have air quality presented in terms of Alberta's Air Quality Index as well as current weather conditions. Data can be accessed through the following airshed websites:

- ACAA - http://www.capitalairshed.ca./
- CRAZ - http://www.craz.ca/
- FAP - www.fortair.org
- LICA - www.lica.ca
- PAMZ - www.pamz.org
- PAS - www.palliserairshed.ca
- PASZA - www.pasza.ca
- WBEA - www.wbea.org
- WCAS - www.wcas.ca

Alberta data collected at National Air Pollution Surveillance (NAPS) network monitoring stations are available at the Environment Canada Environmental Technology Centre website at www.etcentre.org/NAPS/index_e.html. A password is needed to access data from the NAPS website.

Environment Canada has entered into an agreement with most airsheds in the province to share data with the US EPA "AIRnow" site. Environment Canada is relaying air quality data in real time, when it is available, for 24 ozone sites, 24 $PM_{2.5}$ sites and 5 PM_{10} sites. Time delays currently prevent this data from being displayed in real time but the data are merged with other North American data to provide spatial coverage for all lower 48 states and much of the southern portions of Canada, and can be seen for the previous day. Once the data transmission times are reduced there should be maps available covering Alberta as well. The site is at http://airnow.gov/index.cfm?action=airnow.canadamaps. In the near future it is expected that additional parameters such oxides of nitrogen will be added.

Appendix J: Ambient Monitoring Strategic Planning Team Members

Current Members

Name		Organization
Angela	Ball	TransAlta Generation Partnership
Michael	Bisaga	Lakeland Industrial & Community Association
Kerra	Chomlak	Clean Air Strategic Alliance
Kim	Eastlick	Energy Resources Conservation Board
Linda	Jabs	CASA
Myles	Kitagawa	Toxics Watch Society of Alberta
Findlay	MacDermid	RAPID
Bettina	Mueller	Alberta Environment
Keith	Murray	Alberta Forest Products Association
Bob	Myrick	Alberta Environment
Ken	Omotani	TransAlta Generation Partnership
Mike	Pawlicki	Lafarge Canada Inc.
Ian	Peace	RAPID
Roxanne	Pettipas	Canadian Association of Petroleum Producers (CAPP)
Krista	Phillips	Canadian Association of Petroleum Producers
Chris	Baker	Pembina Institute
David	Spink	Prairie Acid Rain Coalition
Karina	Thomas	Alberta Health and Wellness
Merry	Turtiak	Alberta Health and Wellness
James	Vaughan	Energy Resources Conservation Board
Kevin	Warren	Parkland Airshed Management Zone
Brian	Wiens	Environment Canada

Former Members

Justin	Balko	Alberta Health and Wellness
Rob	Bioletti	Alberta Environment
Matthew	Dance	Matthew Dance Consulting
Brian	Free	Alberta Environment
David	Graham	Alberta Environment
Bill	Hume	Environment Canada
Heidi	Jelinski	Hyde Technologies Inc.
Phyllis	Kobasiuk	Beacon for Change Inc.
Carolyn	Kolebaba	Alberta Association of Municipal Districts & Counties
Alexander	MacKenzie	Alberta Health and Wellness
David	McCoy	Husky Oil
Myra	Moore	Fort Air Partnership
George	Pfaff	Petro-Canada
Mike	Queenan	(ESPACE)
B. J. (Brendan)	Vickery	Lafarge Canada, Inc.
Mike	Zemanek	B.C. Government