PRINCE GEORGE air IMPROVEMENT ROUNDTABLE

PRINCE GEORGE AIR QUALITY MANAGEMENT PLAN

PHASE 3 PLAN FINAL REPORT

MARCH 2018

ACKNOWLEDGEMENTS

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Gail Roth is a valuable member of the PGAIR in her capacity as Air Quality Meteorologist with the Ministry of Environment and Climate Change Strategy (ENV) in Prince George. Her commitment to the roundtable is exceptional, as she goes above the demands of her role with ENV to support the roundtable and the community in achieving its goals. Her input to this report was substantial, and very much appreciated. Thank you, Ms. Roth.

The PGAIR Operations Committee members volunteer their time to PGAIR and provided valuable feedback as well as historic knowledge to Phase 3 Plan Final Report. Thank you to all of the members of the Prince George Air Improvement Roundtable Operations Committee.

EXECUTIVE SUMMARY

The Prince George Air Improvement Roundtable (PGAIR) is a volunteer planning group that evolved from the Airshed Technical Management Committee formed in 1995. PGAIR continues to support the multi-jurisdictional nature of air quality management in the airshed through its broad multi-stakeholder roundtable structure. It maintains a focused management effort on air quality issues in Prince George.

The aim of this report is to communicate the results and achievements of work undertaken in the Prince George airshed by the Prince George Air Improvement Roundtable and its member agencies toward the improvement of air quality between 2011 and 2016. The *Phase 3 Implementation Plan* (2011-2016) built on the work carried out under Phases 1 and 2, and concentrated efforts towards reducing particulate matter (most specifically $PM_{2.5}$) from a variety of sources in the airshed.

Phase 3 targets aimed to:

- maintain ambient $PM_{2.5}$ concentrations equal to or more stringent than provincial, national and international ambient air quality objectives:
  - daily $PM_{2.5}$ average not to exceed 25 µg/m^3 by 2013;
  - annual average $PM_{2.5}$ concentrations not to exceed 6 µg/m^3 by 2013 and 5 µg/m^3 by 2016;
- reduce the amount of $PM_{2.5}$ being released into the Prince George airshed from significant sources by 40% by 2016;
- reduce PM emissions in the Prince George airshed by implementing source-specific reduction strategies for 2011-2016 and beyond.

The members of the roundtable recognized that meeting these goals and implementing the key strategies would not be possible without a combination of land use planning and voluntary, educational and regulatory efforts. PGAIR served to coordinate efforts and information sharing between member organizations. It also served as the lead for research, public awareness and educational initiatives. Member organizations focused efforts on investigating and implementing actions relevant to each of the key strategies. The results achieved under the Phase 3 Implementation Plan represent a co-operative effort by all sectors and all members of the community.

Particulate Matter

Particulate matter is an air pollutant that comes from many different sources. It is most commonly measured according to its size. The two most common size fractions are $PM_{2.5}$ and PM_{10}. Both of these size fractions are respirable, can be breathed deep into the lungs, and have the potential to impact human and environmental health.

Reviewing the outcomes of Phase 3 demonstrates notable successes, shortcomings, and highlights some of the challenges of airshed management in Prince George. While none of the ambient $PM_{2.5}$ targets were met every year,

- daily $PM_{2.5}$ concentrations remained at or below 25 $\mu g/m^3$ for an average of 360.17 days per year over the 2011-2016 period, and
- annual average $PM_{2.5}$ concentrations were at or below 6 $\mu g/m^3$ for four out of the six years.

Even more, a detailed evaluation of ambient $PM_{2.5}$ concentrations and trends revealed that significant, measureable reductions of $PM_{2.5}$ have been realized in the city, particularly for the heavy industrial sector situated to the east of downtown (Jackson et al., 2017). This same evaluation identified that the Phase 3 goals were quite rigid and did not account for the 'unmanageable' component of $PM_{2.5}$ (e.g. naturally existing sources and external influences such as forest fire smoke). It was also highlighted that future goals will need to consider recent changes to monitoring technology that now measures $PM_{2.5}$ concentration more completely. Recommendations regarding these factors outlined in the report will be considered for future goal setting.

Research conducted in Phases 1 and 2 identified several major sources that contribute $PM_{2.5}$ emissions from within the Prince George airshed including permitted and non-permitted industry, commercial activities, dust, transportation and wood burning. Some of these emission sources are particularly challenging to address: they are not regulated, and they are distributed across the city`s landscape, making them impractical to measure on a regular basis. For this reason, the overall success of the 40% emissions reduction target is difficult to quantify. Residential heating and wood burning remain important areas for improvement, and strategies to reduce these include education and outreach as major components.

As a partial indicator, air emissions data available from permitted industries (collected by ENV) was reviewed. Major point sources of PM (e.g. large industrial stacks) show a substantial decrease in emissions over time. This trend corresponds with the findings of the Jackson et al. (2017) evaluation.

Many strategic efforts towards reducing $PM_{2.5}$ emissions were implemented. Some notable highlights include the implementation of the City's Clean Air Bylaw, which saw early enforcement of restrictions on outdoor burning activities in the city; the coordination of the Provincial Woodstove Exchange Program at the local and Regional District level; and ongoing communication with the public about the impacts of local and regional air quality events, alongside strategic partners such as the Ministry of Environment and Climate Change Strategy and the Northern Health Authority. Perhaps the largest improvement in PM emissions can be attributed to technology upgrades by industrial partners.

Overall, PGAIR worked to implement strategies outlined in the Phase 3 Implementation Plan through developed networks and partnerships. Progress was made on nearly every identified strategy, and of course, some areas saw more success than others. Most of the strategies are long-term in their scope and results are difficult to quantify. The greatest success by PGAIR, however, is in the engagement of the overall community, which includes residents, businesses and industry, and government at all levels. This community connection will be critical in the move forward into the next phase.

PGAIR is guided in the next phase by the Strategic Plan (2017-2021), which builds on successes of working together at the local level and encourages further improvements across all sectors. The Strategic Plan recognizes that further work is needed to continue to reduce PM emissions across all sectors to ensure a long-term healthy and sustainable community. PM will remain as a priority for PGAIR since research clearly demonstrates its association with negative health outcomes for exposed populations (Brook et al. 2010). Future planning will also include a review of other pollutants, which will be considered for inclusion in air quality management activities under the 2016-2021 Strategic Plan.

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1.0 INTRODUCTION

Particulate matter (PM) has been a significant air quality issue in the Prince George airshed since at least the 1980s, and has been monitored as PM_{10} and $PM_{2.5}$ since 1992. Exposure to PM, especially the finer fraction such as $PM_{2.5}$ is linked to a wide variety of human health impacts, including acute respiratory symptoms, chronic bronchitis, decreased lung function, cardiovascular disease and premature death. (Kim et al. 2015)

Actions taken under the Prince George Air Quality Management Plan (Phases 1 and 2) since 1995 to reduce fine PM in the Prince George airshed have been met with some success, achieving reductions in the coarser fraction ($PM_{2.5-10}$) through measures such as road dust sweeping programs and the application of coarser winter traction material. Improvements in $PM_{2.5}$ levels have been slower, with a downward trend emerging.

This is the final report of the Phase 3 Plan, which builds on management actions identified in Phases 1 and 2. The focus of the community air quality targets is reducing $PM_{2.5}$ emissions, and this is reflected in the management actions taken during Phase 3. This report will summarize current air quality trends, outline successes achieved during the Phase 3 Plan, and outline the future direction for work to be done in the airshed by PGAIR, its member agencies and the residents of Prince George.

2.0 BACKGROUND

2.1 AIR QUALITY TRENDS IN PRINCE GEORGE

An airshed is known as an area where the movement of air is restricted by geographic features and by weather patterns [B.C. Airsheds,online, December 2017]. Prince George's airshed is strongly affected by its location at the confluence of two large rivers: the Nechako River and the Fraser River. Their river valleys form a large depression that is occupied by the main developed part of the city known as the 'bowl' area. Residential and industrial development, as well as the Prince George Airport, characterizes the upland parts of the city. Beyond the city's developed boundaries is forest and agricultural land, along with rural residential properties.

Prince George is subject to a variety of factors that can combine to create air quality problems in the airshed. Prince George has numerous pollutant sources within its boundaries, such as heavy industry, (including the pulp and paper industry and the petroleum refining industry), residential heating and wood smoke, road dust and transportation emissions. Combined with frequent light winds and wintertime thermal inversions, these conspire with valley terrain to trap pollutants where a high density of people live and work.

In addition to those sources located within the city's boundaries, Prince George has been subject to external sources of pollutants from wildfires. High levels of particulate matter from wildfire smoke can represent a significant contribution to Prince George's airshed in a given year, depending on a variety of factors including winter snow pack and spring and summer weather patterns.

Several pollutants types are monitored throughout the Prince George airshed in order to supply information to Provincial government, local governments, stakeholders, and members of the public for the purpose of responding to changes or threats. This air quality data collection is carried out by a network of air quality monitors operated by the Ambient Air Quality Monitoring Working Group in collaboration with the Ministry of Environment and Climate Change Strategy (ENV). For more information about the group, *see Appendix C*. Many communities also support an air quality management committee or task force aimed at bringing stakeholders together in a roundtable format, where each member has an equal opportunity for input. In Prince George, the Prince George Air Improvement Roundtable fulfills this community-based function.

3.0 AIR QUALITY MANAGEMENT IN PRINCE GEORGE

3.1 PRINCE GEORGE AIR IMPROVEMENT ROUNDTABLE (PGAIR)

Since 1995, air quality management in the Prince George airshed has been coordinated through a community-based, multi-stakeholder group – now a non-profit society known as the Prince George Air Improvement Roundtable (PGAIR) – comprised of representatives (largely volunteers) from provincial, municipal and regional governments, Northern Health, industry, business and community groups, the public, and the University of Northern BC.

The current membership and structure of PGAIR is illustrated in *Figure 1*. The Fraser Basin Council provides secretariat support to PGAIR. The Ambient Air Quality Monitoring Working Group is an arms-length body, made up of members from the industrial sector whose emissions contribute significantly to pollutant levels in the airshed. Their financial contributions support the air quality monitoring network in Prince George, and provide data to PGAIR towards managing goals and targets *(see Appendix C for more information)*.

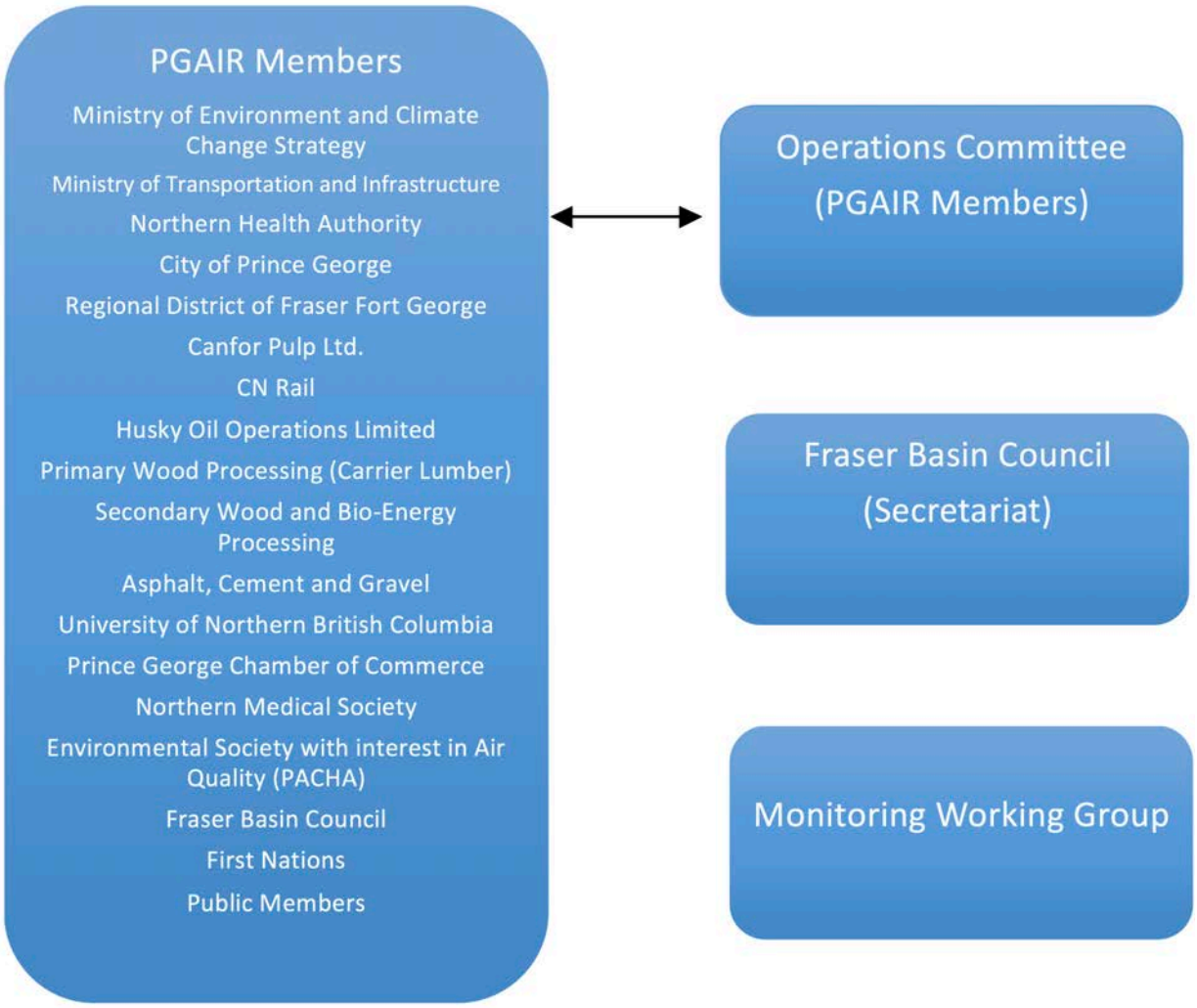

Figure 1: PGAIR organizational structure, with secretariat support from the Fraser Basin Council, and input from the Monitoring Working Group.

Membership in PGAIR is described in the certificate and bylaws of the society, governed by the BC Societies Act (2016), and was originally defined by the Prince George Airshed Technical Committee in their Phase 1 Management Plan report (1998). PGAIR is not a regulatory body and has no jurisdiction over air quality. Instead, PGAIR is responsible, through consensus-based and science-based decision making,[1] for developing and (in part) implementing the Prince George Air Quality Management Plan (Plan).[2] The Plan sets out recommendations for voluntary actions intended to help improve local air quality, in particular, to achieve and maintain acceptable air quality by reducing the emission of those air contaminants that are causing unacceptable air quality, and to prevent future air quality problems from developing.

Development and implementation of the Phase 1, Phase 2, and Phase 3 Management Plans were guided by the following principles:

- Acceptable air quality is everyone's right; protecting air quality is everyone's responsibility;
- Acceptable air quality is an important contributor to a healthy community and a sustainable economy;
- Achieving acceptable air quality requires that local, provincial and, federal government agencies work together. Public and industry commitment to meeting targets is also necessary.

[1] The use of scientific results as a basis for decision-making to implement effective airshed management plans is enshrined in the PGAIR constitution (section 2(c)); similarly, the use of consensus-based decision making is enshrined in the PGAIR bylaws (Part 12) Consensus is defined as "a general agreement by all directors or members, as the case may be, or the lack of expressed objection by a director or member, as the case may be" (section 59).

[2] An air quality management plan provides a non-legal blueprint for managing community development and controlling all air pollution sources within an airshed, and allows the community to focus on those pollutants or issues most important to the community.

3.2 PHASE 1 (1998-2006) AND PHASE 2 (2006-2010)

The Phase 1 Plan, adopted in 1998, identified measures to improve local air quality. In particular, it set out 28 recommendations for actions to reduce and manage sources of fine PM, including industrial emissions, road dust, and residential activities such as old wood burning appliances and open burning. The Plan also addressed land use planning, poor air quality episode management, and monitoring and research requirements for measuring progress and identifying future management needs. The Phase 1 Plan achieved results in a number of areas, including the phasing out of beehive burners, the upgrading of some pollution control equipment at area pulp mills, and the enactment of the City of Prince George *Clean Air Bylaw*.

To continue efforts at improving air quality in Prince George, the Phase 2 Plan was developed in 2006. The Phase 2 Plan represents the bridge between Phase 1 – the completion of the source modeling (dispersion model) study being conducted by the PGAIR Research Working Group (RWG) – and Phase 3, which prioritized $PM_{2.5}$ emission sources for reduction based on the results of this and other research, including a chemical speciation study and the dispersion modelling study. Achievements resulting from work carried out under the Phase 1 and 2 Plans are significant and represent promising signs that management actions undertaken to reduce odour (TRS), PM_{10} and $PM_{2.5}$ have had a positive effect on air quality within the Prince George airshed.

In 2008, at the start of the *Phase 2 Air Quality Management Plan*, $PM_{2.5}$ concentrations were declining relative to previous years. However, $PM_{2.5}$ concentrations in Prince George were still high when compared to other monitored locations across British Columbia (ENV 2008, p28). By Phase 3 (2011), further reductions of $PM_{2.5}$ were observed and annual average concentrations had dropped from 2nd to 6th highest across the province (ENV 2011, pp 22, 26-27, 85), although the overall trend between 2008 and 2011 was unclear. See Figure 2 for the timeline of developments for PGAIR and measures to improve Prince George air quality.

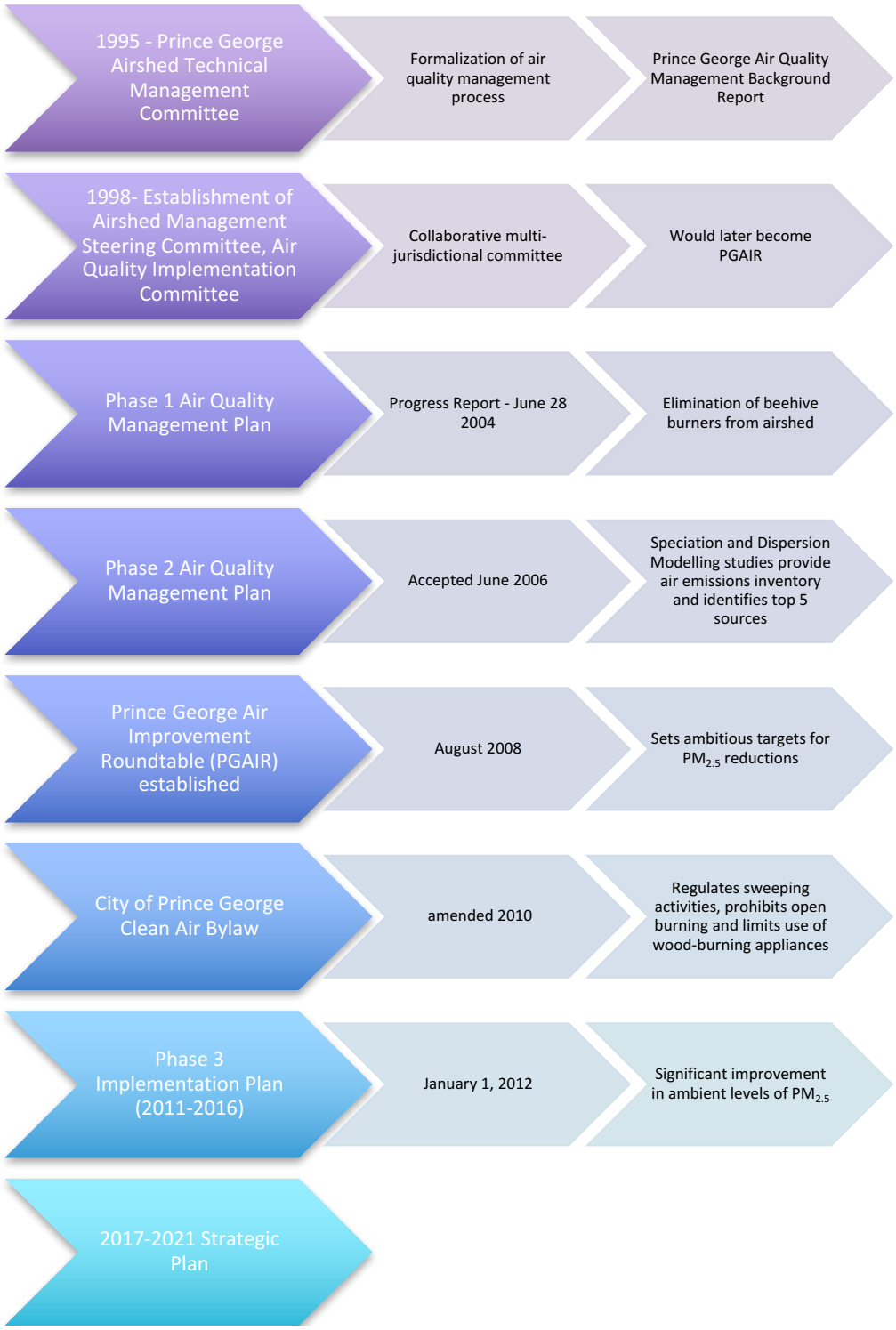

Figure 2: Timeline for development of air quality measures and the creation of PGAIR.

Reconciliation of Sonoma and Stantec studies

Based on the findings of the dispersion model study, there were some areas of disagreement between it and the chemical speciation study in terms of identifying the major sources of fine PM in the Prince George airshed. As such, a critical step in prioritizing sources for reduction under the Phase III Plan was to reconcile, to the extent possible, the major findings and recommendations of the research studies.

The comparison and reconciliation was carried out by members of the Research Working Group with expertise in chemical speciation and/or dispersion modeling, and recommendations were made to PG AIR for consideration and incorporation into management actions.

3.3 PHASE 1 AND 2 ACHIEVEMENTS

Two significant studies were completed during Phase 2. A chemical speciation study and a dispersion modeling study were carried out to identify relative contributions of sources of PM_{10} and $PM_{2.5}$ in the airshed. The results of this research, briefly described below, helped set the goals and targets under the Phase 3 Implementation Plan.

3.3.1 Chemical Speciation Study

A chemical speciation study, which identified the contributions from major contributors of $PM_{2.5}$[5] to the airshed at the Plaza site, was completed by Sonoma Technology, Inc. in 2008.[3]

This study used a particular type of source apportionment, known as receptor modeling, to identify the relative contributions of different $PM_{2.5}$ emission sources in the Prince George airshed. Between December 2004 and March 2006, data (138 24-hour $PM_{2.5}$ filter samples) were collected at the Plaza 400 site. The data (filter samples) were analysed and examined for chemical signatures, which identified the $PM_{2.5}$ sources by comparing them with chemistry samples from local sources or similar source types. The data were examined using two different analytical approaches, chemical mass balance (CMB) and positive matrix factorization (PMF). Comparing the results of both methods provided insight into which sources were clearly identified (i.e. results from both methods agreed), and which were less certain (i.e. the methods produced dissimilar or weakly agreeing results).

The findings of this study indicate that, on average, three major sources contribute generally equal amounts of $PM_{2.5}$ to the Plaza site (see *Table 1* and *Figure 3*):

- Pulp mill emissions (24-25%);
- Wood-burning emissions (18-26%);
- Mobile (including vehicle) emissions (22-24%).

[3] Source Apportionment of $PM_{2.5}$ in Prince George, British Columbia (Sonoma, 2008).

	Average		High Mass Days		Winter		Summer	
	CMB	PMF	CMB	PMF	CMB	PMF	CMB	PMF
Pulp Mill	25	24	27	29	26	25	20	21
Burning	26	18	33	22	32	24	6	0
Carbon (HDDV+LDGV +OtherOC)	24	22	18	24	19	26	40	18
Soil	5	10	4	7	2	4	9	17
Other	20	26	18	18	21	20	25	44

Table 1: Comparison of PMF and CMB source contributions. Average is the overall average (all data); High Mass Days are the days on which the highest 20% of PM2.5 samples were collected. Winter and Summer represent samples collected during each of the respective seasons (Sonoma, 2008).

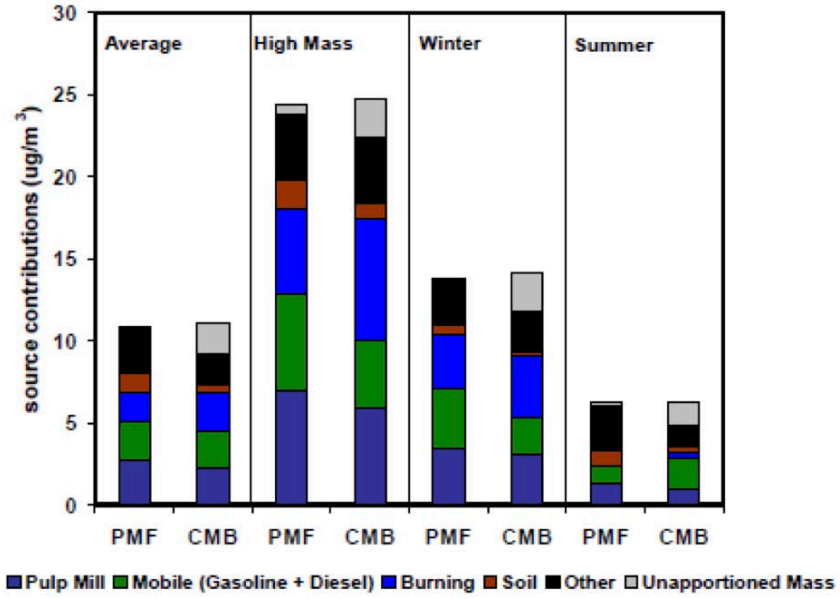

Figure 3: Comparison of PMF and CMB source contributions. Average is the overall average (all data), High Mass is the days when highest 20% of $PM_{2.5}$ samples were collected; Winter days, and Summer days represent samples collected during each of those respective seasons (Sonoma, 2008).

3.3.2 Dispersion Model study

An emissions inventory and dispersion model study was started in 2006 by researchers at UNBC together with the PGAIR Research Working Group (RWG). The study included an extensive micro-emissions inventory that identified all sources of respirable PM (PM_{10} and $PM_{2.5}$) in the Prince George airshed and used the CALMET/ CALPUFF computer model to predict the contribution of each source to ground-level (ambient) fine PM concentrations for the years 2003 to 2005. While the chemical speciation study (described above) provided valuable initial insight about the particulate matter profile in the airshed, the dispersion model study was a necessary component to provide much more detailed and specific information about sources of particulate matter and how they are transported throughout the community. This additional information was needed to thoroughly support the development of the Phase 3 Air Quality Implementation Plan.

An interim report was produced in April 2009 and the general results shared with PGAIR and the public. In the summer of 2009, the interim report underwent an extensive technical review (of all inputs, assumptions and settings used in the study) by an external party (RWDI Air Inc.), increasing confidence in the results among all stakeholders and the public. Approximately 140 recommendations were made, largely to correct minor errors and improve assumptions used in the interim report. These recommendations were reviewed by the RWG and additional recommendations made for remodelling and revision.

$PM_{2.5}$

Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), about 1/30th the size of a human hair most strongly correlates with negative health effects (relative to larger particle sizes). Health impacts to the respiratory and cardiovascular system have been clearly demonstrated by research although several other effects are also being studied.

Sources of $PM_{2.5}$ that are generated by human activity include vehicle emissions, industrial emissions, and other combustion sources like burning wood or coal for heat. Of course there are natural sources as well, such as smoke from wildfires.

Stantec Consulting Ltd. was selected in the fall of 2009 to carry out the recommended remodelling and revision of the study. They produced a final report received by PGAIR and the Ministry of Environment (ENV) at the end of March 2010[4]. The report was formally adopted in April 2010 following reviews by the ENV and the PGAIR Research Working Group.

While the dispersion modeling study provided much more information than discussed here, summary results of the emissions sources are highlighted to demonstrate the type of information that was used to support the selection of the Phase 3 priorities.

The top four major contributors to $PM_{2.5}$ at the Plaza site (2003-2005 annual average) were identified as follows:

- Permitted users (industry) (18%);
- On-road dust (mobile sources) (18%);
- Locomotive sources (11%);
- Commercial restaurants (11%).

A breakdown of the contributions (Stantec, 2010) by source category to predicted annual averaged $PM_{2.5}$ concentrations at the Plaza site, 2003 – 2005, is provided below in Figure 4.

[4] Prince George Air Quality: Dispersion Model Study – A Revision (Final Report) (Stantec, 2010).

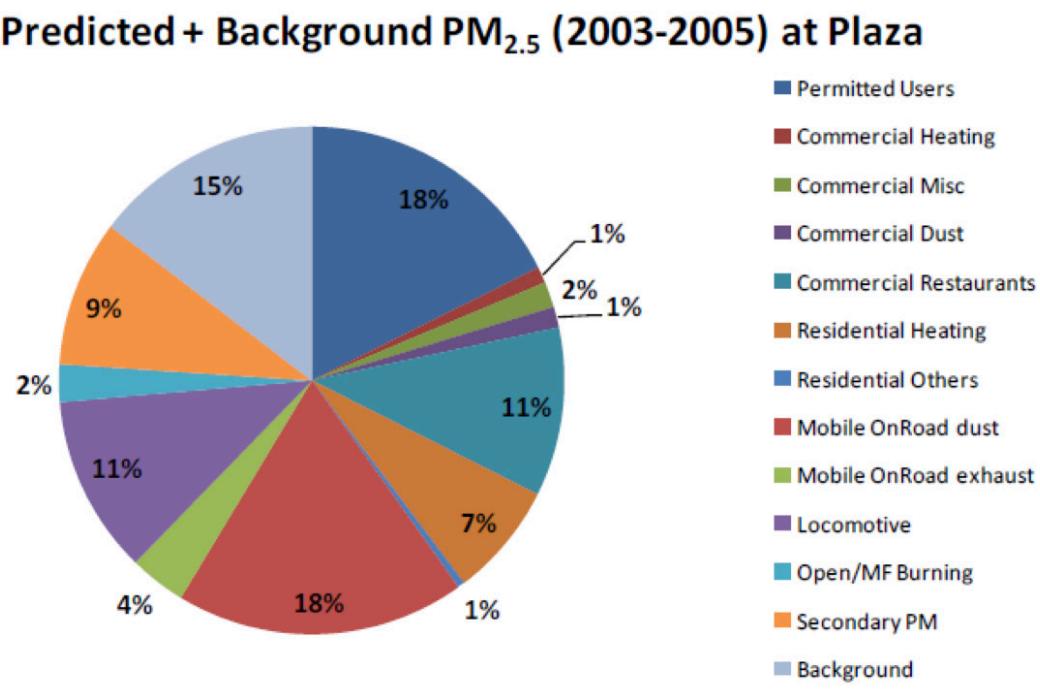

Figure 4: Contributions by Source Category to Predicted Annual Averaged $PM_{2.5}$ Concentrations at the Plaza Site: 2003 – 2005 (Stantec, 2010).

4.0 PHASE 3 PLAN (2011-2016)

4.1 PHASE 3 PRIORITIES AND STRATEGIES

Based on the results of research carried out in Phase 2, the Phase 3 Plan prioritized significant $PM_{2.5}$ sources for emissions reduction. The studies described in Section 2.4 identified that all major sources or sectors in the Prince George airshed were significant contributors to local particulate matter pollution. PGAIR has developed recommendations and management actions under the Phase 3 Plan for each source/sector. Some management actions were carried out by PGAIR, but many were, and remain, the responsibility of member agencies and community members. Although the main focus of reduction efforts was $PM_{2.5}$, reducing other pollutants such as dust (PM_{10}) was also supported in the implementation plan and strategies. The following sources or sectors were included in the Phase 3 Implementation Plan, in addition to Research Education and Coordination activities *(see Appendix A)*:

- Permitted Industry
- Dust
- Non-Permitted Industry & Commercial
- Transportation (mobile)
- Wood burning
- Background (naturally occurring)
- Other Sources

Open burning was included where applicable in the above categories. For example, residential recreational fires and residential land debris burning would be captured in the residential sector.

Permitted Industry

For the purpose of the Phase 3 Plan, the industrial sector includes all small and large industry that contributes PM or other identified pollutants to the airshed. These industries may hold air discharge permits or be required to follow a regulation under the *Environmental Management Act* to release air emissions. This includes such industries as, but not limited to:

- Pulp and paper
- Oil refinery
- Sawmills
- Pellet plants
- Asphalt plants
- Chemical plants

Waste Discharge Regulation

Most activities that discharge pollutants into the air require an authorization or permit. The Waste Discharge Regulation (WDR) defines what industries, activities, and operations require authorizations to discharge or release waste to the air, water, and land under the *Environmental Management Act* (EMA) in B.C.. Some examples of industries whose activities may be affected by the WDR include pulp and paper mills, wood processing facilities and petroleum processing facilities.

Dust

Although dust is often considered part of the larger particulate size category dust emissions contain a significant component of smaller invisible particles ($PM_{2.5}$). Dust sources mainly include "fugitive" (wind-blown dust from open areas), on-road and off-road vehicle use, unswept parking lots, and industrial yards.

Non-Permitted Industry and Commercial

Non-permitted industry and commercial businesses were identified as any commercial operation that contributes to fine PM and or other identified pollutants to the airshed. In many cases, air emissions from these sources are unregulated. Examples of commercial businesses and associated sources of emissions include, but are not limited to:

- Restaurants
- Auto-body shops
- Scrap and salvage yards
- Tire retreading facilities
- Parking lots
- Agricultural burning
- Businesses that primarily use wood and/or oil for space heating purposes

Transportation

The transportation sector encompasses any transportation operation that contributes to fine PM pollution in the airshed. Examples of transportation include, but are not limited to:

- Fleet vehicles
- Rail transportation
- Off-road vehicles
- Equipment and machinery
- Light and heavy duty vehicles
- Individual personal vehicles
- Buses
- Commercial businesses involved in transportation

Woodburning, (or Residential Heating)

The residential category includes all residents living in the Prince George airshed. PGAIR recognises that this particular category is far reaching and includes several recommendations, most of which require ongoing education and awareness of residential practices that can contribute to fine PM emissions in the airshed. Some examples of residential practices or equipment that have been recognized by PGAIR to contribute to fine PM in the airshed include, but are not limited to:

- Wood-burning appliances (e.g. poor wood burning practices, inefficient non-certified wood burning appliances)
- Open burning (recreational fires to larger burns,as defined in the City of Prince George Clean Air Bylaw # 8266)
- Vehicle idling
- Fugitive dust (e.g. dust created by off-road vehicles, on-road fugitive dust created by poor driving practices, yard maintenance practices that create fugitive dust)
- Small equipment (e.g. barbeques, lawn mowers, leaf blowers, snow blowers, and four stoke engines)

Research, Education and Coordination

Phase 3 recognizes research, education and coordination as critical activities that inform and support management actions of the plan. Goals and targets that are informed about air quality conditions, trends and contributing sources in the airshed are measurable and therefore more achievable. They are also the mechanism by which less understood or emerging topics can be identified and investigated in more detail. Upon completion of each research project, new management actions may be developed and incorporated into management actions and plans. PGAIR plays an important role in the coordination of member efforts and is instrumental in reaching out to the public and stakeholders about actions to improve air quality.

In order to meet the targets set in the Phase 3 Plan, PGAIR adopted key strategies to support actions in several important areas: industrial emissions, research and education, transportation, wood burning, dust control, and vehicle emissions. These key strategies are designed to support source-specific responses and potential actions for implementation over the life of the Phase 3 Implementation Plan and beyond *(see Appendix A)*.

Key Strategies

- Collaborate with PGAIR member organizations to develop policies that reduce air quality impacts from new or expanding industries (e.g. identify lands outside the airshed for industry), and provide feedback to industry to encourage the use of best practices and technology to reduce emissions.
- Through research and education, increase public understanding of air quality issues, advisories, potential solutions, and success stories.
- Establish a PGAIR awards and recognition program to recognize achievements to improve air quality by local businesses.
- Collaborate with the transportation sector to reduce emissions through best practices and technology, and through improved transportation planning and infrastructure.
- Reduce emissions from wood-burning heating systems and backyard recreation fires by encouraging woodstove upgrades to EPA/CSA certified models through the Provincial Woodstove Exchange Program, increasing knowledge of proper burning practices and increasing awareness of the City's Clean Air Bylaw.
- Reduce dust by encouraging more paving, improved street and private lot sweeping, appropriate off-road use, and improved residential yard maintenance.
- Reduce vehicle emissions by encouraging more alternative transportation such as biking, transit and carpooling, and improved traffic low, less idling, and more efficient fleet movement. PGAIR may also work with stakeholders to help establish local vehicle emission testing requirements similar to other jurisdictions.

4.2 PHASE 3 TARGETS

The Prince George Air Improvement Roundtable committed to focussing efforts on all particulate matter sources to voluntarily reduce particulate emissions (PM_{10} and $PM_{2.5}$) that are shown (by modeling and other studies) to have a significant impact on local ambient air quality. Since the $PM_{2.5}$ fraction (smallest particles) represents the greatest known risk to health (Brook et al. 2010), two- and five-year targets were set for this pollutant.

The two-year ambitious ambient air quality targets to be achieved by December 31, 2013:

- 24-hour average not to exceed 25 $\mu g/m^3$; and
- an annual average of 6 $\mu g/m^3$ (equivalent to the Province's $PM_{2.5}$ planning goal).

The five-year target stated that by December 31, 2016, the following should be achieved:

- an aspirational target of a 40% reduction on all significant emission sources; and
- an annual average $PM_{2.5}$ ambient target of 5 $\mu g/m^3$.

The goals set by the PGAIR Board of Directors can be thought of as ways to evaluate acute (short-term) and chronic (long-term) exposure to air pollution. The PGAIR's goals related to ambient air quality are organized below according to these concepts.

Goals that consider air quality over short durations of time evaluate acute (short-term) impacts, for example, the number of days that approached or exceeded the 24-hour $PM_{2.5}$ objective. These short-term periods of poor air quality commonly occur on days when a temperature inversion traps pollutants in the "bowl" area of Prince George, or when wildfires during summer months cause smoky conditions locally.

Goals that consider longer periods of time, such as over the course of a given year, consider chronic (long-term) impacts. The annual average takes into account all of the short-term episodes and their magnitudes combined.

Goals that address both types of impacts are important for considering the overall impact of air quality on residents and the community.

5.0 PHASE 3 IMPLEMENTATION PLAN EVALUATION

The Prince George Air Improvement Roundtable has made great progress toward improving air quality for all residents in the Prince George airshed. Through the combined efforts of member agencies and individual residents, significant achievements can be recognized. Despite these achievements, significant work remains for continued improvement to be realized, particularly on non-permitted sources such as residential or individual contributions.

The University of Northern British Columbia (UNBC) conducted an analysis for PGAIR to evaluate if the Phase 3 goals tied to ambient air quality were achieved. Students of the 2017 ENSC 412 class completed the analysis under the support and advisement of their professor, Dr. Peter Jackson. The key findings of this work are presented below. The full report can be read in the Natural Resources and Environmental Science Extension Note series [Jackson et al. 2017].

Change in Monitoring Technology

The technology used to measure $PM_{2.5}$ changed in 2013. The old technology (TEOM) heated the sample, which caused semi-volatile compounds within the sample to evaporate (and would not be measured). The new technology (SHARP) is able to better capture the semi-volatile compounds within the sample. As a result, SHARP analyzers tend to measure higher $PM_{2.5}$ concentrations on average than TEOMs.

5.1 DAILY AIR QUALITY TARGETS

In 2011, the target set by PGAIR was a daily limit of not more than 25 µg/m^3 (24-hour average Provincial $PM_{2.5}$ Objective). This goal suggests that should any day out of 365 exceed 25 µg/m^3, the target would not be met.

The 24-hour Provincial Air Quality Objective (AQO) of 25 µg/m^3 is considered to be achieved if it is met at the 98th percentile of daily average over one year. By this definition, PGAIR's goal could be considered met, however the goal was not stated in these terms.

Goal: 24-hour average not to exceed 25 µg/m^3

Daily $PM_{2.5}$ concentrations were at or below 25 µg/m^3 for an average of 360.17 days per year over the 2011-2016 period. While exceedances did occur, the frequency was less than 5 days on average each year *(see Figure 5)* [Jackson et al 2017].

The data clearly demonstrate that the number of days per year that exceeded the $PM_{2.5}$ limit has declined since the beginning of air quality management activities in the late 1990s. $PM_{2.5}$ concentrations between 2011 and 2016 are historically low with the exception of 2014 when wildfire smoke contributed to more than half of exceedances that year [ENV 2016].

The daily PGAIR target may have been overly stringent in the sense that allowances for impacts from unmanageable sources (such as wildfires) were not explicitly incorporated. Other than wildfire impacts, exceedances most frequently occurred during the cooler months of the year (late fall, winter and early spring). This trend is heavily driven by the weather during these months. When daylight hours are shorter and temperatures are colder, the

atmosphere tends to be more stable and becomes less effective at dispersing pollutants. For this reason, the same amount of pollutants in the atmosphere during the summer does not result in the higher pollutant concentrations experienced in the winter. However, with the addition of pollutants such as residential wood smoke contributing more during cooler months of the year on top of pollutants present all year (e.g. traffic, industry), avoiding daily exceedances becomes increasingly challenging to achieve.

Prince George's airshed is subject to particulate matter contributions from a variety of sources, and because of its location in a river valley, managing air quality is likely to be an ongoing process. In the face of climate change, the changing forest fire regime is expected to become increasingly important with regards to air quality impacts in Prince George (along with other BC communities).

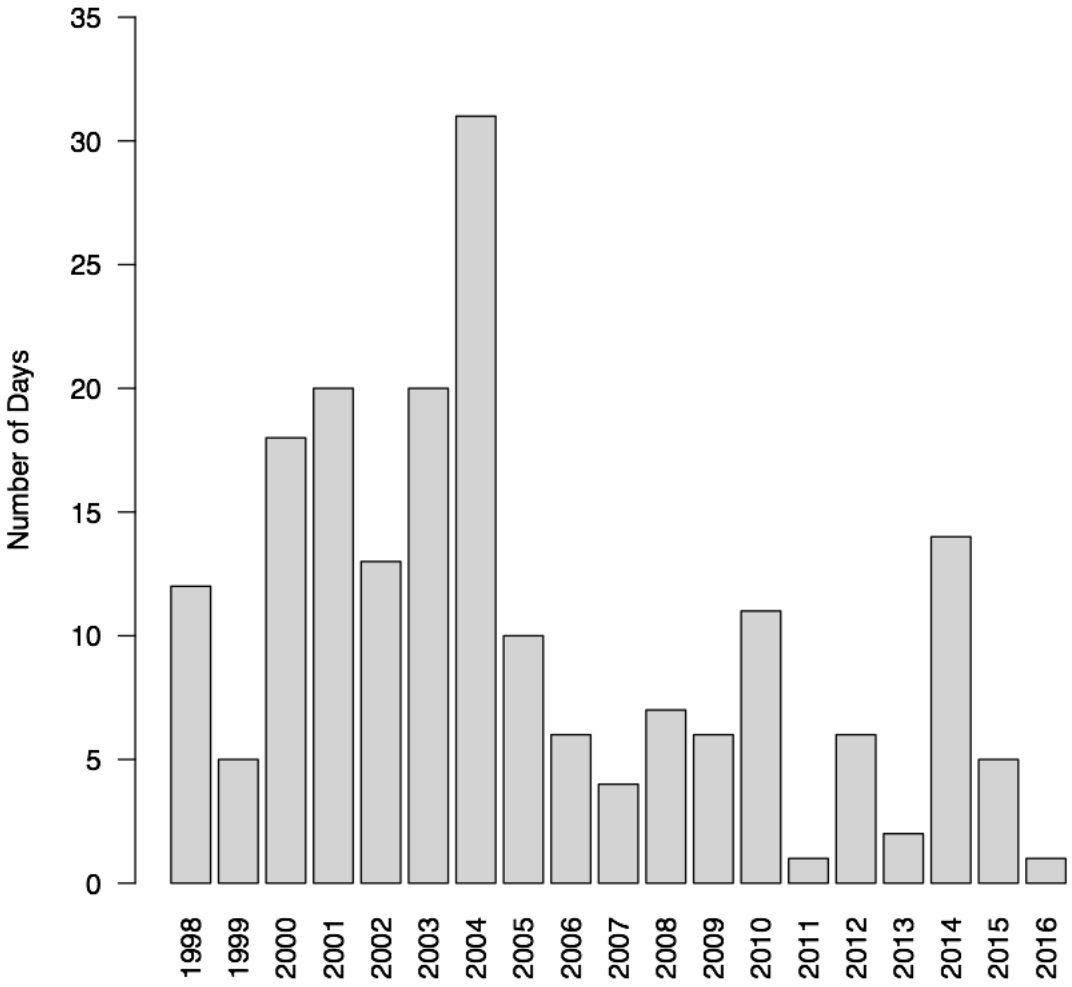

Figure 5: Number of days with 24h $PM_{2.5}$ > 25 µg/m³ (Jackson et al, 2017)

5.2 ANNUAL AIR QUALITY TARGETS

Goal: an annual average $PM_{2.5}$ ambient target of 5 µg/m³

Examining the longer-term trends yields some good news. Jackson et al. (2017) found that the airshed experienced a downward trend in annual average concentrations of $PM_{2.5}$ in Prince George at Plaza 400 over the Phase 3 period *(see Figure 6)*, and longer. This trend continues from 2005, the baseline year used in the dispersion modelling research (Phase 2). In fact, there has been a continuous improvement in the annual mean concentration of $PM_{2.5}$ from 2005 to 2016, continuing the trend of yearly decreases in the mean annual concentration since the beginning of the air quality management planning process [Jackson et al 2017].

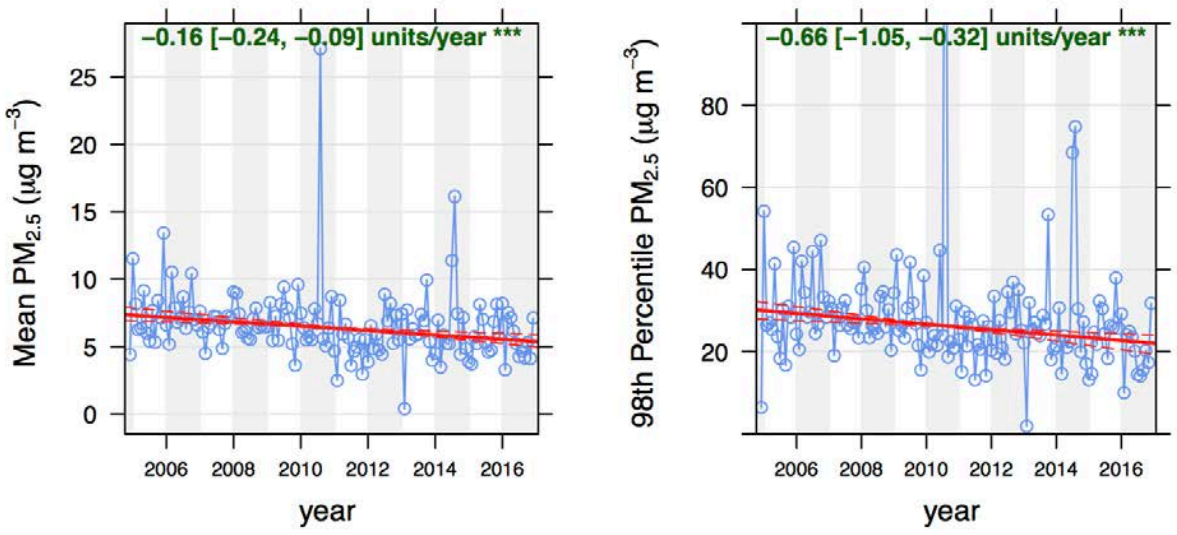

Figure 6: Deseasonalized monthly $PM_{2.5}$ concentrations (µg/m3) at Plaza 400 from 2005-2016 for a) mean, and b) 98th percentile [Jackson et al, 2017]. Deseasonalizing data provides a 'clearer' look at the $PM_{2.5}$ trends without seasonal influences due to the weather.

While overall decreasing $PM_{2.5}$ trends *(see Figure 6)* demonstrate alignment with PGAIR's 2016 goal of meeting an annual average concentration of $PM_{2.5}$ of 5 µg/m³, the target was met only in one year, 2011 *(see Figure 7)*.

The analysis estimated that background emissions account for 18-35% of the annual average which equates to 1-3 µg/m³ based on measurements collected at the downtown (Plaza 400) monitoring station. This means that the manageable component of the PGAIR annual goal (5 µg/m³) is reduced to 2-4 µg/m³. Given the strong influences of meteorology on $PM_{2.5}$ concentrations during the cool weather months (as described above), the 5 µg/m³ would be incredibly difficult and could be considered unreasonable to attain.

The manageability of the 'background' portion of the ambient emissions will need to be considered in future goal setting. Setting future goals that take a minimum or acceptable number of exceedances into account would be a more reasonable approach.

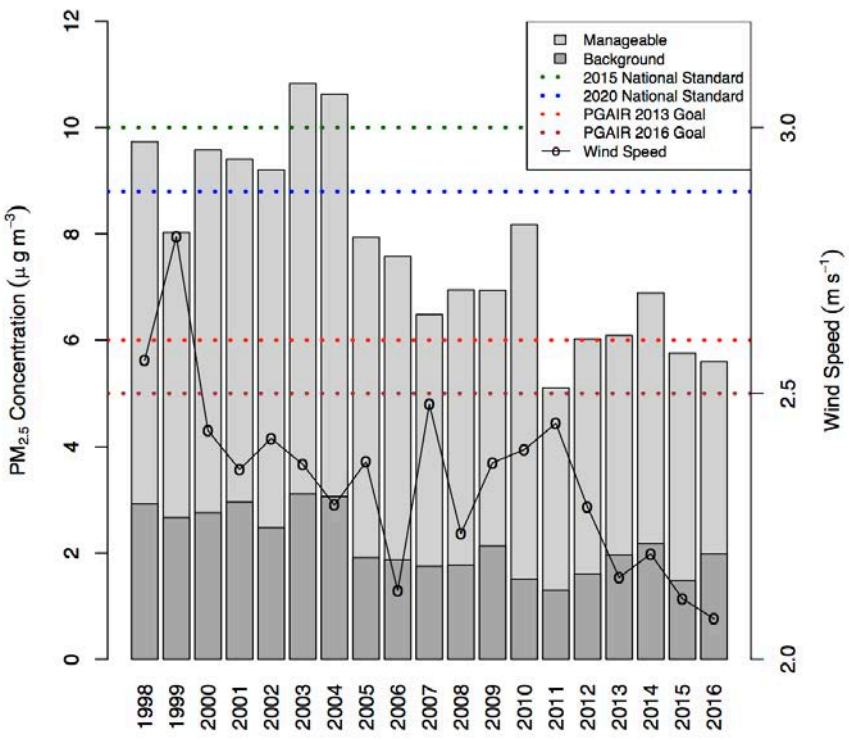

Figure 7: Annual average concentrations of $PM_{2.5}$ at Plaza 400, with PM concentration on the left axis, and wind speed on the right [Jackson et al., 2017]

Looking at annual concentrations of $PM_{2.5}$ tells the general air quality story. However, a closer look can help us answer more detailed questions such as which areas in the community are experiencing the biggest change in emissions. One way to answer this question is to look at where the $PM_{2.5}$ emissions are coming from. When meteorological data is examined (wind direction and speed) and is coupled with $PM_{2.5}$ measurements, a picture can be formed of how much $PM_{2.5}$ is coming from each direction. The windrose displayed in the centre panel of Figure 8 shows the relative contribution of $PM_{2.5}$ emissions by direction. It demonstrates that a significant proportion of the annual concentration measured at the downtown (Plaza 400) station comes from east of the city, which is a heavily industrialized area. The panels surrounding the plot show trends of $PM_{2.5}$ over time for eight wind sectors (northeast, north, northwest, west, southwest, south, southeast, and east). The panel showing $PM_{2.5}$ concentrations from the east have the largest decreasing trend, which suggests the significant efforts made by industry to reduce emissions are working, especially when examining the change in emissions coming from the industrial sector to the east of the city [Jackson et al, 2017]. For more information about industry and partner efforts to reduce emissions, *see Appendix B*.

Background vs. manageable emissions

The idea of background emissions refers to the ambient concentrations of pollutants from natural and anthropogenic sources that originate outside of the airshed's boundaries, and are transported into the airshed. Air quality management relies on the ability to distinguish between the background pollution emissions and those originating locally from within the airshed to determine the extent that management actions can have an impact on local ambient air quality.

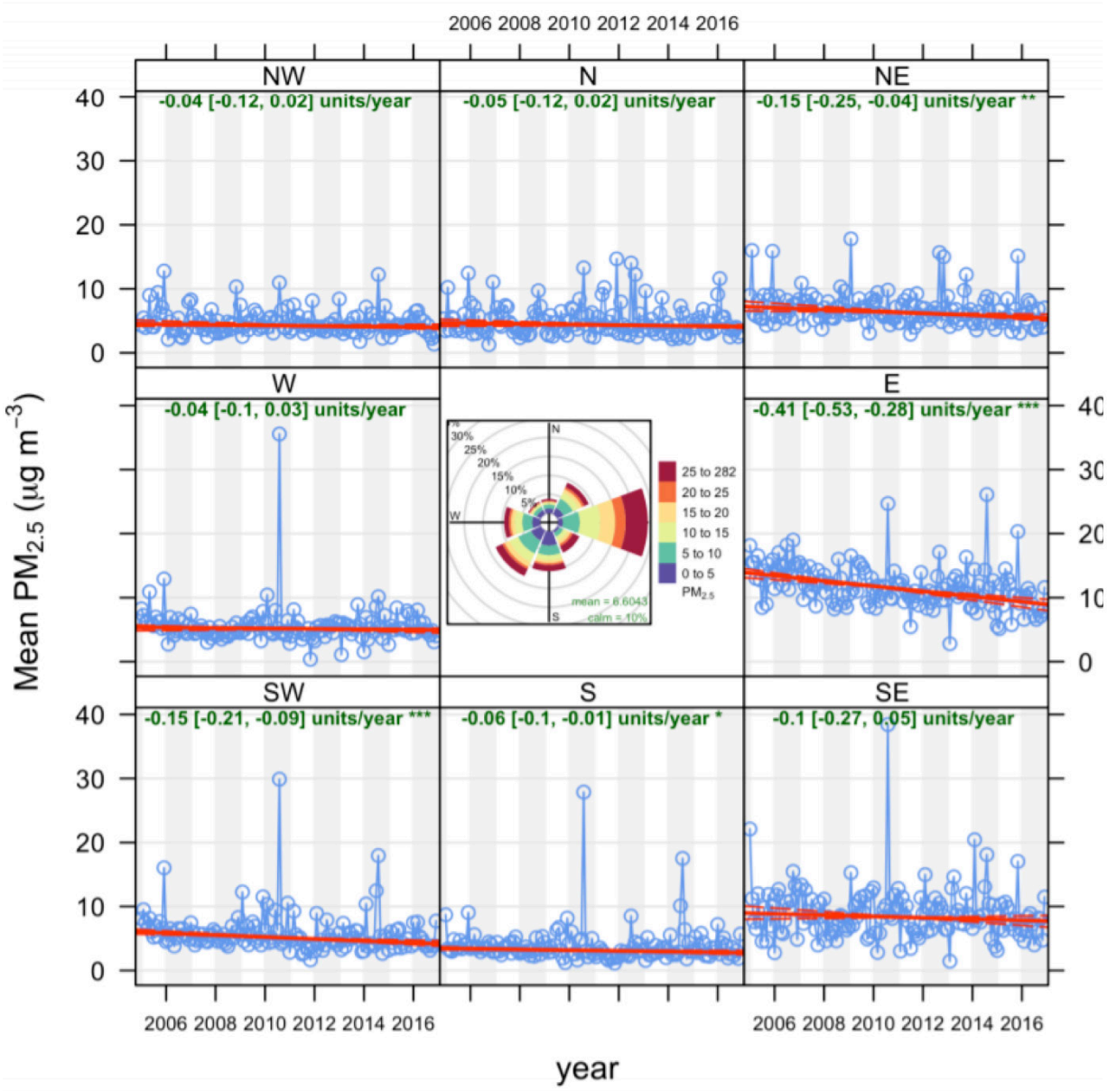

Figure 8: Deseasonalized monthly average $PM_{2.5}$ concentrations at Plaza 400 from 2005-2016 for 8 wind directions. The centre rose diagram shows the proportion of each wind direction and $PM_{2.5}$ concentration contributes to the mean [Jackson et al, 2017]

5.3 THE 40% ASPIRATIONAL TARGET

Setting an "aspirational" target to reduce $PM_{2.5}$ emissions from all significant sources by 40% allowed all members of PGAIR to reach a consensus about the type of voluntary goals that could be collectively achieved over various stages of effort. As PGAIR is not a regulatory body, the target represents a community target, one that requires support from the community at large, acknowledgement that $PM_{2.5}$ emissions are contributed by many activities, and the recognition that actions from each of us as individuals are needed to achieve further air quality improvements.

Research conducted in Phase 1 and 2 identified that several major sources of $PM_{2.5}$ within the Prince George airshed originate from many places including permitted and non-permitted industry, commercial activities, dust, transportation and wood burning. Many of these emissions are released across the city`s landscape making them impractical to measure on a regular basis. **For this reason, the success of the 40% emissions reduction target is difficult to quantify.** To fully evaluate this goal, the comprehensive inventory of all air major emissions completed in Phase 2 would need to be updated. This type of work requires significant funds and is a lengthy process.

As a partial indicator, air emissions data available from permitted industries (collected by ENV) was reviewed. Three approaches were used to summarize PM emissions from permitted industrial sources.

Industry Efforts

Substantial efforts made by local industries operating in the airshed have included upgrades to equipment to reduce emissions discharge. Both Husky Energy and Canfor Pulp Ltd. are able to report significant investments in their respective systems that show a measureable difference in their discharge of particulate emissions.

Approach 1:

Total emissions were calculated based on information in the air permits.

$$\text{Permitted emissions} = \frac{\text{Amount of PM permitted to emit (as stated in permit)}}{\text{hour}} \times \frac{\text{\# of hours permitted to operate}}{\text{year}}$$

Approach 2:

Considering that facilities may not actually operate as many hours as they are permitted to, permitted facilities provided their actual operating hours for each year (2011-2016). These operational hours were substituted for permitted hours.

$$\text{Operational emissions} = \frac{\text{Amount of PM permitted to emit (permit)}}{\text{hour}} \times \frac{\text{\# of hours in operatation (permitee records)}}{\text{year}}$$

For cases where operational hours were unavailable, results from Approach #1 were substituted. (Note: operational hours were provided for more than 90% of the total permitted emissions.)

Approach 3:

For cases where direct measurements of PM emissions are required by industrial permits (e.g. stack testing), the measured emissions and actual operational hours were used to estimate total emissions for each year.

$$\text{Measured Emissions} = \frac{\text{Amount of PM emitted (stack test)}}{\text{hour}} \times \frac{\text{\# of hours in operatation (permitee records)}}{\text{year}}$$

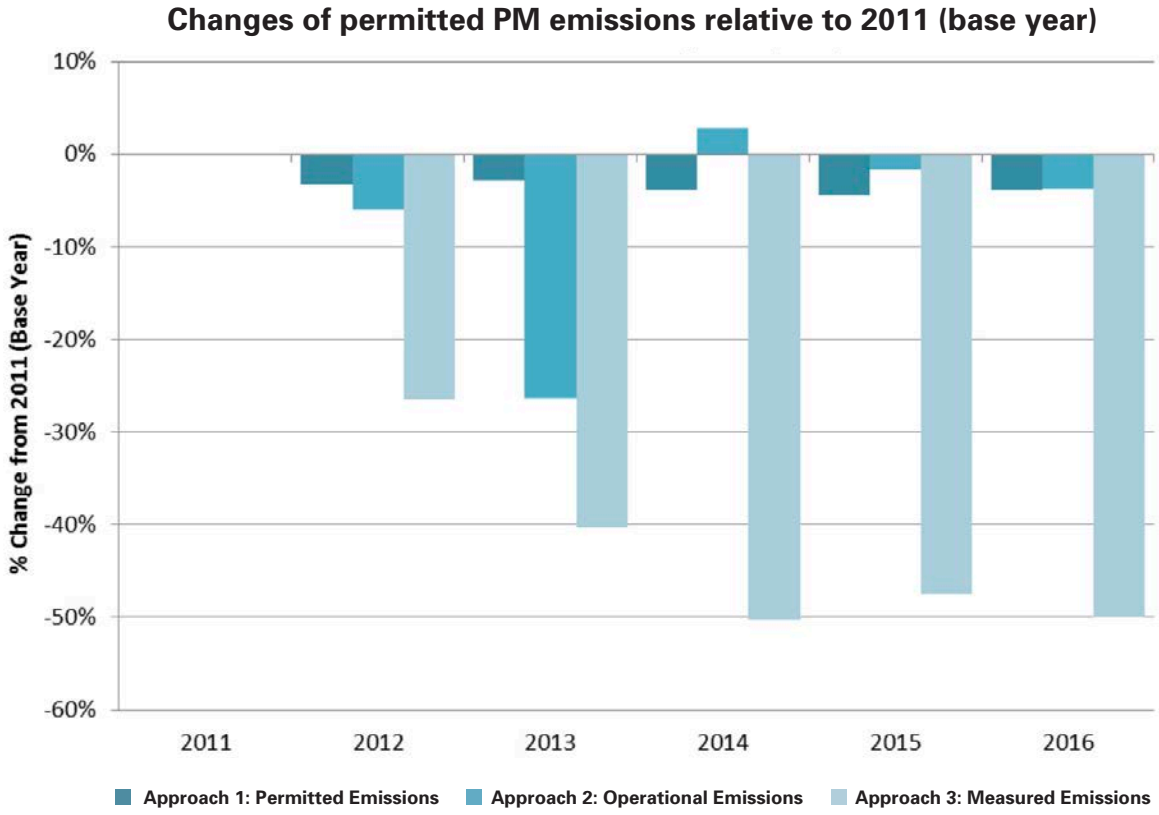

Figure 9: Relative reductions in point source contributions (sources: ENV, PGAIR industrial members)

Stack emissions were averaged for cases where multiple tests were performed on the same stack within the same year. For cases where measured emissions were unavailable, results from Approach #2 were substituted.

The results of all three approaches are illustrated in Figure 9. Approach 1 indicates that the total permitted PM emissions included in permits remained consistent over the six-year evaluation period (2011-2016). Approach 2 shows relatively small year-to-year change, with the exception of the notable reduction in emissions in 2013. These reductions reflect changes to the operational status of permitted activities in that particular year (e.g. facilities becoming non-operational or reducing operations to perform upgrades).

Approach 3 illustrates a consistent reduction of PM emissions throughout the Phase 3 period reaching a reduction of 50% in 2016 (relative to 2011, the base year). This information provides some indication that PM emissions from major point sources (e.g. industrial stacks) substantially decreased between 2011 and 2016 (~ 50 %, Figure 9). While source emission testing and permit emissions information isn't collected in a manner that completely answers PGAIR`s 40% reduction target, it provides an additional piece of evidence that measureable improvements have occurred. This trend is also in agreement with the findings of the Jackson et al. (2017) evaluation.

Some of the significant reductions to permitted PM emissions were achieved through major upgrades to infrastructure and equipment by major emitters, and are described fully in annual member briefing notes, available on our website (pgairquality.com). One example is Canfor Pulp Ltd.'s upgrades at two of their facilities within the airshed: a retrofit to the Northwood Pulp Mill #1 Recovery Boiler including installation of an Electrostatic Precipitator; and, installation of an Electrostatic Precipitator at the Prince George #1 Power Boiler Stack.

5.4 ACHIEVEMENTS BY CATEGORY

By air pollutant category, the following is a detailed outline of achievements seen in the implementation of Phase 3 of the management plan.

5.4.1 Dust

Dust pollution levels were identified in 1995 as the top airshed management concern because of the relationship to major health issues identified in the research. Dust emission sources mainly include 'fugitive' sources, meaning dust blown in from open areas, on-road and off-road vehicle use, unswept parking lots, and industrial yards. The Phase 3 Implementation Plan identified two strategies to focus action on dust:

1. Mitigate the causes of dust in areas that are not paved and at gravel pit operations, construction sites, residential and commercial lots and industry sites; and
2. Mitigate dust in paved areas, in particular, roads, parking lots, and commercial and industry sites.

The City of Prince George introduced the Clean Air Bylaw in 2010, which went a long way toward establishing a culture of improvement around lot maintenance and sweeping in Prince George.

Actions taken on Dust:

PGAIR is committed to making continued improvements in reducing the impact of dust on our air quality. The following are actions taken by PGAIR member agencies:

- PGAIR produced a video called *Keeping the Dust Down*, offering some practical steps to reduce dust kicked up by certain activities. The video features Airiana, our air quality ambassador helping friends and neighbours to understand how their actions create an air quality problem, along with simple ways to prevent it. The video is shared on YouTube, on the PGAIR website and Facebook page. The video, which was released in March 2016, has had more than 100 views.
- The City of Prince George issues an annual sweeping notice to businesses in the city that is also posted on its website and shared through social media. The notice is a reminder of provisions in the 2010 Clean Air Bylaw that require certain actions to be taken to prevent dust pollution during spring sweeping activities. The City of Prince George is a leader in using these techniques in their annual sweeping operations, beginning as soon as roads are snow-free in the spring.

Many of our member agencies are also making dust management a priority at their industrial sites. For detailed information about member contributions, *see Appendix B*.

PM_{10}

PM_{10} includes particles that are 10 microns in diameter or less which is about 1/7th the size of a human hair. PM_{10} includes $PM_{2.5}$ (as described above) as well as larger particles up to 10 microns in diameter. Particles that are 2.5-10 µm in diameter are most often created by mechanical breakdown such as road dust and windblown dust. Some types of pollen are small enough to be included in PM_{10}.

TRS and Odour

What is that smell? Typically, TRS or Total Reduced Sulphur compounds produce an offensive rotten egg or cabbage smell that can be detected by humans at very low concentrations and can pervade the community, especially when the air is calm and stable. Industrial sources of TRS include pulp and paper mills, refineries and sewage treatment facilities. TRS compounds are not normally considered a health hazard, but they are a primary cause of odours.

The Province of British Columbia currently does not have ambient odour objectives for TRS but uses Pollution Control Objectives developed for the Forest Products Industry in the 1970s as an odour reference: 1-hour average of 5 ppb and 24-hour average of 2 ppb.

5.4.2 Permitted Emissions

Permitted emissions come from those industries that are regulated by the Provincial government or that require an emissions permit. Because PGAIR is a non-regulatory body, little influence can be exerted on the permitted portion of the emissions spectrum. However, many of the emissions permit holders are members of PGAIR, signalling a commitment to making improvements toward community health.

PGAIR identified three strategies for action:

1. Encourage implementation of the off-setting policy developed by the Province's regional office for new or expanding industry in Prince George;
2. Secure commitment for the Regional District of Fraser-Fort George – City of Prince George Heavy Industry Land Use Plan (suitable development lands outside of airshed); and

Encourage continuous improvement and use of "best available technology" for current, expanding and new permitted industry.

Through their commitment to clean air, some members in the permitted emitter category have made significant contributions to improvements. In most cases, an upgrade to Best Available Technology (BAT) helped make measureable reductions in emissions of small particulate, or $PM_{2.5}$. Beginning in 2009, the Pulp and Paper Green Transformation Program offered funds to improve the environmental performance of pulp and paper mills in Canada. Prince George's Canfor Pulp Ltd. was a recipient of funds, but extended their commitment to improvements by investing independently in upgrades to local mills.

5.4.3 Non-Permitted Industry & Commercial

The non-permitted industry and commercial category refers to the portion of the airshed emissions that come from industry and commercial establishments that do not require a permit to emit. This category includes large and small businesses such as restaurants, fabricators, commercial heating, autobody shops, building construction, gravel pits and farm operations. The types of emissions they produce include fine particulates that come from cooking, some transportation emissions, dust, and heating sources.

Strategies identified in the Phase 3 Implementation Plan include:

1. Encourage the use of best available technology and best practices to reduce emissions; and
2. Recognize best practices within the commercial and industrial sector.

Engagement with the non-permitted sector is challenging since direct attribution of emissions is not available. Efforts to reduce emissions in this category will be reviewed and remain a focus of PGAIR.

5.4.4 Transportation Emissions

The emissions from the transportation sector implicate all of us in our daily activities, whether they are for personal or business. Long understood to be a major source of pollutants, fine particulates and associated chemical emissions continue to represent a major source of pollution in Prince George. The emissions from vehicles of all types such as personal vehicles, commercial, industrial, airplane and locomotive are included in this category.

Because this category is so diverse, and affects all sectors of society, several strategies were identified to address this emission source:

1. Reduce vehicle idling;
2. Encourage vehicle efficiency programs such as E3Fleet Program and voluntary vehicle emission testing;
3. Encourage alternative transportation;
4. Work with relevant agencies and stakeholders to examine the feasibility for establishing local vehicle emission testing requirements;
5. Collaborate with railway industry to develop emission reduction or mitigation strategies;
6. Encourage alternative fuel/energy sources for transportation.

Significant effort over the term of PGAIR has been taken to address emissions from transportation sources including outreach programs such as an anti-idling campaign. Because improvements depend largely on voluntary efforts, reductions have been limited. Some of the actions taken include the following:

- Transportation Dialogues – February and March 2012, engagement events with the community with a focus on transportation sources such as the airport, CN Rail, and fleet managers;
- Partnership on Anti-Idling – signs posted at schools, public buildings and private businesses that participate in the program.

5.4.5 Wood-burning

Burning wood for heat or other uses has been identified as a significant source of $PM_{2.5}$ emissions in our airshed. The wood-burning category includes residential space heating, using wood-burning appliances and open burning. These activities are regulated by the Prince George Clean Air Bylaw.

The Phase 3 Implementation Plan focused efforts on these four strategies:

1. Reduce emissions from space heating;
2. Encourage clean-burning practices for "backyard" recreation fires;
3. Reduce incidences of illegal burning;
4. Reduce open-burning emissions within the Prince George airshed (City and portion of RDFFG).

Some important achievements can be counted in the area of reducing emissions from wood burning in the city and the area outside city limits. Burning wood represents a substantial contribution to particulate matter emissions during the winter months due to the cold temperatures experienced in the region, and the availability of wood locally for heating. However, it is important for residents to realize the impacts of their wood burning practices, and that the health and quality of life of family and neighbours may be adversely affected.

Actions taken to reduce the contribution of wood-burning emissions to the airshed include:

- Participation in the Provincial Woodstove Exchange Program. Reductions of up to 22 tonnes of particulates from the airshed through the upgrading of over 326 wood burning appliances is a significant improvement;
- An educational video was produced by PGAIR to promote awareness of the contribution of burning wood to pollution in our air shed. This video features Airiana, the character featured in the PGAIR educational video series;
- The City of Prince George Fire Rescue Services prioritized response to illegal open burning, attending to 753 complaints between 2012 and 2016;
- PGAIR submitted comments to the Province regarding proposed changes to the Open Burning and Smoke Control Regulation.

5.4.6 Research, Education and Coordination

The goal of the research, education and coordination category is to improve knowledge and awareness around air quality impacts on the Prince George airshed. The primary objective of much of our work toward clean air is in trying to change ingrained behaviours that contribute to air pollution. Knowledge is not always enough but it is critical to start the process of changing attitudes and behaviours for the better.

The over-arching strategies under this category are:

1. Maintain or improve capacity for PGAIR to deliver its programs and initiatives through sustainable funding.
2. Facilitate public forums and events that promote and encourage clean air practices.
3. Improve awareness of air quality issues and potential solutions.
4. Focus research on improving source and distribution of emissions within the airshed.

PGAIR enjoys a strong relationship with the University of Northern British Columbia; several research studies, including the recent *Trends in fine particulate matter ($PM_{2.5}$) concentrations in Prince George, British Columbia, Canada* by Dr. Peter Jackson et al. contribute enormously to our knowledge of the complexities of our air quality. Early in the history of air quality management in Prince George, Dr. Jackson supported the development of the air quality management planning process and target setting by applying a local perspective to current air quality research.

Actions to improve awareness are strongly linked to in-person outreach and interaction with members of the public and interested groups. A large component also involves coordinating activities with member agencies to advance PGAIR's other air quality improvement categories.

Some activities that PGAIR leads or takes part in include:

- Clean Air Day activities: In 2016, PGAIR held a booth at the Prince George Farmers' Market on Clean Air Day, offering members of the public information about PGAIR and activities that we carry out, about air quality in their community, and the opportunity to take the Clean Air Pledge. The winner of the Clean Air Pledge, Matthew Beckett, was featured on our website [www.pgairquality.com] and Facebook page [Prince George Air Improvement Roundtable]. The Clean Air Pledge is made available on our website for anyone in the community to sign and submit;
- Bike to Work Week: PGAIR has sponsored some part of the annual Bike to Work Week for the past several years. Typically, a 'Celebration Station' was provided by PGAIR, and participants were encouraged to continue their alternate transportation habits;
- Anti-idling: Transportation emissions are a major contributor to fine particulate matter in our air. PGAIR has engaged with partners around the community to encourage drivers to shut off their car engines while waiting in a parking space, e.g., at schools. Signs are posted to remind people that "Idling Gets You Nowhere". PGAIR also maintains an "Idling Hotspot Map" on our website where members of the public can report where in the community they see idling vehicles. This information is used to identify problem locations that may be used to target future "Idle Free Zone" signs;
- Website and Facebook: The online presence of PGAIR is an important ongoing communication activity for the roundtable. The Facebook page is the key point of interaction with the public about air quality issues and activities, and is supplemented with a considerable depth of information on the webpage. All of the educational videos, for example, are available through both venues, and statistics are collected about the level of interaction.

6.0 CONCLUSION AND NEXT STEPS

Steady progress toward cleaner air in Prince George is the result of continued efforts by many community members over the past 20 or so years. Each phase of the Air Quality Management Plan yielded improved knowledge of the airshed and measureable achievements. Along with other important work, sources of particulate matter pollution were identified in Phases 1 and 2 of the Air Quality Management Plan, which helped to inform actions that were planned and undertaken during the Phase 3 Plan period.

The analysis of local air quality and meteorological data by the University of Northern British Columbia, and the Ministry of Environment and Climate Change Strategy enabled PGAIR to evaluate management actions in meeting community air quality targets set in the Phase 3 Plan (2010-2016). Overall, significant progress has been made toward improving particulate matter pollution in our airshed, but further efforts are needed to address some sources of $PM_{2.5}$.

The Phase 3 Implementation Plan targeted multiple sources of particulate matter based on investigative work carried out during Phase 2. Several point sources (permitted) of PM were identified in the airshed inventory, along with a number of non-point sources (non-permitted). The very nature of non-point sources of pollution makes them difficult to manage, therefore they must be addressed using different approaches. By identifying and naming some of the sources of particulate emissions, this enabled management actions to be designed to directly address the source in question.

PGAIR's industrial partners, or permitted partners, have made significant progress in reducing their particulate matter contributions to the airshed. Significant emissions reductions were achieved through updated technology and practices that came online during the Phase 3 Implementation Plan period (2011-2016), including the pulp and paper Green Transformation projects and public and private sweeping operations improvements. Efforts by all industrial partners have had a positive impact, which is evident in the reduced load of particulate matter from permitted sources, especially those in the eastern part of the city.

However, these represent only a portion of the pollution released into our air. The remaining sources of PM pollution include a wide variety of types and origins, many of which come from the everyday lives of most of our residents. These PM emissions might be in the form of wood smoke from a chimney, vehicle exhaust, or venting from a restaurant. Identifying management actions to address non-point source, or non-permitted emitters is a greater challenge, as few regulatory options currently exist.

PGAIR developed education and awareness outreach activities that have advanced air quality awareness and improvements among residents and the commercial business sector to begin to address these sources. Efforts to reduce the contributions from locally produced wood smoke (for heating) have resulted in many upgrades to more efficient wood burning appliances. Increased restrictions on wood burning appliances in certain parts of the city may be warranted, along with greater education around clean burning techniques and the health impacts of wood smoke. The success of future management actions depends on a commitment from the entire community to reduce emissions. While great strides have been made by the point source or permitted emitters, much work needs to be done at the community level to tackle those elusive non-point source emissions.

In addition to local PM emissions, it is evident from this work that there is a significant contribution to our air quality from sources beyond the boundary of the airshed. Several summers in recent history have been dominated by significant wildfire events, carrying smoke into the atmosphere and into the airsheds of many communities. Prince George was affected by wildfire smoke for several days or more during 2011 and 2014, and again in 2017, though this recent data is not included in the analysis. Every sign points to increased wildfire activity in the face of a changing climate, and it is likely that many more smoky days will plague our airshed in the years to come. The result is that air quality targets may be difficult to meet, and should therefore incorporate allowances for exceedances due to weather, wildfire or any other external sources beyond our management control.

PGAIR is currently guided by the Five-Year Strategic Plan (2017-2021), which continues efforts in all of the identified source areas but also allows flexibility to set new community air quality goals in light of the evidence from Phase 3 ambient air quality trends. There is also the opportunity to explore community-defined goals for other pollutants such as those that produce odour, or Volatile Organic Compounds (VOCs). Future goals may need to take into account the reality of the industrial contributions to the local economy, as well as the impacts of wildfire smoke on the local airshed, and allow a maximum number of exceedance events.

One final word: All individual residents can make improvements that will go a long way toward mitigating the lingering particulate matter pollution issues, which include wood smoke and transportation emissions, by examining personal contributions to the airshed and making relatively small adjustments to personal habits that, when combined at the community level, make a big difference.

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APPENDIX A: PHASE 3 IMPLEMENTATION PLAN

The Phase 3 Implementation Plan was released in 2011 and guided air quality management actions in Prince George under the Prince George Air Improvement Roundtable for the years 2011 to 2016.

The Phase 3 Implementation Plan can be found at www.pgairquality.com

APPENDIX B: MEMBER ACTIONS AND ACHIEVEMENTS

Partner	2011	2012	2013	2014	2015	2016	Comments
Permitted Emitters							
Canfor Pulp Ltd.			Commissioning period began for particulate reduction on a Wood Waste Power Boiler stack (representing Best Available Technology)	Sponsored and launched interactive educational kiosk in partnership with The Exploration Place and Science Centre. The kiosk focuses on education around air quality	Electrostatic precipitator on #1 boiler at PG Pulp = 95% reduction	50% reduction in particulate emissions	
					Replaced atmospheric black liquor fiber filter at Intercon = elimination of largest source of TRS	Hydroseeded 20 acres to reduce fugitive dust	
					Installed ash reinjection system on #2 boiler at PG Pulp= 40% reduction in ash loads to landfill = less fugitive dust	Treatment of the equivalent of 12km of roads with CaCl to reduce dust	
					Northwood's #1 Recovery Boiler = reduced TRS		
Carrier Lumber				Cyclone replacement, idling restriction protocols, bulk diesel with 5% ethanol, defined and documented action plan to respond to air quality advisories	Planer and ventilation upgrades = net reduction in particulate		
Columbia Bitulithic Ltd.			Investment in new technology to adapt to new conditions	Dust suppression at grounds and anti-idling protocols implemented	Installation of variable-frequency fan to improve energy efficiency and reduce GHGs		
Husky Oil Operations Limited	LDAR implementation program realizing 54% reduction in fugitive process VOC emissions	Upgrades to Wastewater treatment plant reduced odours; >90% VOC and TRS emission reduction from wastewater treatment confirmed by independent study	Catalyst deSOx additive incorporated for use; 70% reduction in SO2 emissions from refinery sources in the past decade; heater BAT upgrades = reduced NOX	Leak detection and repair program conforming to CCME Code of Practice to limit fugitive emissions of VOCs = 70 tonnes removed from air shed annually		Road dust control measures included calcium chloride application, reinforced policy of using pedal bicycles, revamped vehicle policy to limit contractor vehicle usage	As mentioned in past briefing notes, Husky has been working to reduce emissions for more than a decade including a 63% emission reduction in fugitive process volatile organic compounds (VOCs) and a 70% emission reduction in sulphur dioxide (SO2) from refinery sources. This is in addition to the reductions in vehicle exhaust emissions starting in the mid-2000s when sulphur in gasoline and diesel were reduced by 90% and 97% respectfully. Husky invested over $100 MM on the Prince George Refinery to meet Environment Canada Regulations in the mid-2000s.
			Upgrades to Wastewater treatment plant reduced odours			Improved monitoring and control systems on refinery heaters to reduce fuel useage	

Non-permitted Commercial or Industry							
CN		Climate strategy scored 98% on 2012 Dow Jones Sustainability Index					
Prince George Chamber of Commerce						Adminstration and delivery of CN's Carbon Footprint Reduction Project, with UNBC and PGAIR	
Local Government							
City of Prince George		District Energy System redesign to reduce particulate emissions, removing up to 30.7 tonnes of PM/year from wood combustion and 70 tonnes/year from truck traffic from airshed	Free Fare For Clean Air; public communication regarding efficient burning practices, building a bike lane on Northwood Pulpmill Road to encourage alternative transportation	Free Fare for Clean Air on air quality advisory days	Early season sweeping in the downtown core	Asphalt recycling facilities utilized	
			Purchased electric vehicle in partnership with UNBC, NH and RDFFG	Bike laning one leg of Northwood Pulpmill road and a section of Foothills Blvd to encourage alternative transportation	Dedicated staff person to air quality-related activities	Transit planner hired to maximize efficiency and service of transit bus routes	
			Highest emission ratings for fleet vehicles maintained	Public messages about proper wood-burning techniques	Secured funding for bike racks, and other infrastructure to encourage active transportation	MoU for purchase and use of electric vehicle with RDFFG, UNBC, NH	
Regional District of Fraser-Fort George	Waives heating unit permits for woodstove exchange participants	Prince George Area Industrial Land Area - identification of potential areas for heavy industrial land development, lower air quality sensitivity	Dust suppression activities at RDFFG facilities; policies to support dust suppression techniques for permit holders	Supported Woodstove Exchange Program by waiving Heating Unit Permit fees	Supported Woodstove Exchange Program by waiving Heating Unit Permit fees	Supported Woodstove Exchange Program by waiving Heating Unit Permit fees	
			Purchased electric vehicle in partnership with UNBC, NH and CPG	Incorporated dust suppression/air quality language in permits related to aggregate processing	Dust suppression techniques for sweeping operations	Dust suppression techniques for sweeping operations	
				Shared operation of EV with CPG, UNBC, NH	Anti-idling program promotion	Anti-idling program promotion	
					Shared operation of EV with UNBC, NH, CPG	Shared operation of EV with UNBC, NH, CPG	
UNBC					Reduced vehicular traffic by organizing a car-count event; participated in Bike-to-Work-Week events	Reduced vehicular traffic by organizing a car-count event; participated in Bike-to-Work-Week events	
					Operated Bioenergy plant to reduce reliance on fossil fuels, and employs electrostatic precipitator to reduce PM emissions	Operated Bioenergy plant to reduce reliance on fossil fuels, and employs electrostatic precipitator to reduce PM emissions	

Fraser Basin Council		Provided staff resources to PGAIR for delivery of programs such as the Woodstove Exchange Program, the Clean Air Forum, etc. including operational support for PGAIR	Provided staff resources to PGAIR for delivery of programs such as the Woodstove Exchange Program, the Clean Air Forum, etc. including operational support for PGAIR	Provided staff resources to PGAIR for delivery of programs such as the Woodstove Exchange Program, the Clean Air Forum, etc. including operational support for PGAIR	Provided staff resources to PGAIR for delivery of programs such as the Woodstove Exchange Program, the Clean Air Forum, etc. including operational support for PGAIR	Provided staff resources to PGAIR for delivery of programs such as the Woodstove Exchange Program, the Clean Air Forum, etc. including operational support for PGAIR	
PACHA							
Northern Health	Continued to work with partners to communicate air quality messages including air quality advisories and associated media follow ups	Continued to support MoE on complex air discharge permits and/ or permit applications across the region	Updated air quality printed materials and developed a new air quality banner	Continued reviews of air quality-related referrals from other agencies like MoE to ensure that health impacts and Phase 3 objectives were taken into account	Worked with Ministry of Environment to incorporate the new Smoky Skies Bulletins into public communications	Incorporated more comprehensive air quality and health messaging into Official Community Plan reviews	
	Continued air quality and health knowledge management	Chaired PGAIR's Education and Awareness Working Group – Public education, awareness & encourage social behaviour change	Worked with the Health Authority Air Quality Council to develop provincial resources for Environmental Health Officers	Air quality education and awareness initiatives with Northern Health staff	Promoted air quality and health messages through hospital waiting room screens and on website	Developed a responsible wood burning campaign to educate the public on reducing wood stove emissions (social media, blog, contest)	
				Formed internal Air Quality Steering Committee to provide leadership and support to staff around indoor and outdoor air quality	NH has incorporated air quality and health messaging into their Environmental Assessment review process (e.g. Giscome Quarry)	Dedicated staff specifically to support air quality and health promotion within NH – will provide regional support and knowledge management	
Ministry of Environment	Provided an information release regarding work that was completed in collaboration with city residents to collect ambient air samples within selected neighbourhoods where odours were being persistently reported.			Participated in BC Games Sustainability Forum to discuss ways to improve air quality during the 2015 Canada Winter Games	Provide funding to PGAIR to support public education efforts and engagement with the business community regarding air quality issues	Provide funding to PGAIR to support public education efforts and engagement with the business community regarding air quality issues	
				Provided funding to PGAIR to assist with the engagment of the Prince George business community with air quality issues and what they can do to improve air quality		Released air quality summary report for Prince George (2014 data).	
	Maintained air quality monitoring instruments and issued air quality advisories as necessary	Maintained air quality monitoring instruments and issued air quality advisories as necessary	Maintained air quality monitoring instruments and issued air quality advisories as necessary	Maintained air quality monitoring instruments and issued air quality advisories as necessary	Maintained air quality monitoring instruments and issued air quality adivisories as necessary	Maintained air quality monitoring instruments and issued air quality adivisories as necessary	

				Adopted an interim provincial SO2 ambient air quality objective (lower than previous objective) or expanding emission sources.		Provided a guidance document, New National Air Quality Standards for SO2, to facilitate the transition to the new lower SO2 CAAQS (national standards) to be implemented by 2020	
						Revised the Solid Fuel Burning Domestic Appliance Regulation	
				Relseased an air quality report that summarized trends of particulate matter (PM2.5 and PM10) . Data up to 2013 was included.		Developed Smoky Skies Bulletins, a type of public notice being issued by the Ministry in collaboration with Northern Health Authority, to improve communication on wildfire smoke.	
Ministry of Trans-portation					Grassy areas in City are cleared of winter abrasives yearly	Incorporated reduced vehicle idling practices on all construction sites within City	
				Modified sweeping activities to reduce impacts to air quality such as discontinuing during air quality advisory, and beginning earlier in spring	Sweeping equipment moved from brooms to pick-up machines.	Adherence to Clean Air Bylaw guidelines for clean sweeping practices including wetting dry surfaces prior to sweeping	
				Maintenance contractors modified winter traction materials to include fewer fine particulates	Ensured all MoT-responsibility roads in City are non-gravel	Increased total kilometers swept each year, subject to need	
Other Partners							
Private member (Veller)			Promotes best available technology in wood burning appliance industry and home heating	Continues to promote efficient, clean burning of all solid fuel products, including pellet	Added natural gas heating into the solid fuel heating to help reduce emissions	All products used for heating are now considered to be high efficient and clean burning	
Private member (Fisher)			Personal actions include consumer choices that reduce emissions, and participation on PGAIR	Personal actions include consumer choices that reduce emissions, and participation on PGAIR	Personal actions include consumer choices that reduce emissions, and participation on PGAIR	Personal actions include consumer choices that reduce emissions, and participation on PGAIR	
Private member (AJ Safety Centre/FBC)					Implemented dust control measures on site	Promote fuel efficiency at office, and in community through PGAIR Executive committee	

APPENDIX C: PRINCE GEORGE AIR QUALITY MONITORING

Since the early 1990s, an extensive monitoring network funded by government agencies and industrial partners (comprising the Prince George Monitoring Working Group) has measured a number of pollutants in the Prince George airshed, including $PM_{2.5}$, PM_{10}, sulphur dioxide (SO_2), nitrogen oxides (NOx), total reduced sulphur (TRS), ozone (O_3), and carbon monoxide (CO) *(see Figure A1)*.

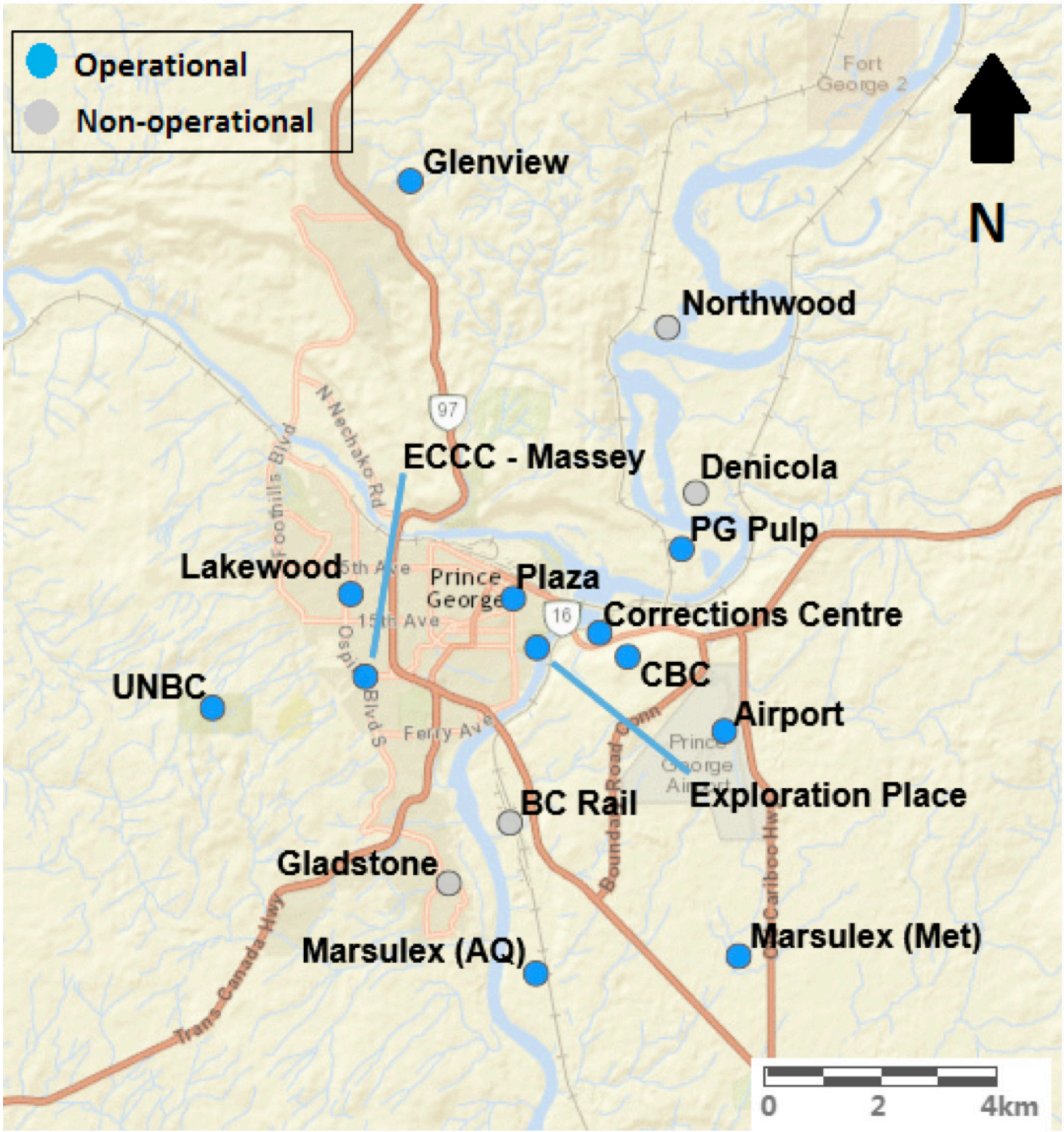

Figure C1: 2017 Location of Monitoring Sites and Meteorological Sites in Prince George (Ministry of Environment and Climate Change Strategy).