
# FINAL REPORT

**of the**

**Puget Sound Clean Air Agency**
**$PM_{2.5}$ Stakeholder Group**

Prepared with the Assistance of

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## Executive Summary

### ■ Charge

In 1998 the Puget Sound Clean Air Agency convened a broad-based stakeholder group to provide direction on how the agency might approach reducing levels of fine particulate matter (known as $PM_{2.5}$) in the Puget Sound Region. Specifically, the Group was charged with providing recommendations on emission reduction strategies that would help to ensure that the Region remains in attainment of the EPA's new $PM_{2.5}$ standard and that might enable the Region to successfully strive to meet the $PM_{2.5}$ health goal recommended in 1996 by the Agency's Particulate Matter Health Committee. The Health Committee goal has the same annual exposure limits as the EPA standards (although the form differs in that the EPA standard is averaged over three years while the Health goal is averaged over only one year). However, the Health Committee's 24-hour goal is more stringent in terms of daily exposure than the EPA daily limit.

### ■ Process

The $PM_{2.5}$ Stakeholders Group, which consisted of 25 members representing government, diesel fleet operators, industry sources, the health community, the fuels industry, environmental and community interests, the hearth products industry, small businesses, and outdoor burning industries and agencies, met eleven times over the past fifteen months to develop its recommendations on emission reduction strategies. The Group strove for convergence on its recommendations and respected any remaining differences in perspective as reflected in this report.

Because addressing fine particles is a relatively new effort, the stakeholders participated in joint learning with the Agency staff regarding $PM_{2.5}$ air quality data, sources that emit $PM_{2.5}$, and analysis of potential strategies to reduce fine particulate emissions. The process consisted of staff presentation and analysis (developed with input from stakeholders), group discussion and debate, individual member ranking of strategies within each emission source category, and then collective analysis and debate across all emission source categories to develop recommendations for the Agency to consider. The source categories analyzed by the Group included industry, indoor and outdoor burning, on-road and off-road mobile sources, and other miscellaneous sources of fine particulate matter.

### ■ Observations

Some key observations give meaningful context to the Group's recommendations. While much of the country has little or no data regarding $PM_{2.5}$, the Puget Sound region had the foresight to begin collecting limited $PM_{2.5}$ air quality data consistently over the last 4 years. While not directly comparable to the data that will be gathered in the future by the newly required network of $PM_{2.5}$ monitoring stations, current data indicate that the region appears to be able to achieve compliance with the new EPA annual and daily standards; however, staff did note that a meteorological event, such as an extended stagnation period in winter, could cause an exceedence of the EPA daily standard. In addition, the daily exposure limit as recommended by the Health Committee has been exceeded in the Region on numerous occasions. Thus, a sense of prudence and of seeking opportunities for meaningful reductions of $PM_{2.5}$ pervaded the Group.

As individual source categories were examined by stakeholders to identify emission reducing strategies, it became evident that many sources, such as industry, public transit fleets and agencies and industries involved in indoor and outdoor burning have previously taken steps to decrease the amount of fine particulate they might otherwise emit. As well, robust national debates are currently occurring concerning next generation requirements for other sources, such as diesel and gasoline fuels specifications and new engine emission standards, which, when new requirements are established, appear to be highly likely to produce significant $PM_{2.5}$ reductions.

While recognizing that many emission reduction measures have been previously implemented, or may in the future be mandated nationally, stakeholders recognized significant opportunities across all sources to continue to reduce $PM_{2.5}$ emissions. When evaluating these sources for possible emission reduction strategies, stakeholders acknowledged and considered a variety of factors and perspectives. Among these were notions that providing incentives and increasing education may produce greater air quality benefits than new regulations in some circumstances; that participation in national initiatives should be given serious consideration, while not necessarily foreclosing the possibility of regional action; that all sources should contribute emission reductions where reasonable; and that certain strategies should be given additional consideration because of the additional air quality benefits they might produce for such air quality problems such as toxics, ozone and visibility.[1] Stakeholders identified and considered these factors in both their discussions and evaluations of proposed strategies.

In addition, stakeholders acknowledged that there are some inherent uncertainties in the assumptions required to effectively estimate emission reduction percentages and costs, and relied on staffs' best professional judgment for their discussions and evaluations of proposed strategies. Stakeholders also recognized that despite potential costs, it is important for the region to move forward with $PM_{2.5}$ emission reduction efforts because of the significant benefits associated with achieving both the Health Committee goals and EPA standards.[2]

## ■ Recommendations

After analysis and discussion of the various sources and $PM_{2.5}$ emission control strategies, the Group developed their recommendations based upon three key criteria: a strategy's emission reduction potential; its overall cost-effectiveness[3]; and the ease or difficulty of implementing the strategy. The Group was not specifically aware of the level of effort it might take the Agency to fully develop and implement any one strategy, nor the precise level of effort and resources which the Agency may have to devote to any one strategy or the full set of strategies. As such, the Group organized its recommendations into three categories based upon the three criteria above in order to prioritize where the Group believes the Agency should focus its efforts and resources in reducing $PM_{2.5}$ levels in the Puget Sound region.

The categories used by the Group to develop its recommendations are defined as follows:

**Category A:** (worth considerable effort by the Agency to pursue)

[1] The Stakeholders Group was aware that the Clean Air Agency would be convening a carbon monoxide/ ozone advisory committee in late 1999/early 2000 to address the Region's continued maintenance with EPA's ozone standards. The Group recommends that the future carbon monoxide/ozone committee be aware of its $PM_{2.5}$ efforts, just as the $PM_{2.5}$ Group considered possible beneficial effects in particular for ozone while targeting fine particulate matter reductions. Please see Appendix A for a list of those strategies that would provide secondary benefits.

[2] Detailed and exhaustive cost/benefits analyses for each strategy were not prepared due to the resources and time required for such analyses.

[3] Please see Appendix B for cost-effectiveness calculations.

- substantial amount of emission reductions and/or
- reasonable cost to implement and/or
- clear path of implementation

**Category B:** (worth some effort by the Agency to pursue)
- lesser amount of emission reductions and/or
- cost less reasonable and/or
- additional work required to establish the path to implementation

**Category C:** (may/may not be worth additional effort for the Agency to pursue)
- minimal emission reductions and/or
- costly to implement and/or
- additional preparation and analysis required to establish the path to implementation

Although these recommendations do not necessarily represent full consensus among all stakeholders on all aspects of all strategies, they do represent a strong sense of convergence around the sources and strategies that stakeholders believe are worth the Agency spending time and effort on to reduce fine particulate matter emissions. (For more information on specific stakeholder differences on strategies or differing emphasis on specific tactics or interpretations, see the body of the report, as appropriate.)

One area of strategic differences between stakeholders that deserves mention here is the fuels area. Most diesel and gasoline fuel used in the region is also refined in Washington State. There are significant national debates taking place on proposed new fuel quality standards to lower the sulfur content in gasoline and diesel fuels, which will most likely result in a lower sulfur content for both of these fuels. As well, there are other national rulemakings ongoing regarding lowering the emissions specifications for both lightweight and heavyweight diesel engines. Stakeholders support these discussions as critical for the next generation standards for fuels and engines, believe that they hold great promise for reducing $PM_{2.5}$emissions (and ozone precursors) from these sources, and recognize that the Clean Air Agency should be a supportive participant in the debate. Stakeholders differ as to the amount of time and energy the Agency should devote to these discussions, and as to whether or not regional efforts to have Washington refineries produce lower sulfur (or other less polluting) fuels prior to--or beyond--whatever is required nationally, is a good use of the Agency's resources to reduce $PM_{2.5}$ emissions.

In addition, stakeholders recognized that the strategies as analyzed have not been fully developed nor are they necessarily ready for direct implementation in most cases. In this regard, the strategies and subsequent recommendations in this report provide a strong sense of direction for the Agency to pursue to reduce $PM_{2.5}$ emissions within Puget Sound, rather than a detailed tactical course of action.

The following chart displays the categorical recommendations developed by the Group along side the key criteria analyzed and discussed for each strategy. (For further detail on the strategies, please see Appendix C, Source White Papers.)

| Category | Strategy | Less $PM_{2.5}$ Tons / Year | Cost / Ton | Implementation Observations |
|---|---|---|---|---|
| A | Reduced sulfur fuels for use by industry | 160 tpy Sox | $750/ton SOx | Fairly easy to implement, however, may require retrofit of existing equipment |

| | | | | |
|---|---|---|---|---|
| | Develop a fuel conversion incentive program for industry to replace coal, distillate and residual fuels oil combustion with natural gas or electricity | 340 tpy Sox | $4,500/ton SOx | Costly to implement |

| | | | | |
|---|---|---|---|---|
| | Require "process reliability" plans for industrial sources | 20 | $5,500 | Easy to implement; likely support by sources because of potential benefits to sources and in many cases already required |
| | Develop a program requiring the removal, replacement by a gas, pellet or certified wood burning heater, or licensing of an uncertified wood heater at the time of sale of any residence in the four county area | 7,858 | $2,800 | Potentially difficult to implement due to possible need for state legislative action and resistance from home owners; implementation may be easier if adopted by local jurisdictions instead of at the state or regional level |
| | Jointly promote with the manufactured log industry a program to educate and encourage homeowners who burn wood to burn manufactured logs | 546 | $2,600 | Easy to implement and would likely receive support from the hearth products industry |
| | Develop a program with possible monetary incentives for homeowners to retrofit their existing fireplace with natural gas log sets where gas lines are available | 780 | $6,100 | Moderately easy to implement as fireplace retrofits are currently occurring in many areas; a formal program would take advantage of the current trend |
| | Prohibit burning of land clearing debris | 470 | $9,700 | Overall fairly easy to conceptualize, however may encounter some resistance from building industry |
| | Require waste pickup and prohibit outdoor burning in areas as soon as yard and waste pickup services are in place | 6900 | $5,600 | Although an extension of services already provided in other areas, may be difficult to implement because of cost and disposal traditions in the more rural areas of the region |
| | Prohibit summer outdoor burning | 2,340 | $4,000 | Easy to implement as most summer burning is already banned by local fire officials |
| | Targeted education and enforcement of existing outdoor burning regulations | 345 | $460 | Relatively easy to implement, however might be difficult to enforce effectively |
| | Support EPA in the development of new, lower, diesel truck emission standards | 446 | $28,500 | Easy to implement; discussions currently occurring at the national level |
| | Support EPA in the development of a national rule to reduce sulfur in gasoline | 1,912 SOx | $12,200/ ton SOx | Easy to implement; EPA has issued a proposed rule on sulfur in gasoline |
| | Support EPA in the development of a coordinated engine standard and fuel strategy for diesel vehicles, including a reduction in diesel sulfur levels | 1,137 $PM_{2.5}$ 1,152 SOx | $13,900 | Easy to implement; national strategy currently in progress and EPA has proposed draft rules |
| | Work with Ecology to tighten the current inspection and maintenance program for diesel opacity and to evaluate potential of routine on-road testing | | $13,700/ ton SOx | More data and discussion required for implementation; challenges associated with out of state vehicles traveling through the region |
| B | Public recognition program for industrial facilities that reduce $PM_{2.5}$ emissions | 10 | $3,000 | Easy to implement |
| | Support fuel neutral emission standards for light and medium duty trucks | | | Easy to implement; national strategy currently in progress |
| | Develop an incentive/regulatory program for the installation of natural fueled indoor burning appliances in new developments where gas lines are available | 104 | $10,000 | Requires further examination to determine the best path for implementation; need to discuss gas line expansion with gas utilities and WUTC |
| | Cleaner fuels and promotion of good operation and maintenance for construction equipment | 41 tpy $PM_{2.5}$ 108 tpy SOx | $7,200 $2,700 SOx | Implementation may be difficult at the regional level; sulfur in diesel is active as a national issue |

| | | | | |
|---|---|---|---|---|
| | Use cleaner fuels for marine engines in the Puget Sound Region along with improved operations and maintenance of marine diesel engines | 39 tpy $PM_{2.5}$ 134 tpy SOx | $1,700 $480 SOx | Difficult to implement and enforce as there is much national and international vessel traffic in Puget Sound; may require ship retrofits |
| | Encourage clean engine and low emission technologies for aircraft engines and promote the use of clean alternatives for airport ground support operations | 160 | $2,400 | Requires consultation with the airline industry and further understanding of federal initiatives to develop a clear implementation path; Agency working on latter part of strategy now |
| | Develop infrastructure for and promote use of natural gas vehicles through funding from sources such as the Congestion Mitigation and Air Quality Improvement (CMAQ) program and other appropriate sources. | | -[$19,600][4] to $142,000 | Complexity and timeframe required varies dependent upon the specific implementation strategies and funding sources selected; some are ready to pursue, others will take time |
| | Improve fugitive dust education and enforcement | 258 | $620 | Easy to implement; can build off of prior and existing efforts |
| | Control emissions from char-broilers in restaurants | 350 | $5,600 [5] | Fairly easy to implement but need some discussion with restaurant industry, especially concerning retrofit and O&M costs |
| A - C | Require California diesel (lower aromatics) in the Puget Sound Region[6] | 615 | $6,200 - $18,400 | Difficult to implement; requires more analysis on possible reductions and cost to implement |
| C | Stricter emission standards for industry | 50 | $6,500 | More work required to implement given the lack of knowledge regarding efficiency and effectiveness of stricter standards and controls |
| | Emissions trading and banking system | 50 | $2,200 | Difficult to implement due to the complexity required to establish system, and difficult to monitor once in place |
| | Promote and leverage funding for the introduction into service of hybrid vehicles | | $1,400,000 | Difficult to implement |
| | Request EPA to certify clean air retrofit kits for heavy duty diesel trucks | 81 | $13,500 | Difficult to implement at a local level |
| | Develop retrofit/rebuild incentives with Ecology and fleets | 81 | $13,500 | Difficult to implement; substantial technical work required before implementation |

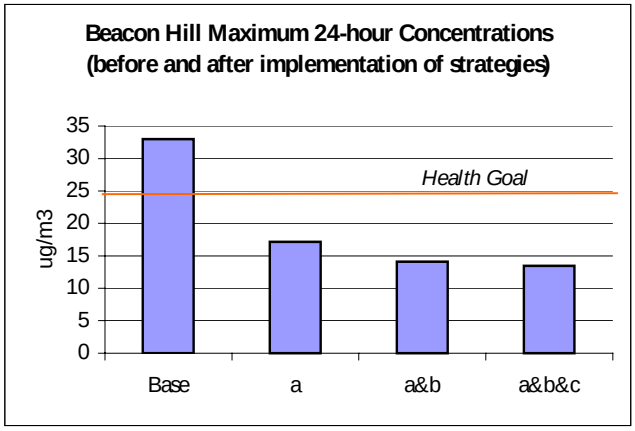
## ■ Conclusions

The emission reduction strategies recommended by the Group represent a robust set of actions that the Agency can begin to pursue to significantly reduce levels of $PM_{2.5}$ in the Puget Sound Region. The Group's recommendations cut across all sources, requiring industry, indoor and outdoor burning, mobile sources, and others to contribute to reducing overall $PM_{2.5}$ regional levels. Implementing the recommended strategies will require a long-term commitment from the Clean Air Agency, both to develop and then to implement the strategies, in order to produce the emission reductions they promise.

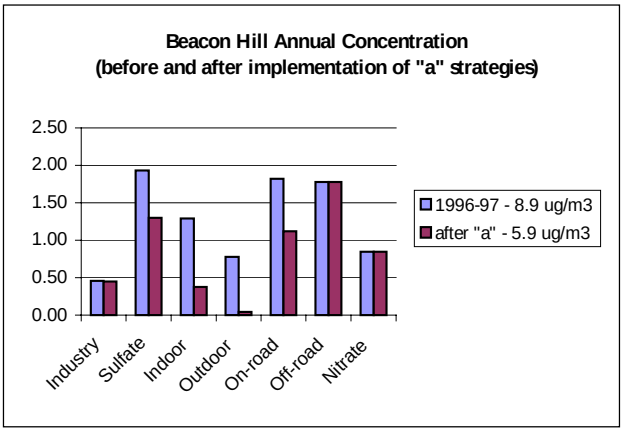
When the recommended strategies or a combination of these strategies are fully implemented over the next decade, the Region will have significantly improved air quality, will be sufficiently secure in its

[4] Negative cost per ton indicates that a cost savings is realized concurrently with an emission reduction.
[5] The cost element does not include retrofitting of the broiler and installation of the control equipment, which can vary widely.
[6] Stakeholders were divided on which category this strategy should be in, see page 23 for discussion of this issue.

ability to maintain attainment with the EPA's daily and annual $PM_{2.5}$ standard, and will be well on the way to meeting the challenge represented by the Health Committee's recommended goal.




Specifically, if all of the Category A strategies were implemented, it is estimated that the 24-hour maximum $PM_{2.5}$ concentrations measured at the Beacon Hill monitoring sites would be well below both the 24-hour Health Committee goal and the EPA standard.[7] In addition, if both the Category A and B strategies were implemented, estimations indicate that the maximum $PM_{2.5}$ concentrations measured at the Marysville, Duwamish and Tacoma Tideflats monitoring sites would also meet the 24-hour Health Committee goal and be well below the 24-hour EPA standard.[8]




With respect to annual concentrations, if all of the Category A strategies were fully implemented, using Beacon Hill as a reference point, there would be an estimated 30% reduction in its overall annual $PM_{2.5}$ levels.[9]

It is clear that implementation of the strategies would bring the Region closer to meeting the daily Health Committee goals, and hence, to improved human health conditions in the Region. The Group believes its recommendations represent a strong sense of direction for the Agency, tempered by the prudence of looking for meaningful, cost-effective opportunities to reduce fine particle emissions and inspired by the possibility of achieving significant improvements to the Region's air quality.

We appreciate the opportunity to serve the Agency, its Board, and citizens of the Puget Sound Region.

[7] See pages 1 and 2 of the main body of the report for specifics on the Health Committee's $PM_{2.5}$ goals and the EPA standards.
[8] See Appendix D for additional information regarding the effects of implementing the strategies. In addition, please note that calculations are based on the emission reduction estimates contained in the individual source white papers; different assumptions might affect the emission reduction estimates and therefore could change the ultimate outcome of the effects of strategy implementation.
[9] If the Category A and Category B strategies were fully implemented, Beacon Hill could realize an estimated 40% reduction in its overall annual $PM_{2.5}$ levels.

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## Introduction

The $PM_{2.5}$ Stakeholders Group (the Group) was convened by the Puget Sound Clean Air Agency in 1998 to provide the Agency with direction on how to further reduce particulate emission levels within the Puget Sound region. Participants represented a variety of interests including government, diesel fleet operators, industry sources, the health community, the fuels industry, environmental and community interests, the hearth products industry, small businesses, and outdoor burning industries and agencies. Agency staff provided technical support and background information to the stakeholders group. The Group met over the course of 15 months and analyzed and evaluated strategies designed to produce particulate matter emission reductions within the Puget Sound Region.

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## Background

### ■ Particulate Matter

PM refers to pollutant particles released into the air by various sources. The pollutant particles, known as particulate matter (PM), are classified, and then regulated based on size. The coarser particles, known as $PM_{10}$ measure up to 10 microns in diameter and finer particles, those less than 2.5 microns in diameter, are known as $PM_{2.5}$. These finer particles are produced by many sources including fireplaces and wood stoves, land clearing fires, backyard burning, industrial boilers, and internal combustion engines, particularly those using diesel fuels. In addition, $PM_{2.5}$ can be formed in the atmosphere as secondary particles from gases such as sulfur oxides (SOx) and nitrogen oxides (NOx).

The finer $PM_{2.5}$ particles behave more like a gas than the coarser $PM_{10}$ particles. Because of their size, these particles can cause significant health effects, in particular respiratory illness, as they are easily inhaled and can lodge deep into the pulmonary system of the lungs. When they collect in the lungs they can cause structural and chemical changes internally as well as act as carriers for other toxic and carcinogenic materials. Pre-adolescent children, the elderly and people with pre-existing respiratory diseases are the most susceptible to health risks caused by $PM_{2.5}$. Some $PM_{2.5}$ particles, especially acidic aerosols such as sulfuring and organic acids resulting from combustion processes are believed to be more harmful than other $PM_{2.5}$ particles. In addition, fine particles in air not only impact human health, but can impair visibility, contributing to regional haze.

### ■ Particulate Matter Health Committee Goal

In 1995 the Puget Sound Clean Air Agency convened a group of experts to discuss health effects associated with particulate matter. The Agency convened the Particulate Matter Health Committee (Health Committee) because of concerns expressed throughout the health community both locally and nationally about the effects of particulate matter on human health. These concerns were prompted by scientific research that indicated that finer particulate matter had a significant effect on human health.

The Health Committee was convened and charged with evaluating the EPA standard for particulate matter and determining if the then existing federal $PM_{10}$ standard sufficiently protected public health. If the federal standard for $PM_{10}$ was determined insufficient for protecting health, the Committee was directed to develop a recommended goal for finer particulate matter ($PM_{2.5}$) levels in the Puget Sound Region.

The Committee reviewed and evaluated studies on the health effects of particulate matter and determined that the federal $PM_{10}$ standard was not sufficiently protective of human health. Based on its research and discussions, the Health Committee recommended both a 24 hour and annual goal for $PM_{2.5}$ that are more protective of human health than the $PM_{10}$ standard. The Committee's recommended goals[10] are as follows:

- 25 micrograms per cubic meter of air ($\mu g/m^3$) $PM_{2.5}$ averaged over 24 hours
- 15 $\mu g/m^3$ $PM_{2.5}$ annual (arithmetic average over the course of one year)

The Health Committee's $PM_{2.5}$ goals were presented to and formally acknowledged by the Puget Sound Clean Air Agency Board in 1996. At that time, the Board directed the Agency to convene a process to explore what the regional impacts might be of striving to meet the Health Committee goals for fine particulate matter.

**$PM_{2.5}$ Stakeholders Process**

At the Board's direction, the Clean Air Agency began to develop a stakeholders process designed to discuss the potential regional effects of endeavoring to reach the recommended $PM_{2.5}$ goal. Before the stakeholders committee was formally convened however, the EPA adopted a national $PM_{2.5}$ standard to help address and reduce the health impacts of finer particulate matter. The focus of the stakeholders' process was then expanded to include a discussion of how the region could ensure attainment with the new $PM_{2.5}$ standard.

**EPA Particulate Matter Standards**

EPA published final revisions to its particulate matter standards in July of 1997. (The standard had last been revised in 1987.) As noted above, the revisions included the addition of a $PM_{2.5}$ standard. EPA developed the revised standards in response to research indicating that health effects were occurring even when levels of particulate matter in the air were in compliance with the $PM_{10}$ standard, indicating that fine particles ($PM_{2.5}$) are largely responsible for the health effects of greatest concern. In addition, EPA indicated that the existing $PM_{10}$ standard did not adequately protect visibility. EPA retained the original annual $PM_{10}$ standard, revised the 24-hour $PM_{10}$ standard by changing its form to be more protective against short-term exposure to coarse particles and added the following $PM_{2.5}$ standards:[11]

- 65 $\mu g/m^3$ $PM_{2.5}$ 24 hr (based on 98$^{th}$ percentile of data collected and averaged over three years)
- 15 $\mu g/m^3$ $PM_{2.5}$ annual (averaged over three years)

[10] The Health Committee also recommended a lower $PM_{10}$ standard than the current EPA $PM_{10}$ standard. The $PM_{2.5}$ Stakeholder Committee did not expressly address this issue; it was assumed that achieving the $PM_{2.5}$ goal would likely result in a sufficient decrease in $PM_{10}$ as well.

[11] The new EPA standards were challenged in court, and in May of 1999 a three-judge panel of the U.S. Court of Appeals for the District of Columbia Circuit issued an opinion regarding, in part, EPA's new $PM_{2.5}$ standard, explaining that the EPA must have a clearly articulated rationale, or that Congress must provide a rationale, for selecting a standard that could affect the national economy. The Court did not question the science and process used by EPA to set the more protective standards but questioned the criterion used to determine where the standard was set. On June 18, 1999 the Court ruled that the $PM_{2.5}$ standard should remain in place, but that parties will be allowed to apply for the standard to be vacated if "the presence of this standard threatens a more imminent harm." On June 28, 1999 EPA and the Department of Justice filed a petition asking the full DC Circuit to reverse the decision.

Note that the Health Committee's daily goal is stricter than EPA's daily goal. Annually, the Health Committee's goal and EPA's standard are the same numerically, however differ in form. The EPA standard is averaged over three years while the Health Committee goal is averaged over only one year.

**Stakeholder Group's Charge**

The Group was officially convened in 1998 and charged with providing the Clean Air Agency with direction on how to further reduce particulate emission levels within the Puget Sound region. Specifically, the Group was charged with both providing directional recommendations to the agency to ensure that attainment is maintained under the EPA's new $PM_{2.5}$ standard[12]; and assessing the potential directions and implications of striving to reach the stricter recommended Health Committee goals in the Puget Sound region. Emission reduction strategy recommendations provided by the stakeholders group will play an important role in advising the Clean Air Agency on how to proceed to ensure that public health in the Puget Sound Region is sufficiently protected from the effects of fine particulate matter, and that the Region never suffers any consequences for being out of attainment with the national $PM_{2.5}$ standard.

In order to develop its recommendations, the stakeholders group reviewed the existing data and knowledge regarding concentrations, source contributions and geographic areas of concern in relation to EPA's $PM_{2.5}$ standard and the recommended goals of the Health Committee. The Group evaluated a range of emission reduction strategies, considering potential emission reductions, cost-effectiveness, feasibility, and additional costs and benefits associated with the implementation of the strategies. Stakeholders acknowledged the inherent uncertainties associated with some estimates of strategy evaluations and relied on staffs' best professional judgment for their discussions and evaluations of proposed strategies. Stakeholders also recognized that despite potential costs, it is important for the region to move forward with $PM_{2.5}$ emission reduction efforts because of the significant benefits associated with achieving both the Health Committee goals and EPA standards.[13]

**Available Data**

To provide the stakeholders with background information regarding the levels of $PM_{2.5}$ in the region, staff presented air quality data collected from multiple $PM_{2.5}$ monitoring sites. The Puget Sound region is unique in that the Clean Air Agency has collected $PM_{2.5}$ data for some time. Although data were collected on a limited schedule and using a non-federal reference method, they provide a good indication of the region's overall $PM_{2.5}$ concentrations.

Using these data, agency staff explained the relation between the Region's $PM_{2.5}$ concentrations and the daily and annual standards and goal. Staff explained that the region appears to be able to achieve the EPA daily standard; however, a lengthy (5 days) stagnation period or other meteorological influence could cause the region to exceed the standard. Staff noted that the data indicate that the region has exceeded the Health Committee's daily goal on numerous occasions. Currently, the region appears to be able to meet

[12] The Court of Appeals opinion referenced in footnote 11 was issued during the course of the Clean Air Agency's $PM_{2.5}$ stakeholder process. Despite the Court of Appeals opinion, the stakeholder group agreed that it should continue its efforts to provide necessary direction to the Clean Air Agency regarding potential emission reduction strategies. The group agreed that continuing the process would be the most prudent course of action given that a possible outcome of an appeal and subsequent EPA action could be the implementation of these new standards, or potentially even stricter federal standards. The stakeholder group also agreed that part of its charge was based on the recommended Health Committee goals and not just compliance with the federal standard. Finally, the group agreed that it was important for the stakeholders group to provide the Clean Air Agency with direction regarding how it, and the region, should proceed with addressing fine particulate matter, no matter what the eventual standard turns out to be.

[13] Detailed and exhaustive cost/benefits analyses for each strategy were not prepared due to the resources and time required for such analyses.

the annual EPA standard and annual Health Committee goal, however additional factors such as regional growth could cause increased levels of $PM_{2.5}$ and threaten an exceedence.

The additional scientific and technical data reviewed by the stakeholders during the process was based upon the Clean Air Agency's emission inventory and receptor modeling conducted within the region. Agency staff noted that although the emissions inventory and receptor modeling were independent methods of analyses, they should be examined together as each has technical shortcomings and neither alone are a complete tool. When combined however, these independent methods of analyses provide sound and consistent information and identify the same major sources of emissions.

The emissions inventory is a list, by source, of air contaminants directly emitted into the Region's air. The data in the emissions inventory are based on calculations and industry surveys for sources in the region. The emissions estimates are developed using emission factors, which are a method for converting source activity levels into an estimate of emissions contributions for those sources. Although the latest available methods are used for the emission estimation calculations, including local regional data, the accuracy of the estimates is limited to the accuracy of the emission factors and the activity levels available. In addition, the emissions inventory includes only those emissions generated by sources in the region and does not include emissions transported into the region.

Receptor modeling is a chemically based process that analyzes particulate captured by filters. Each particulate source emits different chemicals, so each source has its own "chemical fingerprint". Samples from filters are analyzed in light of the different chemical fingerprints, which allows the analyst to determine how much of the mass on the filter comes from what source. This method is particularly good for identifying what type of emissions are occurring in specific areas (e.g., high impact areas and representative areas such as industrial and residential). There are limitations to the method, as it requires current source fingerprints, which are expensive and difficult to determine. Another difficulty associated with receptor modeling is that some sources have similar "fingerprints", which causes the sources to be categorized together (e.g., gas and diesel powered vehicle emissions cannot be distinguished).

**Annual Emissions**

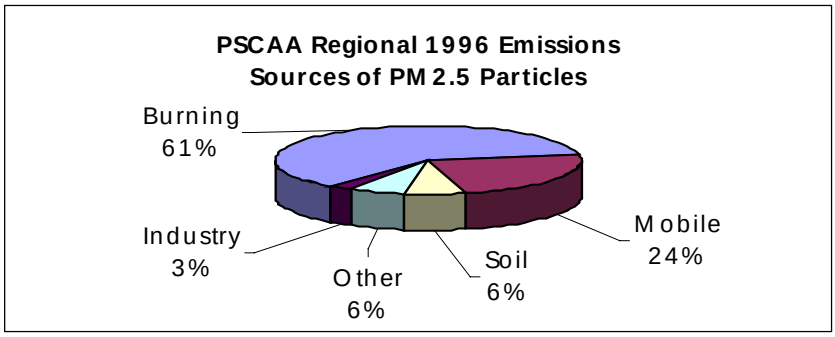
The emissions inventory and receptor modeling are used to determine the major emitting sources and the annual percentages of $PM_{2.5}$ contributed by each source. The data indicate that major $PM_{2.5}$ emitting sources include industry, indoor burning, outdoor burning, on-road mobile, off-road mobile and other sources (e.g., dust). Both analyses, the emissions inventory and receptor modeling, indicate that the major $PM_{2.5}$ source categories appear to be burning and mobile sources.

The analyses also identify a seasonal difference among the emission contributions of the various source categories. Overall, there is a higher emission of fine particulates during winter months than during the summer months. (Winter = 10,647 tons/90 days, summer = 6,225 tons/90 days) During the winter months residential wood burning sources are predominant and during the summer months, open burning and mobile sources contribute the highest percentages of $PM_{2.5}$. Please see Table 1, below, for the annual and seasonal emissions breakdown of each of the major emitting sources, and Figure 1 for a display of annual emission sources.

Table 1

| Source | % Contribution to Annual Primary $PM_{2.5}$ Emissions | % Contribution to Winter Primary $PM_{2.5}$ Emissions | % Contribution to Summer Primary $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|---|---|
| Industry | 3% | 2% | 4% | 1,036 |
| Indoor Burning | 38% | 63% | 2% | 12,966 |
| Outdoor Burning | 23% | 9% | 39% | 7,798 |
| On-road Mobile | 12% | 9% | 17% | 4,128 |
| Off-road Mobile | 12% | 7% | 22% | 4,033 |
| Other (e.g., dust) | 12% | 10% | 16% | 4,109 |
| **TOTAL** | **100%** | **100%** | **100%** | **34,070** |

Figure 1




Receptor modeling also allows for emissions to be tracked geographically. Certain sources may be bigger or smaller contributors to overall particulate concentrations depending upon their location. For example, modeling for residential areas demonstrates a different breakdown in source contribution than those data sets from sites located in more industrial areas. Geographically, data show that burning sources tend to be highest in residential neighborhoods, particularly in the winter.[14] In industrial areas, mobile sources and dust are the greatest contributors of particulates.[15]

**Secondary Particles**

In addition to direct or primary particulate emissions, $PM_{2.5}$ can also be formed in the atmosphere from sulfur oxides (SOx) and nitrogen oxides (NOx). Sulfur oxides convert into sulfates and nitrogen dioxide into nitrates, both of which are $PM_{2.5}$ contributors. According to receptor modeling results from Beacon Hill, which is considered representative of many sites in the region, sulfates comprise about 21% of the site's annual $PM_{2.5}$ and nitrates about 10% annually. These percentages increase in the summer months (sulfates 28%, nitrates 13%) as the chemical conversion process is enhanced by sunlight.

The major sources of the precursors to secondary particles include mobile sources and industrial sources. Annually, mobile sources contribute approximately 53% of the Region's sulfur oxides and 83% of the Region's nitrogen oxides. Industry contributes 34% of the Region's sulfur oxides and 6% of its nitrogen oxides.

The emission inventory numbers can be combined with the receptor modeling results from Beacon Hill in order to estimate the total contribution to ambient concentrations from each source category to $PM_{2.5}$.

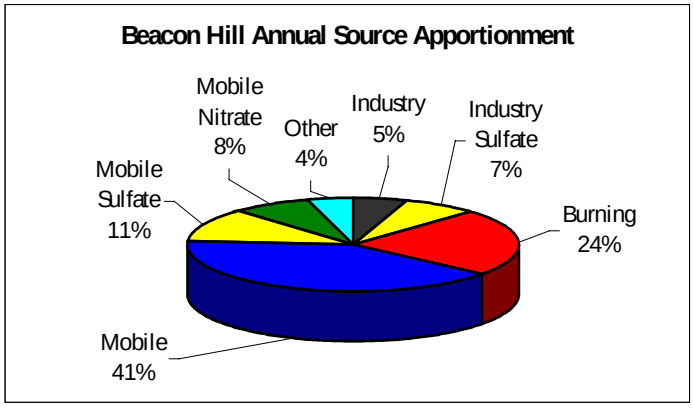
[14] E.g., Puyallup 80%, Lake Forest Park 76%, and Marysville 81%

[15] E.g., Kent mobile 36%, soil 14%, Duwamish mobile 34%, soil 33%, Tacoma mobile 27%, soil 43%. Note, however, soil numbers are based on $PM_{10}$ data so it becomes less of an issue when addressing $PM_{2.5}$ as only about 20% of dust consists of the finer $PM_{2.5}$ particles.

However, performing these calculations adds another layer of uncertainty to the estimated results. There may or may not be a direct relationship between the emission inventory estimates for sulfur dioxide and nitrogen dioxide and the formation of sulfates and nitrates. The reaction times for the formation of secondary particles vary with relative humidity and sunlight. Furthermore, emissions from mobile and industrial sources occur at differing heights above the surface, different locations, and at different temperatures.

With these additional uncertainties in mind the results of the modified calculation[16] for the source apportionment of the annual $PM_{2.5}$ for Beacon Hill can be graphed as follows: [17]

Figure 2




On an annual basis, industry's portion increases from 5 to 13 % of the $PM_{2.5}$ mass, while the mobile source category's contribution increases from 40 to 60%. Burning remains around 23%, while other nitrate and other sulfate are approximately 1 and 3 % respectively. The effect of partitioning will be less pronounced in the winter when the highest ambient concentrations are measured. The sulfate percentage drops from 22% annually to 13% in the winter, while the nitrate drops from 10% annually to around 5% in the winter.

**Process Description**

The $PM_{2.5}$ Stakeholders Group convened by the Clean Air Agency met a total of 11 times over the course of 15 months. The first nine meetings focused on the various source categories of $PM_{2.5}$– and strategies to reduce the $PM_{2.5}$ from these sources–within the Puget Sound Region, which included industry, indoor burning, outdoor burning, mobile sources and other miscellaneous sources of $PM_{2.5}$. To prepare participating stakeholders for each of the source meetings, Clean Air Agency staff developed White Papers for the individual source categories. The White Papers explained the emissions contributions by and existing emission reduction measures associated with the source, selected potential emission reduction strategies and a description of each, and a list of emission reduction strategies identified but not selected for presentation to the Group.[18]

Each White Paper was developed with the assistance of stakeholders. Prior to the meeting on a specific source category, Clean Air Agency staff contacted those stakeholders who expressed a specific interest in the source category. Stakeholders provided information and input on potential emission reduction strategies associated with the source, which was then incorporated into the White Paper.

[16] Source apportionment with the added step of partitioning the sulfates and nitrates according to the emissions inventory.
[17] Note that for these calculations, the mobile source category includes both on-road and off-road mobile sources, as receptor modeling is unable to distinguish the difference. In addition, these calculations estimate the total $PM_{2.5}$ contribution to ambient concentrations from each source category. In contrast, the emissions inventory identifies the percentage of primary emissions being contributed from each source category (including precursors for secondary particles); hence, the percentage contribution for each source category differs as one methodology estimates contributions to ambient air concentrations (source apportionment) and the other estimates direct primary emissions (emissions inventory).
[18] Please see Appendix E for a list of those strategies identified by not selected for presentation to the Group.

The last two meetings of the Group were dedicated to developing and approving the stakeholder group's final recommendations. To assist the Group in this task, a subgroup was formed to develop the Group's initial recommendations. (Please see *Development of Recommendations* below for a description of the subgroup's process.) The initial recommendations were then presented to the full stakeholders group for its input. The recommendations were then revised, incorporating the views of the full group, and this final report developed based upon the full group's recommendations.

**Approach to strategies**

Prior to the specific source meetings staff evaluated the selected, potentially viable, reduction strategies for the specific emission sources. Staff provided common ways to compare the strategies with the criteria. Staff evaluations were included in the White Papers, which were distributed to the full stakeholders group prior to the individual sources meetings. (For more detail, please see the source White Papers in Appendix C) The various reduction strategies were then presented by staff and discussed by the stakeholders at the meetings. After each meeting, stakeholders evaluated the strategies presented and returned the completed evaluations to the Clean Air Agency. (Please see Appendix F for the stakeholder evaluation summaries.) Evaluations were them compiled and distributed at the following stakeholders meeting.

To evaluate the strategies presented by staff, the stakeholders agreed to a set of criteria by which to evaluate strategies. These evaluations were conducted in order to help record over the course of the process the directions that each stakeholder initially supported. The evaluations were based on the following criteria:

- *emissions reduction contribution* (i.e., What is the range of potential emissions reductions created by the implementation of the reduction strategy?)
- *implementation feasibility* (i.e., Can the emissions reduction strategy be easily implemented within the current source and/or regulatory system, or will new systems/structures have to be developed in order to implement the reduction strategy?)
- *authority* (i.e., Are the actions necessary to implement the emission reduction strategy within the Clean Air Agency's jurisdiction alone or are the implementation actions beyond the scope of the Clean Air Agency's jurisdiction and require action of other jurisdictions to be implemented?)
- *implementation time* (i.e., What is the time frame before which the emissions reduction from the reduction strategy actually takes effect?)
- *implementation approach* (i.e., Is the strategy regulatory in nature, incentive-based or voluntary?)
- *cost per ton of reduction* (i.e., How much will it cost per ton of reduction to implement and maintain the emissions reduction strategy?)
- *externalities* (i.e., Are there any indirect negative or positive environmental [including secondary air benefits], health, or cost-related effects that might result from implementation of the emissions reduction strategy?)
- *economic impact* (i.e., What is the financial impact on individual sources [or group of individual sources] of the cost associated with implementing the emissions reduction strategy?)

In addition to specific evaluation criteria, stakeholders were also asked to rank the presented strategies overall. When comparing the stakeholder rankings with the criteria evaluations, it became evident that stakeholders weighted some criteria more heavily than others, such as emission reduction potential, cost and ease of implementation.

**Cross-Cutting Perspectives**

Throughout the course of the $PM_{2.5}$ Stakeholder group discussions, several issues emerged regularly across emission source categories and across potential emission reduction strategies. These issues factored into stakeholder discussion of the strategies and the development of suggested strategy

adjustments. In addition, some of these issues were also considered in stakeholder evaluation of the emission reduction strategies recommended to the agency.

- Education - A prominent issue throughout the Group's discussions was the role of education within emission reduction strategies. Stakeholders strongly supported those strategies that incorporated a substantial education component. There was general agreement among stakeholders that, where prudent, education efforts should be a leading component of any strategy and that these efforts should generally precede a strict regulatory approach where feasible and logical.

- Incentives - Also considered by stakeholders was the notion of incentives vs. regulation. Stakeholders believed that where appropriate, in addition to education, incentives designed to change emitting behaviors are desirable as an initial approach to reducing emissions. It was agreed that a stronger regulatory approach might then be employed as a follow-up measure to deter emitting practices where they have not been curbed due to incentives provided. Stakeholders acknowledged that where regulations currently exist, these regulations should be effectively enforced.

- Previous Control Efforts - In discussing and analyzing various $PM_{2.5}$ sources, stakeholders considered opportunities for meaningful emission reductions in light of previous control efforts. In those source categories where considerable emission controls have already been implemented and have had a substantial impact on emissions contributions, stakeholders recognized that additional opportunities for emission reductions might yield minimal benefits and/or would be cost prohibitive. Concurrently, stakeholders recognized that despite previous emission reduction efforts, practicable opportunities for substantial emission reductions from all sources may still exist and that, where logical, all source categories should contribute to regional emission reductions.

- Cost Effectiveness - Stakeholders also considered the cost effectiveness of the emission reduction strategies they evaluated. It was noted that the individual sources and the Clean Air Agency itself have limited resources and that those resources should be focused on measures that produce the greatest amount of emission reductions at a reasonable cost. Strategies providing minimal reduction benefits at higher costs or with significant implementation challenges generally received less support from stakeholders.

- Secondary Benefits - Although the Group was convened to provide recommendations on reduction strategies for $PM_{2.5}$, stakeholders also recognized that some of the emission reduction strategies produced additional health and air quality benefits, in particular benefits associated with secondary particles, ozone and visibility. Stakeholders acknowledged that although a large percentage of the region's $PM_{2.5}$ consists of primary particles, secondary particles are of significant concern because of their specific health effects. Stakeholders recognized that some studies have shown that health impacts are greater when there are secondary particles present, particularly sulfates, in addition to primary particles and that the emissions levels of the precursors of secondary particles should be reduced where possible. Also, as ozone is currently a pollutant of concern in the Puget Sound Region, strategies that also provided additional ozone benefits were generally more strongly supported by stakeholders. In addition, stakeholders indicated that those strategies that contribute to improving visibility throughout the Puget Sound should also be considered in light of their additional benefits to air quality. Stakeholders supported the potential of these strategies to improve overall air quality and human health and to address air quality issues comprehensively, not just one pollutant at a time.[19]

[19] Please see Appendix A for those $PM_{2.5}$ strategies that would provide secondary benefits.

- Implementation Timeframe - Throughout the process a wide range of strategies, and timeframes to implement those strategies, were analyzed and discussed by the $PM_{2.5}$ group. Stakeholders acknowledged that the strategies are not necessarily easy to implement and require effort, time and resources. They agreed that strategies that might not necessarily be fully implemented in a short time frame were none the less worth moving forward with. Although these longer-term strategies would not produce immediate air quality benefits, stakeholders recognized that their potential emission reductions are substantial and would contribute towards meeting the Health Committee goal. In addition, stakeholders recognized that there are also strategies that are more easily implemented and can be fully implemented within a shorter time frame. Stakeholders agreed that these strategies were also important because of the more immediate benefits to air quality. These shorter-term strategies would also help ensure that the region does not go out of attainment with EPA's $PM_{2.5}$ standard.

- National and Regional Dynamics - Stakeholders also recognized that $PM_{2.5}$ concentrations – and the actions which would increase or reduce them – throughout the region are dynamic, subject to many influencing elements some of which are poorly understood or difficult to predict. Where appropriate, stakeholders considered those elements in their discussions . Factors considered included changes nationally and regionally that would both increase and decrease levels of $PM_{2.5}$. With respect to increased concentrations of $PM_{2.5}$, stakeholders acknowledged that the region would continue to grow and that a likely consequence of that growth – absent sufficient reduction strategies – would be an increase in pollutant concentrations. Stakeholders recognized that factors such as national changes to fuel and engine specifications, as well as continued automobile fleet turnover, would contribute to decreases in $PM_{2.5}$ concentrations as well. Although the Group did not have the data to quantify precisely these influencing factors, they recognized the changing dynamic of $PM_{2.5}$ levels.

- Fuels - The Group also recognized the special role of fuels in any regional effort to reduce particulate emissions, as this source has significant potential to contribute substantial reductions to both primary and secondary $PM_{2.5}$ contributions. Several characteristics of fuels made them unique in the Group's discussions and considerations. First, fuel strategies cut across various source categories (e.g., on-road trucks, off-road equipment, marine engines, and industrial boilers) and across different types and grades of fuels, (gasoline, diesel and fuel oil). Second, there are several national efforts currently underway that will change standards associated with fuels. EPA has recently proposed draft regulations that would reduce sulfur in gasoline to reduce the precursors to ozone formation.[20] A secondary benefit of reducing sulfur in gasoline is the reduction in secondary particulate emissions. EPA is also now beginning the regulatory process to reduce sulfur in diesel. Also occurring at the national level is the regulatory process that would both lower emission standards for larger diesel engines, and lower engine emissions for sport utility vehicles and light duty trucks, regardless of what fuel type was used. Third, stakeholders also considered the possibility of potential fuel changes that might be able to be implemented at the regional level, (such as requiring low aromatics in diesel fuels in the Puget Sound region or even requiring low sulfur fuels in the region prior to the implementation of new federal requirements). Finally, stakeholders recognized that most of the fuels used in the Puget Sound Region are produced within the region itself, and hence gained an appreciation of the technical and economic implications of these issues. Given the number of complicating and competing factors associated with fuel strategies, these strategies produced the greatest differences in opinion among stakeholders with respect to the approach of the strategies and the degree to which certain strategies should be recommended and/or pursued. Those differences have been respected throughout the Group process and have been captured below in the individual source discussions.

[20] Please see page 20.

**Process for Developing Recommendations**

The goal of the stakeholders group was to evaluate and comment upon potential emission reduction strategies in order to provide the Clean Air Agency with direction as to where it should focus its efforts to further reduce particulate emissions within the region. In order to provide a clear and strong sense of direction, stakeholders developed specific recommendations around the source categories and strategies presented to the Group.

To develop recommendations, the wrap-up subgroup (empowered by the full stakeholders group) began with an analysis of the strategies and the stakeholder evaluations of those strategies. The subgroup held several conference calls to discuss methods for selecting recommended strategies and the criteria that should be used to develop recommendations. Throughout the subgroup's discussions, members consistently converged around three key criteria in identifying those strategies that seemed the most worthwhile for the Agency to pursue. The three criteria were a strategy's emission reduction potential, its overall cost-effectiveness and the ease or difficulty associated with implementation of the strategy. Although other factors were also considered, such as the additional air quality benefits associated with a strategy, the three key criteria were the foremost drivers in determining the level of support for specific strategies.

Based on the three key criteria listed above, three categories were developed to prioritize strategies in a manner to recommend to the Agency where it should focus its efforts and resources in reducing regional $PM_{2.5}$ levels. The categories used to develop the Group's recommendations are defined as follows:

**Category A:** (worth considerable effort by the Agency to pursue)
- substantial amount of emission reductions and/or
- reasonable cost to implement and/or
- clear path of implementation

**Category B:** (worth some effort by the Agency to pursue)
- lesser amount of emission reductions and/or
- cost less reasonable and/or
- additional work required to establish the path to implementation

**Category C:** (may/may not be worth additional effort for the Agency to pursue)
- minimal emission reductions and/or
- costly to implement and/or
- additional preparation and analysis required to establish the path to implementation

Strategies were initially categorized by the subgroup and then presented to the full stakeholders group for their input, edits and approval. Although the recommendations produced through the categorization process do not necessarily represent full consensus among all stakeholders on all strategies, they do represent a strong sense of convergence around the sources and strategies that stakeholders believe are the most productive for the Agency to act upon. Where there were recommended strategies on which stakeholders had divergent perspectives with respect to emphasis and approach, those differences were respected by the Group in its efforts and are reflected in the text of the individual source categories.

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## Recommendations

Based upon the technical and informational data assembled by the Clean Air Agency, the stakeholders group analyzed the following major sources of $PM_{2.5}$ emissions and reduction strategies associated with each: industry, indoor burning, outdoor burning, on-road and off-road mobile sources, and other sources. The source categories and directional recommendations provided by the stakeholders group are described in detail, source by source, in the following sections. The recommendations follow the descriptions of the source, the existing control measures, and opportunities for reductions in general. They are displayed in both a narrative and table format in order to help the reader see both how much of the source might be affected by a particular strategy and how many of the strategies are in each of the recommended priority categories for action.

The Group recognizes that the strategies described as follows are not fully fleshed out and/or necessarily ready for direct implementation. Rather, they are the products of joint learning with staff, and group debate and refinement. They represent a strong sense of direction for the Agency in how to pursue a path to reduce emissions from particular sources.

## ■ Industry

Industrial sources account for approximately 3% of the Region's overall annual $PM_{2.5}$ emissions, 6% of the regional NOx emissions and 34% of regional SOx emissions. Included in this source category are facilities in the Puget Sound Region that report more than 25 tons annual direct emissions of particulate matter less than ten micrometers ($PM_{10}$), nitrogen oxides (NOx) or sulfur oxides (SOx). These include manufacturing, utility, military, and wholesale facilities. They are classified into large and small emission reporting sources, operating permit sources and facilities for which the Washington State Department of Ecology has adopted industry specific standards, (e.g., pulp mills and aluminum smelters). Within the industrial sources, manufacturing accounts for 91% of the overall industrial $PM_{2.5}$ emissions. Please see Table 2, below, for the emissions breakdown.

Table 2 – Industry (3% of Region's overall annual $PM_{2.5}$ emissions)

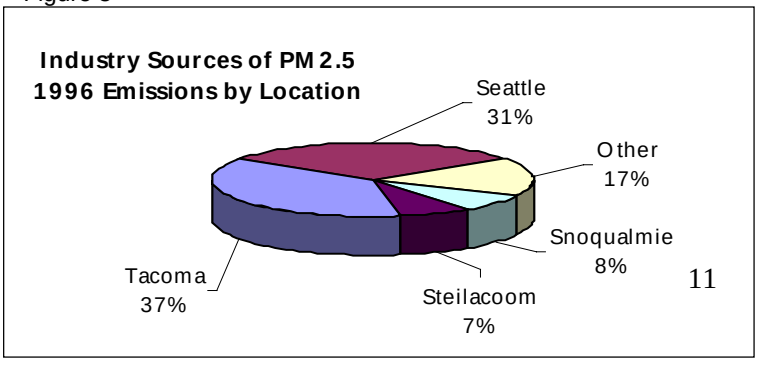
| Source | % Contribution to Annual Industrial $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|
| **Ecology Sources** | 27% | 277 |
| **Operating permit sources** | 56% | 579 |
| **Large emission reporting sources** | 6% | 60 |
| **Small emission reporting sources** | 11% | 120 |
| **TOTAL** | 100% | 1,036 |

Seasonally, industry emissions remain constant throughout the year with little variation in emissions contributions. Geographically, industry sources contribute significantly more within industrial areas than their regional percentage would indicate (e.g., 37% of the industrial source $PM_{2.5}$ emissions originate in the Tacoma area and 31% in the Duwamish area). (See Figure 3, below.)

**Existing Control Measures for Industry**

Industrial sources are substantially regulated at the federal, state and local levels. The small percentage contribution of industrial sources to primary $PM_{2.5}$ is largely due to the

Figure 3



amount of existing controls on industrial stack emissions. (Please see Appendix C, Industry White Paper, for a detailed description of the federal, state and local controls.) Generally, at the federal level, the Clean Air Act (CAA) restricts industrial emissions in several ways. State Implementation Plans (SIP) are required under the CAA and are designed to ensure that areas achieve and maintain compliance with national air quality standards. Under the SIP, Washington State has developed emission standards for all existing industrial sources. In addition, the CAA established operating permit requirements for all major sources of pollutants and contains standards for new pollutant sources. Standards also include testing and monitoring requirements for sources. In addition to the SIP, Washington State also administers a federal permit program designed to keep new point sources from causing air quality degradation. Locally, the Clean Air Agency has adopted regulations and standards similar in form to Ecology's for sources under its jurisdiction. The Clean Air Agency regularly inspects facilities for compliance with regulations applicable to particulate matter and sulfur dioxide emissions. In addition, several of the facilities are required to continuously monitor their emissions and submit monthly reports to the Clean Air Agency.

**Opportunities for Reduction**

Due to the control measures already in place at the federal, state and local level, industry sources represent a small percentage of the Region's overall $PM_{2.5}$ emissions (3%). Because of the level of existing controls and the small contribution of industrial sources to the Region's overall $PM_{2.5}$, significant reductions are difficult to achieve in the industrial source category.

Although direct $PM_{2.5}$ emissions from industry are minor contributors to the regional $PM_{2.5}$ emissions, about 1/3 of the regional sulfur oxides are emitted from industry. This means that industry is a significant contributor to the secondary particulate, sulfates. Strategies targeted at reducing SOx would provide the greatest emission reduction benefits in this category.

**Recommendations for Industry**

Following are the recommended strategies for industry, displayed by category.[21]

Category A

- Reduced sulfur fuels for use by industry. Allow only low sulfur fuels to be burned in the Clean Air Agency jurisdiction.

- Develop a fuel conversion incentive program for industry to replace coal, distillate and residual fuels oil combustion with natural gas or electricity. Replace coal, distillate and residual fuel oil combustion with natural gas, electric or less polluting recycled fuels by providing a reasonable payback for the conversion.

- Require "process reliability" plans for industrial sources. Better define environmental management systems to achieve specific emission reductions, especially recurrent upset conditions. Facilities must be committed to examining the magnitude and cause of upset conditions and to designing a strategy to prevent them. Sufficient training and educational support is needed to analyze process performance to produce technological improvements and significant preventive maintenance.

Category B

- Public recognition program for industrial facilities that reduce $PM_{2.5}$ emissions. Establish a program for publicly recognizing emission reduction accomplishments that go beyond existing standards, such as positive public statements or published top ten lists.

[21] See Appendix C, Industry White Paper, for more details on the strategies below.

Category C

- Stricter emission standards for industry. Tighten existing emission standards for particulate matter and ensure that current reasonably available control technology (RACT) requirements are applied to all existing sources.

- Emissions trading and banking system. Design an emission trading and banking system that assigns an economic value to emission reductions, creating an incentive to reduce emissions, or seek reductions from others who have reduced more. Sources could voluntarily reduce emissions below standards and "bank" the emission reduction credits for future use or open market sale.

| Category | Strategy | Less $PM_{2.5}$ Tons / Year | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|
| A | Reduced sulfur fuels for use by industry | 160 tpy SOx reduction | $750/ton SOx | Fairly easy to implement, however, may require retrofit of existing equipment |
| | Develop a fuel conversion incentive program for industry to replace coal, distillate and residual fuels oil combustion with natural gas or electricity | 340 tpy SOx reduction | $4,500/ton SOx | Costly to implement |
| | Require "process reliability" plans for industrial sources | 20 | $5,500 | Easy to implement; likely support by sources because of potential benefits to sources and in many cases already required |
| **B** | Public recognition program for industrial facilities that reduce $PM_{2.5}$ emissions | 10 | $3,000 | Easy to implement |
| **C** | Stricter emission standards for industry | 50 | $6,500 | More work required to implement given the lack of knowledge regarding efficiency and effectiveness of stricter standards and controls |
| | Emissions trading and banking system | 50 | $2,200 | Difficult to implement due to the complexity required to establish the system and difficult to monitor once in place |

## ■ Indoor Burning

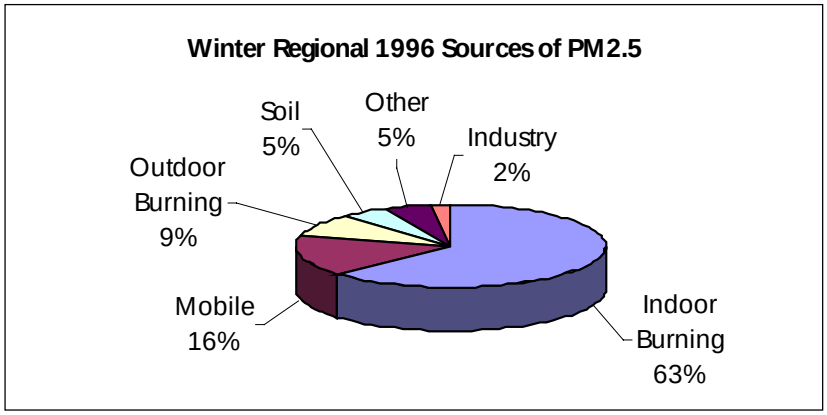
Indoor burning sources account for approximately 38% of the Region's overall annual $PM_{2.5}$ emissions, and 63% of the Region's overall winter emissions. Emissions in this category are produced by burning in fireplaces, uncertified wood stoves, catalytic, and non-catalytic certified wood stoves. Within this category, fireplaces are the largest contributors of $PM_{2.5}$ emissions at 61%. (Staff estimates that on a region-wide basis, about 60% of homes have fireplaces.) Please see Table 3, below, for the indoor burning emissions breakdown.

Table 3 – Indoor Burning (38% of Region's overall $PM_{2.5}$ annual emissions)

| Source | % Contribution to Annual Indoor Burning $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|
| **Fireplaces** | 61% | 7,909 |
| **Uncertified stoves** | 25% | 3,241 |
| **Catalytic stoves** | 7% | 908 |
| **Non-catalytic stoves** | 7% | 908 |
| **TOTAL** | **100%** | **12,966** |

During the winter season, indoor burning emissions increase, accounting for approximately 63% of the Region's overall $PM_{2.5}$ emissions. (See Figure 4.) Exceedences of PM air quality standards are more likely to occur in the winter when weather conditions are cold and still. These weather conditions (inversions) cause pollution to be trapped close to the ground. Air quality can quickly deteriorate under these conditions, increasing the chance of an exceedence. Given the large percentage of emissions contributions from indoor burning during the winter season, it significantly contributes to the levels of pollution throughout the region. In addition, the levels of emissions currently generated by indoor burning are likely to contribute to the exceedences of the Health Committee's daily standard and reduce the probability that the Region will effectively move towards meeting the Health Committee's annual goal.

Figure 4




Geographically, indoor burning emissions are higher in residential areas, lower in urban and industrial areas. The problem is exacerbated in valleys where there are a high percentage of residential units because PM might remain for extended periods of time during episodes of air stagnation.

**Existing Control Measures**

Indoor burning is regulated by both the federal and state Clean Air Acts (CAA). (Please see Appendix C, Indoor Burning White Paper, for a detailed description of the federal, state and local controls.) Under the federal CAA there are specific emission standards for wood stoves. The Washington State CAA has also implemented wood stove emission standards, which are stricter than the federal standards. In addition, the Puget Sound Clean Air Agency, under state law, implements two-staged "Burn Bans" designed to reduce emissions from indoor burning sources when air quality is impaired. During the first stage of a burn ban only certified appliances may be used, (unless the uncertified stove is the only source of heat), and during the second stage no wood burning appliances, certified or not, are to be used unless they are the sole source of heat. The State also engages in educational efforts to increase the public's awareness about the health effects of wood smoke. The Puget Sound Clean Air Agency has adopted regulations similar in form to Ecology's to implement in its jurisdiction.

**Opportunities for Reduction**

In spite of significant cooperative and successful efforts over the past ten years to reduce emissions from indoor burning, this source category continues to be a significant source of particulate matter, contributing 38% of the Region's overall annual $PM_{2.5}$ emissions and 63% of its overall winter emissions. Fireplace emissions in particular appear to be a substantial contributor to overall indoor burning emissions.

Burn bans during periods of impaired air quality have successfully reduced the levels of PM during these periods, which means that the Region's peak PM levels (generally occurring in the winter season) are lower as a result. However, given the high percentage contributions of these sources, the number of alternatives that exist for indoor burning, and the number of individuals engaged in the practice of indoor

burning, there is a substantial opportunity to affect overall particulate emission levels by addressing indoor burning issues.

**Recommendations for Indoor Burning**
Following are the recommended strategies for indoor burning, displayed by category.[22]

Category A:

- Develop a program requiring the removal, replacement by a gas, pellet or certified wood burning heater, or licensing of an uncertified wood heater at the time of sale of any residence in the four county area. Design a program which makes the following four options available to buyers and sellers at the time of sale of a residence:
  - install gas into fireplace or replace wood stove with gas appliance
  - eliminate the fireplace or wood stove
  - install certified insert in fireplace or replace wood stove with pellet or certified stove
  - continue to use the uncertified device and pay a fee to continue use, not use the device during impaired air quality

- Jointly promote with the manufactured log industry a program to educate and encourage homeowners who burn wood to burn manufactured logs. Develop a partnership between the Clean Air Agency, the manufactured log industry and distributors, and the Hearth Products Association to educate the public about the benefits of burning manufactured logs and to promote the use of manufactured logs instead of wood.

- Develop a program with possible monetary incentives for homeowners to retrofit their existing fireplace with gas log sets where gas lines are available. Develop a partnership between the Clean Air Agency, the natural gas utilities and hearth products industry to encourage retrofitting conventional fireplaces with gas. An educational component would be implemented as part of any program developed by the partnership to inform the public about the convenience, cost, safety and beneficial air quality effects of fireplace retrofits.

Category B:

- Develop an incentive/regulatory program for the installation of natural gas fueled indoor burning appliances in new developments where gas lines are available. Require low emission heat sources (e.g., natural gas, electricity) in new developments. Fireplaces and wood stoves would be prohibited in new developments to prevent new emissions.

**Category C:** None of the indoor burning emission reduction strategies were classified by stakeholders as a Category C strategy.

| Category | Strategy | Less $PM_{2.5}$ Tons Per Year *(when strategy fully implemented)* | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|

[22] See Appendix C, Indoor Burning White Paper, for more details on the strategies that follow.

| | | | | |
|---|---|---|---|---|
| **A** | Develop a program requiring the removal, replacement by a gas, pellet or certified wood burning heater, or licensing of an uncertified wood heater at the time of sale of any residence in the four county area | 7,858 | $2,800 | Potentially difficult to implement due to possible need for state legislative action and resistance from home owners; implementation may be easier if adopted by local jurisdictions instead of at the state or regional level |

| | | | | |
|---|---|---|---|---|
| | Jointly promote with the manufactured log industry a program to educate and encourage homeowners who burn wood to burn manufactured logs | 546 | $2,600 | Easy to implement and would likely receive support from the hearth products industry |
| | Develop a program with possible monetary incentives for homeowners to retrofit their existing fireplace with natural gas log sets where gas lines are available | 780 | $6,100 | Moderately easy to implement as fireplace retrofits are currently occurring in many areas and a formal program would take advantage of the current trend |
| **B** | Develop an incentive/regulatory program for the installation of natural gas fueled indoor burning appliances in new developments where gas lines are available | 104 | $10,000 | Requires further examination to determine the best path for implementation; need to discuss gas line expansion with gas utilities and WUTC |

## ■ Outdoor Burning

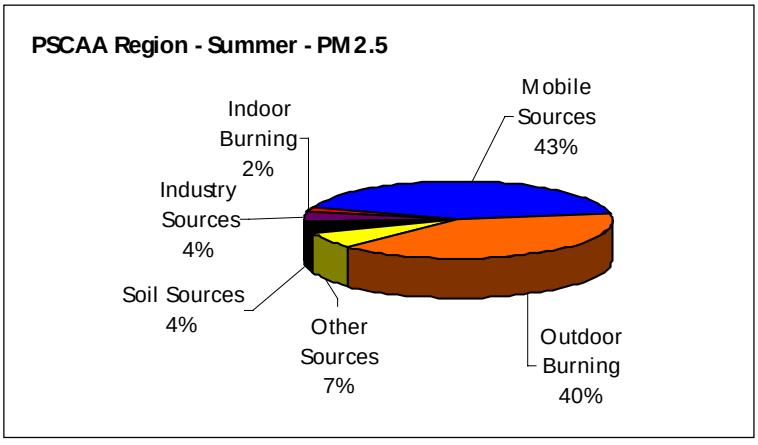
Outdoor burning sources account for approximately 23% of the Region's overall annual $PM_{2.5}$ emissions. Sources in this category include yard waste burning, garbage burning, land clearing, silvicultural (forestry) and other burning. Please see Table 4, below, for the outdoor burning emissions breakdown.

Table 4 – Outdoor Burning (23% of Region's overall annual $PM_{2.5}$ emissions)

| Source | % Contribution to Annual Outdoor Burning $PM_{2.5}$ Emissions | % Contribution to Summer Outdoor Burning $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|---|
| **Yard Waste (natural vegetation)** | 62% | 68% | 4,835 |
| **Garbage** | 29% | 24% | 2,261 |
| **Land Clearing** | 6% | 6% | 468 |
| **Silviculture** | 2% | <2% | 156 |
| **Other** | 1% | <1% | 78 |
| **TOTAL** | 100% | 100% | 7,798 |

In the summer season, outdoor burning contributes approximately 40% of the overall $PM_{2.5}$ emissions, with yard waste burning contributing the greatest amount (68%) of the outdoor burning sources. (See Figure 5.) In the winter, outdoor burning emissions drop to 9% of the overall $PM_{2.5}$ emissions. Because outdoor burning is largely a summertime activity, when inversions occur infrequently, it is more of a threat to meeting the annual $PM_{2.5}$ standards rather than the daily standards. As well, outdoor burning in the summer months does contribute to visibility concerns and affects the clarity of the Region's viewsheds and can have significant exposure concerns for those persons adjacent to the burning activity.

Figure 5



Geographically, more burning occurs in the rural areas. Yard waste and garbage burning are big contributors in the rural areas. For example, 50% of the residents in unincorporated King County do not have curbside garbage pickup. Although impacts from outdoor burning are primarily rural and immediately affect those in close proximity to the burning activity (e.g., neighbors), $PM_{2.5}$ behaves like a gas, allowing it to transport easily and causing effects over a broader area. In addition, despite outdoor burn bans in the urban growth areas, illegal burning still occurs in urban areas. Expanding the "no burn areas" has been challenging due to the need to provide reasonable alternatives for yard waste and debris to land developers and homeowners.

**Existing Control Measures**

As with indoor burning, outdoor burning is regulated by both the federal and state Clean Air Acts (CAA). (Please see Appendix C, Outdoor Burning White Paper, for a detailed description of the federal, state and local controls.) Under the federal CAA, the State Implementation Plan requirements are designed to ensure that areas achieve and maintain compliance with the national air quality standards. The state CAA contains numerous provisions designed to reduce emissions from outdoor burning including rules prohibiting outdoor burning in the urban growth areas, as defined in the state Growth Management Act, and prohibiting burning of non-vegetation materials, (e.g., garbage). In addition, burning is prohibited in areas where alternative disposal methods of organic refuse are available, reasonably economical, and less harmful to the environment. The Puget Sound Clean Air Agency has adopted the state strategies of no burning of prohibited materials and no burning in urban growth areas. (Note, currently, burning is authorized only outside of the urban growth areas in King, Snohomish and Pierce counties. In Kitsap County legal burning permits are authorized in urban growth areas, but only until December 31, 2000, when a burning ban will become effective in all of Washington's urban growth areas as defined in the Growth Management Act and by the counties.)

**Opportunities for Reduction**

Outdoor burning accounts for 23% of the Region's overall $PM_{2.5}$ emissions and 40% of the Region's summer $PM_{2.5}$ emissions. Although there are currently regulations in place that ban burning in the urban growth areas, a substantial amount of burning occurs in the rural areas where garbage and yard waste pickup services are minimal, expensive or nonexistent. In addition, residents within the urban growth areas do not necessarily comply with the current regulations. It appears that targeted emission reduction strategies would reduce the percentage of outdoor burning emissions, particularly in the summer season when the greatest amount of outdoor burning takes place.

**Recommendations for Outdoor Burning**

Following are the recommended strategies for outdoor burning, displayed by category.[23]

Category A:

- Prohibit burning of land clearing debris. Prohibit land clearing debris in development projects.

- Require waste pickup and prohibit outdoor burning in areas as soon as yard and garbage pickup services are in place. Develop a cooperative effort among the Clean Air Agency and the four counties within its region to provide and market reasonable alternatives to burning of storm debris, yard waste and garbage. Once reasonable alternatives are in place, require mandatory yard waste and garbage pickup.

- Prohibit summer outdoor burning. Prohibit outdoor burning in the summer months outside of the urban growth areas.

[23] See Appendix C, Outdoor Burning White Paper for more details on the strategies that follow.

- Targeted education and enforcement of existing outdoor burning regulations. Increase and target education efforts to inform the public of the health, environmental, and legal impacts of outdoor burning and of burning alternatives available. As follow-up to a targeted education effort, increase enforcement of burning regulations already in place.

**Category B:** None of the outdoor burning emission reduction strategies were classified by stakeholders as a Category B strategy.

**Category C:** None of the outdoor burning emission reduction strategies were classified by stakeholders as a Category C strategy.

| Category | Strategy | Less $PM_{2.5}$ Tons Per Year *(when strategy fully implemented)* | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|
| **A** | Prohibit burning of land clearing debris | 470 | $9,700 | Overall fairly easy to implement, however, may encounter some resistance from building industry |
| | Require waste pickup and prohibit outdoor burning in areas as soon as yard and waste pickup services are in place | 6900 | $5,600 | Although an extension of services already provided in other areas, may be difficult to implement because of cost and disposal traditions in the more rural areas of the region |
| | Prohibit summer outdoor burning | 2,340 | $4,000 | Overall fairly easy to implement as most summer burning is already banned by local fire officials, however, may be difficult politically |
| | Targeted education and enforcement of existing outdoor burning regulations | 345 | $460 | Relatively easy to implement, however enforcement might be difficult to do effectively |

## ■ On-Road Mobile Sources

On-road mobile sources account for approximately 12% of the Region's overall annual $PM_{2.5}$ emissions and contribute to 30% of the region's SOx and 59% of the region's NOx. Sources include gasoline and diesel cars, trucks, buses, and motorcycles. Washington State data indicate that in the Clean Air Agency region , 2,679,692 on-road vehicles were registered in 1998. 97% or the registered vehicles were fueled by gasoline, 2% by diesel and under 1% by natural gas or propane. 95% of the vehicle miles traveled (VMT) were gasoline-powered vehicles and 5% were diesel vehicles. Despite the higher number of gas-powered vehicles and the percentage of vehicle miles traveled by these vehicles, the relative contribution of on-road diesel vehicles to regional $PM_{2.5}$ emissions is far greater (74%) than its gasoline counterpart (26%). In addition, diesel vehicles as a class emit far more visible smoke emissions at start up and at lower speeds than gasoline vehicles. Please see Table 5, below, for the on-road mobile source emissions breakdown.

Table 5 – On-Road Mobile Sources (12% of Region's overall annual $PM_{2.5}$ emissions)

| Source | % of Vehicle Miles Traveled in the Region | % Contribution to Annual On-Road Mobile $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|---|
| **Gasoline sources** | 95% | 26% | 1,073 |

| | | | |
|---|---|---|---|
| **Diesel sources** | 5% | 74% | 3,055 |
| **TOTAL** | 100% | 100% | 4,128 |

There are no substantial seasonal and geographic variations with respect to on-road emissions in the Puget Sound Region. These sources contribute consistently over the course of the year and throughout the Region.

**Existing Control Measures**

There is a wide variety and number of emission control measures applicable to on-road mobile sources. Control measures include vehicle emission standards, motor vehicle fuel specifications, alternative fuel vehicle fleet mandates, and vehicle inspection and maintenance programs that test opacity (and, hence, indirectly PM emissions). (Please see Appendix C, On-road Mobile Source, Part I White Paper, for a detailed description of the federal, state and local controls.)

Federal vehicle emission standards limit the tailpipe emissions from cars and light duty trucks (gasoline and diesel vehicles under 8500 pounds). In addition, the EPA also certifies pollutant-specific emission limits for heavy-duty urban bus engines and heavy duty-truck engines at the point of manufacture. EPA has also published guidance recommending opacity limits for heavy-duty vehicles and the Washington State Department of Ecology (Ecology) requires regular smoke opacity (thickness) testing of all registered 1968 and newer on-road diesel vehicles.

Fuels are regulated at the federal level as well. Maximum diesel fuel sulfur content (0.05% by weight) was established by EPA in 1993. The current cap on sulfur in gasoline is 1000ppm, set by the American Society for Testing and Materials (ASTM).

To promote the procurement of alternative fuel vehicles, the 1992 Energy Policy Act (EPAct) is aimed at accelerating the use of alternative fueled vehicles (AFV) and applies to federal, state, and alternative fuel provider fleets that oversee operations and management--leased or owned--of at least 50 light duty vehicles (8500 lbs. or less).

**Opportunities for Reduction**

Mobile sources present a significant opportunity for reduction of both primary $PM_{2.5}$ and NOx, a secondary source of $PM_{2.5}$. This source category contributes 12% to the Region's overall annual $PM_{2.5}$ emissions and 59% of the Region's NOx emissions. Within mobile sources, diesel fuel vehicles are a significant source of $PM_{2.5}$ despite the fact that they represent only 2% of the registered vehicles in the Clean Air Agency Region.

Opportunities for reductions are significant, in particular for the diesel fleet, because there are several potential paths to reducing emissions from on-road mobile sources. Nationally, there is currently a proposed rulemaking that would require similar stricter emission standards for cars and heavier vehicles such as sport utility vehicles, minivans and pickup trucks. These standards would likely specify tailpipe emission standards that are 50% lower than the current standards and would apply regardless of the type of fuel the vehicle uses. In addition, EPA is currently proposing that refineries make gasoline with a lower sulfur content, in large part so that the emission control technologies for the new engines function effectively. EPA has proposed a 30ppm average, 80ppm cap for sulfur in gasoline. Sulfur in gasoline reduces the effectiveness of a vehicle's catalytic converters, which are designed to lower the NOx gasoline powered vehicles emit. This strategy is being implemented to control ozone precursors, but has the incidental benefit of reducing secondary $SO_2$. EPA has also begun a rulemaking process to establish new fuel quality requirements for diesel that will address lowering the sulfur levels in diesel.

Opportunities also exist for the Region to take advantage of available federal funding to increase the acquisition of alternative fuel vehicles. In addition, opportunities exist to reduce emissions from current diesel fleets through improved fleet inspection and maintenance.

**Recommendations for On-Road Mobile Sources**

Following are the recommended strategies for on-road mobile sources, displayed by category. There are differences of interpretation and emphasis by stakeholders on some of these strategies. These are described on pages 25-26 following the description of the strategies.[24]

Category A:

- Support EPA in the development of new, lower, diesel truck emissions standards. Support EPA in a 50% reduction in the $PM_{2.5}$ standard for new diesel trucks (greater than 8,500 pounds gross vehicle weight) to match the current standards for urban buses.

- Support EPA in the development of a coordinated engine standard and fuel strategy for diesel vehicles, including a reduction in diesel sulfur levels. Support EPA in the development of reduced emissions standards for diesel engines and a companion fuel strategy designed to optimize overall emissions reductions from diesel-burning vehicles.

- Support EPA in the development of a national rule to reduce sulfur in gasoline. Support EPA in the development of a national rule to lower sulfur levels in gasoline to reduce primary and secondary $PM_{2.5}$ and to ensure that next generation catalytic converters function effectively.

- Work with Ecology to tighten the current Inspection and Maintenance program for diesel opacity and to evaluate potential of routine on-road testing. Work with the Washington State Department of Ecology to tighten the current program for opacity testing of heavy duty vehicles by adopting the recommended EPA guideline as the pass/fail standard in Washington State. Evaluate, with Ecology, the potential emission reduction and cost-effectiveness of routine on-road identification and testing of "gross smoking" heavy-duty vehicles, including Washington state vehicles and out of state vehicles.

Category B:

- Support fuel neutral emission standards for light and medium duty trucks. Support EPA in the development of stricter emission standards for light and medium duty vehicles that are the same regardless of the fuel burned.

- Develop infrastructure for and promote use of natural gas vehicles through funding from sources such as the Congestion Mitigation and Air Quality Improvement (CMAQ) program and other appropriate sources. Partner with the Puget Sound Clean Cities Coalition (PSCCC) and other transportation and business community interests to set a regional 2005 goal and develop an infrastructure for natural gas transit bus, school bus and truck fleet procurements through a program of incentives and market penetration opportunities.

Category A – C

- Require California diesel fuel in the four county region.[25] Require diesel with lower aromatics, comparable with California's diesel aromatic standard.

[24] See Appendix C, On-road Mobile Sources White Paper, for more details on the strategies that follow.
[25] Stakeholders were divided on which category this strategy should be in, see page 23 for a discussion of this issue.

Category C:

- Promote and leverage funding for the introduction into service of hybrid vehicles. Partner with PSCCC and other transit operators to promote and leverage funding (including existing federal grant programs) for the introduction into service of advanced low and zero emission technologies (e.g., diesel/electric and natural gas/electric).

- Request EPA to certify clean air retrofit kits for heavy duty diesel trucks (Adopt retrofit/rebuild model for diesel engines in Washington State). Support EPA to 1) recognize certified Urban Bus Program clean air retrofit/rebuild kits as a voluntary, credited heavy-duty truck and school bus retrofit/rebuild option, and 2) to certify other comparable clean air kits for use in heavy-duty diesel trucks and school buses.

- Develop retrofit/rebuild incentives with Ecology and fleets. Partner with Ecology and heavy-duty fleet managers to develop meaningful incentives (grants, tax breaks, etc.) to support voluntary retrofit and rebuild programs that help reduce excess engine exhaust smoke emissions while meeting truck and school bus fleet operational needs.

| Category | Strategy | Less $PM_{2.5}$ Tons/Year | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|
| **A** | Support EPA in the development of new, lower, diesel truck emissions standards | 446 | $28,500 | Easy to implement; discussions currently occurring at the national level |
| | Support EPA in the development of a coordinated engine standard and fuel strategy for diesel vehicles, including a reduction in diesel sulfur levels | 1,137 $PM_{2.5}$ 1,152 SOx | $13,900 $13,700/ ton SOx | Easy to implement; national strategy currently in progress and EPA has proposed draft rules |
| | Support EPA in the development of a national rule to reduce sulfur in gasoline | 1,912 SOx | $12,200/ ton SOx | Easy to implement; EPA proposed rule on sulfur in gasoline |
| | Work with Ecology to tighten the current Inspection and Maintenance program for diesel opacity and to evaluate potential of routine on-road testing | | $34,000 | More data and discussion required for implementation; challenges associated with out of state vehicles traveling through the region |
| **B** | Support fuel neutral emission standards for light and medium duty trucks | | | Easy to implement; national strategy currently in progress |
| | Develop infrastructure for and promote use of natural gas vehicles through funding from sources such as the Congestion Mitigation and Air Quality Improvement (CMAQ) program and other appropriate sources. | | -[$19,600][26] to $142,000 | Complexity and timeframe required varies dependent upon the specific implementation strategies and funding sources selected; some are ready to pursue, others will take time |
| **A - C** | Require California diesel fuel in the 4 county region (see discussion below) | 615 | $6,200-$18,400 | Difficult to implement; requires more analysis on possible reductions and cost to implement |
| **C** | Promote and leverage funding for the introduction into service of hybrid vehicles | | $1,400,000 | Difficult to implement |
| | Request EPA to certify clean air retrofit kits for heavy duty diesel trucks (Adopt retrofit/rebuild model for diesel engines in Washington State) | 81 | $13,500 | Difficult to implement at a local level |

[26] Negative cost per ton indicates that a cost savings is realized concurrently with an emission reduction.

| | | | | |
|---|---|---|---|---|
| | Develop retrofit/rebuild incentives with Ecology and fleets | 81 | $13,500 | Difficult to implement; substantial technical work required before implementation |

While there is consensus supporting federal actions on improving fuel and engine emissions performance, stakeholders expressed differences in opinion regarding the best way for the Clean Air Agency to proceed with fuel oriented strategies. Four issues reflect these differences:

1. How much of the fuels debate should be resolved at the national level? Some stakeholders believe that fuels should only be addressed in the national forum, as resolution of these issues are of national importance particularly because of the potential economic impacts on both producers and consumers that fuel-oriented emission reduction strategies might have. Others believe that in addition to participating proactively in the national debate, the region should also consider pursuing regional fuel quality requirements, as allowed under the Clean Air Act, to expedite the use of lower sulfur fuels or other less polluting fuels in the Puget Sound region, especially if national standards would not produce air quality benefits as quickly or to the extent desirable as the region might need them to.

   A particular strategy which stakeholders discussed in this regard was the possibility of requiring the achievement of a lower aromatics performance standard for diesel fuel, such as is now required in California (referred to in this report as California diesel). Some stakeholders ranked this strategy in Category A, since it could be an effective addition to a comprehensive approach to reducing pollution from diesel, including reducing sulfur in diesel. They contend that diesel fuel overall is a significant source of $PM_{2.5}$; that current marketing plans of automobile manufacturers seek to expand the use of diesel fuel, especially for light duty trucks and larger sport utility vehicles; and they fear that the new federal rules now being considered on engines and fuels may allow exceptions for diesel fuel or for light trucks and diesel sport utility vehicles over 8,500 lbs. Other stakeholders believe that the California diesel strategy should be in category B, thus recommending that the Agency research it further. For these stakeholders, after sulfur in diesel is reduced at the federal level, if further monitoring and research at the Region's air quality shows the need for additional $PM_{2.5}$ reductions, and if additional investigation shows the cost and technical implications of implementing lower aromatics is not excessive, then the Agency would be ready to give this strategy serious consideration. Other stakeholders believe this strategy deserves to be in Category C, because the air quality basis for requiring California diesel in the Puget Sound Region is weak, especially in light of the significant improvements to air quality that are going to result from national rules lowering sulfur in diesel (and gasoline) as well as from the other strategies in Categories A and B. They contend that requiring fuel producers to make the changes to both reduce sulfur and lower aromatics will both be extremely technically challenging and cost prohibitive for the area's refineries. They believe that requiring refineries to go in two technical directions at once is not sound, especially in light of the cost. They believe that the Agency needs much greater information on the air quality benefits lower aromatics would produce here and a comprehensive analysis of whether or not those benefits are indeed necessary to achieve the Region's air quality goals. Hence this strategy is shown as having received support from stakeholders in all the categories.

2. How active should the Clean Air Agency be in the national fuels debate? All stakeholders believe that the Clean Air Agency needs to be a supporter and participant in the nation fuels debate. However, some believe that while it is important for the Agency to follow developments associated with the nation fuels debate, it is more prudent for the Agency to focus its efforts, authority, and limited resources on those $PM_{2.5}$ reduction strategies that the agency can effectively implement under its own authority in a reasonable time frame. Other stakeholders believe that the fuels debate is of such significance that the Agency should proactively engage in the national debate and advocate for as stringent a set of fuel quality specifications as possible.

3. To what degree should one view the relationship of fuel quality specification to engine emission requirements for both gasoline and diesel fuels as linked? Stakeholders unanimously support the development of a coordinated engine and fuel strategy to reduce overall particulate emissions from mobile sources, regardless of the fuel type used. Some believe that the resolution of this linked discussion is the best way to achieve improved fuel quality specifications and do not consider a "fuels only" approach to be the most effective. Others also support a coordinated engine and fuels approach, however they believe that independent actions that provide clear and substantial benefits such as reducing sulfur in fuels should be promptly pursued.

4. How comprehensively should one view the overall air quality impacts from improved fuel quality specifications for gasoline in the $PM_{2.5}$ process versus focusing primarily on reducing fine particulate emissions? Some stakeholders believe that lower sulfur levels in gasoline would not provide substantial particulate reductions so it is therefore not an appropriate $PM_{2.5}$ strategy. Stakeholders supporting this position recognize that the greatest benefits from reduced sulfur in gasoline are associated with ozone, and contend that a more appropriate forum for the strategy to be debated will be the stakeholders group that the Clean Air Agency will convene in the near future to discuss ozone issues. These stakeholders believe that the current effort should focus specifically on those regional strategies that will provide the greatest particulate reductions in the Puget Sound region, not ozone.

   Other stakeholders emphasize the ozone benefits produced by lower sulfur in gasoline. They assert that reduced sulfur levels also provide enough particulate reductions to appropriately support lower sulfur gasoline in the current forum. Reducing sulfur in gasoline is necessary for a comprehensive approach to $PM_{2.5}$ in order to ensure that the future generations of catalytic converters have the ability to reduce NOx, which, while being a major ozone precursor, is also a source of secondary particles of $PM_{2.5}$. These stakeholders argue that the overall air quality effects associated with both particulates and ozone compels the strategy to be recommended strongly in this process. These stakeholders point out that when air quality problems are focused on in isolation of each other-such as separating the $PM_{2.5}$ and ozone problems-the cost for implementing change for one problem may appear higher that if more comprehensive benefits were considered.

## ■ Off-Road Mobile Sources

Off-road mobile sources account for approximately 12% of the Region's overall $PM_{2.5}$ emissions, 24% of region's annual nitrogen oxide emissions, and 22% of regional sulfur oxide emissions. Sources include aircraft, airport ground equipment, boats, ships, lawn and garden equipment, farm and logging equipment, construction equipment, rail and other recreation vehicles (e.g., off-road motorcycles and all-terrain vehicles). The biggest contributors of non-road mobile source NOx emissions are ships at 48% and diesel miscellaneous at 36%. In addition, ships contribute 78% of the non-road mobile SOx emissions and diesel miscellaneous contribute 16%. Please see Table 6, below, for the off-road mobile source emissions breakdown.

Table 6 – Off-Road Mobile Sources (12% of Region's overall $PM_{2.5}$ emissions)

| Source | % Contribution to Annual Off-Road Mobile $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|
| **Ships** | 20% | 807 |
| **Aircraft** | 23% | 928 |
| **Boats** | 12% | 484 |
| **Diesel miscellaneous** | 33% | 1,330 |
| **Gasoline miscellaneous** | 12% | 484 |

| | | |
|---|---|---|
| **TOTAL** | 100% | 4,033 |

Seasonally, recreational boat and lawn equipment emissions are higher in the summer. The remainder of the off-road source emissions remains fairly constant throughout the seasons. Geographically, ship and boat emissions are higher in the Puget Sound and Lake Union areas due to port activity. Aircraft emissions are largely concentrated in the Sea-Tac area. Although there are several smaller airports throughout the Puget Sound Region, emission contributions from these sources are less significant than at Sea-Tac.

**Existing Control Measures**

There are minimal existing control measures for the majority of sources within the off-road mobile source category and the measures that do exist are largely federally regulated. The EPA regulates commercial jet aircraft with emission standards that focus on hydrocarbons (volatile organic compounds) and oxides of nitrogen. With respect to water vessels, EPA regulates outboard and personal watercraft emissions for hydrocarbons and nitrogen oxides. In addition, EPA's comprehensive non-road engine control program regulates boats, ships and tugs and construction equipment. For diesel engines, the regulated pollutants include particulates. Federal emission standards for lawn and garden equipment focus on limiting exhaust pollutants other than PM. There are no state or local standards for off-road mobile sources.

**Opportunities for Reductions**

Although containing a diversity of sources, the off-road mobile source category provides an opportunity for creating emission reductions across sources primarily by focusing on the fuels associated with the sources. Diesel fuel sources comprise a large percentage of the category and emission reduction strategies targeted at diesel burning sources could potentially have a considerable impact on the Region's overall $PM_{2.5}$ emissions. In addition to direct $PM_{2.5}$ emissions, off-road mobile sources contribute a significant percentage of secondary source emissions. Fuel-targeted strategies would also produce reductions in secondary emissions contributions. With regard to aircraft and airport operations, federal initiatives are being considered which may provide opportunities to the region for linkage or leverage for progress.

**Recommendations for Off-road Mobile Sources**

Following are the recommended strategies for off-road mobile sources, displayed by category.[27]

Category A: None of the off-road mobile emission reduction strategies were classified by stakeholders as a Category A strategy

Category B:

- Cleaner fuels for construction equipment. Require lower sulfur content fuel for construction equipment and promote good operation and maintenance of construction equipment.
- Cleaner fuels for marine engines. Require cleaner fuels for local, (within the Puget Sound Region), marine traffic and promote good operation and maintenance of marine engines.

- Encourage clean engine and low emission technologies for aircraft engines and promote the use of clean alternatives for airport ground support operations. Develop a program to encourage the use of low emission technologies for aircraft including retrofits and fuel additives. Promote the use of clean alternative power sources, (e.g., natural gas and electric) for airport ground equipment.

[27] See Appendix C, Off-road Mobile Sources White Paper, for more details on the strategies below.

Category C: None of the off-road mobile emission reduction strategies were classified by stakeholders as a Category C strategy

| Category | Strategy | Less $PM_{2.5}$ Tons / Year | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|
| B | Cleaner fuels and promotion of good operation and maintenance for construction equipment | 41 tpy $PM_{2.5}$<br>108 tpy SOx | $7,200<br>$2,700 SOx | Implementation may be difficult at the regional level especially if one views sulfur in diesel as a national issue |
| | Use cleaner fuels for marine engines in the Puget Sound Region along with improved operations and maintenance of marine diesel engines | 39 tpy $PM_{2.5}$<br>134 tpy SOx | $1,700<br>$480 SOx | Difficult to implement and enforce as there is much national and international vessel traffic in the Puget Sound Could; may require ship retrofits |
| | Encourage clean engine and low emission technologies for aircraft engines and promote the use of clean alternatives for airport ground support operations | 160 | $2,400 | Requires consultation with the airline industry and further understanding of federal initiatives to develop a clear implementation path; Agency working now on the latter part of the strategy |

## ■ "Other" Sources

Other sources account for approximately 12% of the Region's overall $PM_{2.5}$ emissions, 9% of its annual NOx emissions, and 9% of its annual SOx emissions. The source category is very broad and encompasses a number of sources. Included in the category are dust emitted from construction activities and road traffic, restaurants with charbroilers, residential, commercial and industrial fuel combustion sources (much of which is from space heating), small industrial processes that emit particulates, and auto refinishing. Please see Table 7, below, for the other sources emissions breakdown.

Table 7 – Other sources (12% of Region's overall $PM_{2.5}$ emissions)

| Source | % Contribution to Annual "Other" $PM_{2.5}$ Emissions | Tons of Emissions Per Year |
|---|---|---|
| **Dust** | 53% | 2,178 |
| **Restaurants (with charbroilers)** | 17% | 699 |
| **Other fuel burning** | 25% | 1,027 |
| **Auto body shops** | <1% | |
| **Miscellaneous** | 5% | 205 |
| **TOTAL** | 100% | 4,109 |

Seasonally, emissions from this source category remain fairly constant with the exception of dust. Dust emissions tend to increase in the summer months when the weather is drier and moisture does not limit the amount of dust that is mixed into the air. Geographically, dust emissions are higher in industrial areas. In addition, restaurant emissions cause localized air quality effects in the areas where they are located.

**Existing Control Measures**

There are some existing control measures for dust sources. Federally, new source performance standards regulate dust from some industrial sources and Clean Air Agency regulations require the use of reasonably available measures to reduce dust. In addition, the agency has entered into cooperative arrangements with the Associated General Contractors (a construction industry trade association) to educate contractors about the use of these reasonable measures. There are no federal regulatory requirements for restaurants and there is little activity among local and state air agencies to regulate them.

**Opportunities for Reduction**
"Other" sources contribute 12% to the Region's $PM_{2.5}$. When taken as a whole, the source category contributes significantly to regional emissions, but it poses a unique challenge because it encompasses a number of sources, most of which are small contributors. Because of the vast array of sources, two easily identifiable and significant contributors were targeted, dust and restaurant emissions. Dust was focused on as a source because it contributes approximately 6% to the Region's overall $PM_{2.5}$ emissions and restaurants because they contribute 2% of the Region's overall emissions and have substantial localized impacts. Both dust and restaurants present the opportunity to develop targeted strategies that could produce a fairly substantial reduction to the region's overall $PM_{2.5}$ emissions and/or to the localized health effects of $PM_{2.5}$.

Although a fairly high percentage of the "other" category emissions are from fuel burning, the fuel burning category is comprised of a large group of diverse sources making it difficult to reduce emissions from these sources, except as other fuel strategies are implemented that may then beneficially alter the fuels used by these sources.

**Recommendations for "Other" Sources**
Following are the recommended strategies for the "other" sources, displayed by category.[28]

Category A: None of the "other" emission reduction strategies were classified by stakeholders as a Category A strategy.

Category B:
- Improve fugitive dust education and enforcement. Improve enforcement of and education about the Clean Air Agency's fugitive dust requirements
- Control emissions from char-broilers in restaurants. Require particulate control technology for restaurants with char-broilers.

Category C: None of the "other" emission reduction strategies were classified by stakeholders as a Category C strategy.

| Category | Strategy | Less $PM_{2.5}$ Tons Per Year | Cost Per Ton | Implementation Observations |
|---|---|---|---|---|
| **B** | Improve fugitive dust education and enforcement | 258 | $620 | Easy to implement; can build off of prior and existing efforts |
| | Control emissions from char-broilers in restaurants | 350 | $5,600[29] | Fairly easy to implement but need some discussion with restaurant industry, especially concerning retrofits and O&M costs |

## ■ Secondary Particles

Besides looking at specific $PM_{2.5}$ sources, the stakeholders also considered the sources of secondary particles. In addition to direct or primary particulate emissions, $PM_{2.5}$ can also be formed in the atmosphere from sulfur oxides (SOx) and nitrogen oxides (NOx). Sulfur oxides convert into sulfates and nitrogen dioxide into nitrates, both of which are $PM_{2.5}$ contributors. According to receptor modeling

[28] See Appendix C, Other Sources White Paper, for more details on the strategies described below.
[29] This cost element does not include retrofitting of the broiler and installation of the control equipment, which can vary widely.

results, sulfates comprise about 21% of the Region's annual $PM_{2.5}$ and nitrates about 10% annually. These percentages increase in the summer months (sulfates 28%, nitrates 13%) as the chemical conversion process is enhanced by sunlight.

The major sources of the precursors to secondary particles include mobile sources and industrial sources. Annually, mobile sources contribute approximately 53% of the Region's sulfur oxides and 83% of the Region's nitrogen oxides. Industry contributes 34% of the Region's sulfur oxides and 6% of its nitrogen oxides. Please see Table 8, and Figures 6 and 7, below, for the secondary source emissions breakdown.

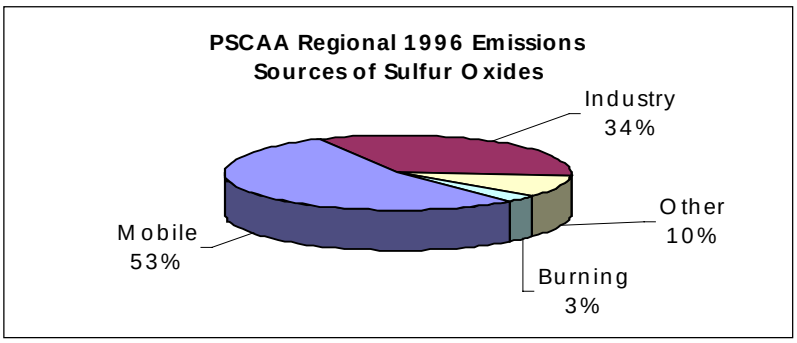
Table 8 – Secondary Sources

| Source | % Contribution to Annual SOx | % Contribution to Annual NOx |
|---|---|---|
| **Mobile** | 53% | 83% |
| **Industry** | 34% | 6% |
| **Burning** | 3% | 2% |
| **Other** | 10% | 9% |
| **Total** | 100% | 100% |

**Existing Control Measures**

There are both national and local restrictions on sources of the precursors of secondary particles. The majority of these restrictions apply to mobile sources and major industrial sources. Mobile measures include NOx controls (such as catalytic converters) and a nationwide standard for sulfur in diesel, which influences the effectiveness of secondary source controls on diesel vehicles. Locally, sulfur dioxide removal technology is required on large industrial point sources, as are low NOx emitting conditions.

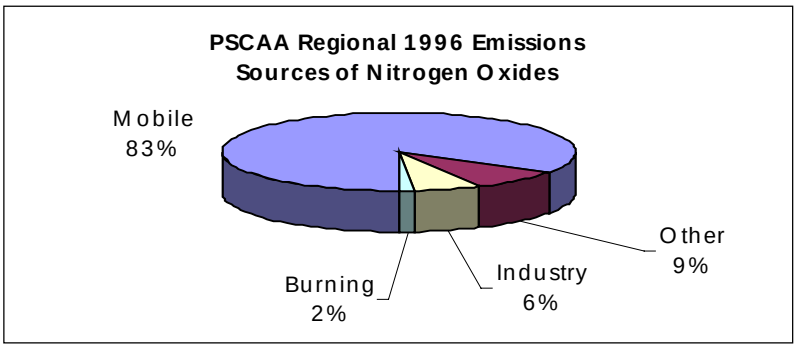
Figure 6




**Opportunities for Reduction**

Secondary sources contribute a significant amount of the Region's annual $PM_{2.5}$; sulfates comprise approximately 21% and nitrates about 10%. Although there are currently some controls in place, both industrial sources and mobile sources represent a meaningful opportunity for overall $PM_{2.5}$ reductions. Strategies considered within those source categories to reduce primary $PM_{2.5}$ emissions should also be recognized for their beneficial secondary particle reductions. These reductions are especially significant given that some studies have shown that health impacts are greater when there are secondary particles present, particularly sulfates, in addition to primary particles.

Figure 7




**Recommendations for Secondary Sources**

The Group considered secondary particles when it analyzed specific sources and proposed emission reduction strategies; the Group did not analyze sources of secondary particles separately. Reiterated below are the specific source

strategies that reduce secondary, as well as primary, particles.[30]

Category A:

- Reduced sulfur fuels for use by industry. Allow only low sulfur fuels to be burned in the Clean Air Agency jurisdiction.

- Develop a fuel conversion incentive program for industry to replace coal, distillate and residual fuels oil combustion with natural gas or electricity. Replace coal, distillate and residual fuel oil combustion with natural gas, electric or less polluting recycled fuels by providing a reasonable payback for the conversion.

- Support EPA in the development of new, lower, diesel truck emissions standards. Support EPA in a 50% reduction in the $PM_{2.5}$ standard for new diesel trucks (greater than 8,500 pounds gross vehicle weight) to match the current standards for urban buses.

- Support EPA in the development of a national rule to reduce sulfur in gasoline. Support EPA in the development of a national rule to lower sulfur levels in gasoline to reduce primary and secondary $PM_{2.5}$ and to ensure that next generation catalytic converters function effectively.

- Support EPA in the development of a coordinated engine standard and fuel strategy for diesel vehicles, including a reduction in diesel sulfur levels. Support EPA in the development of reduced emissions standards for diesel engines and a companion fuel strategy designed to optimize overall emissions reductions from diesel-burning vehicles.

Category B:

- Cleaner fuels for construction equipment. Require lower sulfur content fuel for construction equipment and promote good operation and maintenance of construction equipment.

- Cleaner fuels for marine engines. Require cleaner fuels for local, (within the Puget Sound Region), marine traffic and promote good operation and maintenance of marine engines.

- Encourage clean engine and low emission technologies for aircraft engines and promote the use of clean alternatives for airport ground support operations. Develop a program to encourage the use of low emission technologies for aircraft including retrofits and fuel additives. Promote the use of clean alternative power sources, (e.g., natural gas and electric) for airport ground equipment.

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## Conclusions: Benefits of Pursuing These Strategies

The Puget Sound Region has an opportunity to achieve substantial air quality improvements over the next decade on fine particulates. Even as the region is now installing the monitoring which will further guide and inform this effort, current data establish the magnitude of the effort that the region needs to take.

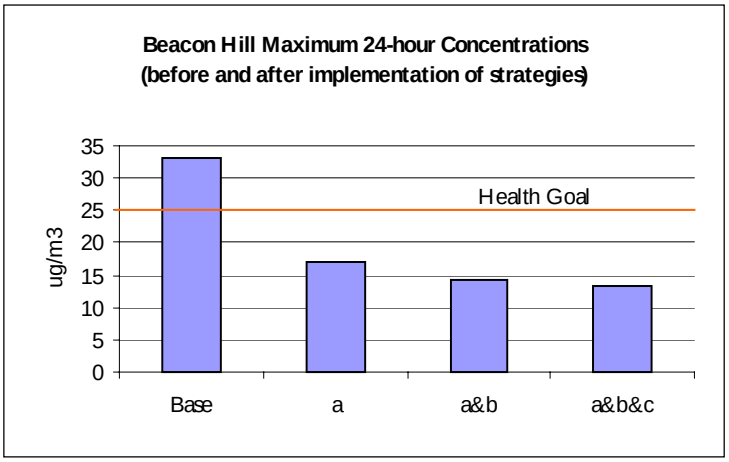
The emission reduction strategies recommended by the Group represent a robust set of actions that the Agency can take in order to reduce levels of $PM_{2.5}$ in the Puget Sound Region. The Group's recommendations cut across all sources, requiring industry, indoor and outdoor burning, and mobile

[30] Please see Appendix C for individual source white papers that provide additional detail on the strategies below.

sources to contribute to reducing overall $PM_{2.5}$ regional levels. In addition, the recommended strategies will also require a long-term commitment from the Clean Air Agency, as the recommended strategies are not necessarily "ready to go" and will require substantial effort on the Agency's part to bring to fruition.

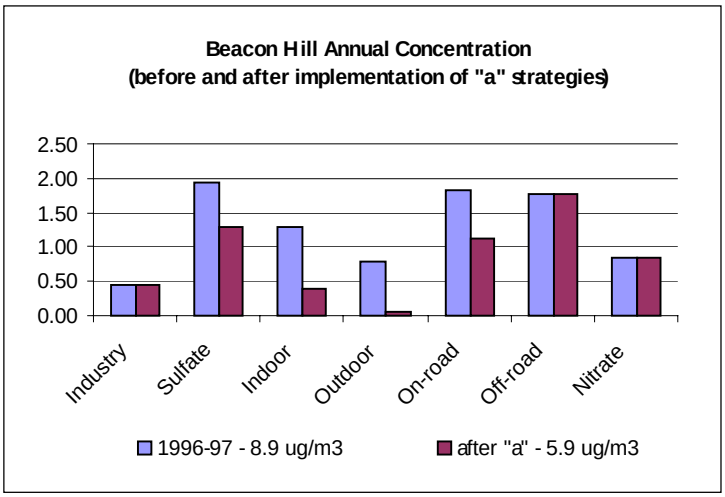
When the recommended strategies or a sufficient combination of these strategies are fully implemented over the next decade, the Region will have significantly improved air quality, will be sufficiently secure in its ability to maintain attainment with the EPA's daily and annual $PM_{2.5}$ standard, and will be well on the way to meeting the challenge represented by the Health Committee's recommended goal.

Figure 8




Specifically, if all of the Category A strategies were implemented, it is estimated that the 24-hour maximum $PM_{2.5}$ concentrations measured at the Beacon Hill monitoring sites would be well below both the 24-hour Health Committee goal and the EPA standard.[31] In addition, if both the Category A and B strategies were implemented, estimations indicate that the maximum $PM_{2.5}$ concentrations measured at the Marysville, Duwamish and Tacoma Tideflats monitoring sites would also meet the 24-hour Health Committee goal and be well below the 24-hour EPA standard. [32]

Figure 9




With respect to annual concentrations, if all of the Category A strategies were fully implemented, using Beacon Hill as a reference point, there would be an estimated 30% reduction in its overall annual $PM_{2.5}$ levels.[33]

It is clear that implementation of the strategies would bring the Region closer to meeting the daily Health Committee goals, and hence, to improved human health conditions in the Region. The Group believes its recommendations represent a strong sense of direction for the Agency, tempered by the prudence of looking for meaningful, cost-effective opportunities, and inspired by the possibility of achieving significant improvements to the Region's air quality.

[31] Please see pages 1 and 2 of the main body of the report for specifics on the Health Committee's $PM_{2.5}$ goals and the EPA standards.

[32] Please see Appendix D for additional information regarding the effects of implementing the strategies. . In addition, please note that calculations are based on the emission reduction estimates contained in the individual source white papers; different assumptions might affect the emission reduction estimates and therefore could change the ultimate outcome of the effects of strategy implementation.

[33] If the Category A and Category B strategies were fully implemented, Beacon Hill could realize an estimated 40% reduction in its overall annual $PM_{2.5}$ levels.

We appreciate the opportunity to serve the Agency, its Board, and the citizens of the Puget Sound Region.