DEPARTMENT OF
ECOLOGY
State of Washington

# Regional Haze

## State Implementation Plan

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# Regional Haze

## State Implementation Plan

*by*
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# Executive Summary

In 1977, Congress amended the Clean Air Act (CAA) with provisions to protect scenic vistas in certain Class I Areas. In these amendments, Congress declared the following national visibility goal:

> *"The prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution."* (CAA § 169A)

Environmental Protection Agency (EPA) adopted the Regional Haze Rule (RHR) on July1, 1999 to establish a comprehensive visibility protection program for the nation's 156 mandatory Class I Areas. The RHR addresses visibility impairment from widespread haze caused by emissions from numerous, multiple sources. These emissions are often mixed and transported over long distances.

The objectives of the RHR are to improve existing visibility in mandatory Class I Areas, prevent future impairment of visibility by man-made sources, and meet the national goal of natural visibility conditions in all 156 mandatory Class I Areas by 2064.

The RHR establishes several planning periods extending from 2005 to 2064. The state of Washington is required to develop a Regional Haze (RH) State Implementation Plan (SIP) for each period. The RH SIP must provide for improvement of visibility on the Most Impaired Days (the haziest or worst 20% of days) and protection of existing visibility on the Least Impaired Days (the clearest or best 20% of days) in the state's 8 mandatory Class I Areas. The RH SIP must also address mandatory Class I Areas outside of the state that are reasonably anticipated to be affected by emissions from Washington.

This first RH SIP for the state of Washington covers the initial (or foundational) planning period that extends from 2005 to 2018. The state's foundational SIP establishes the basis for future control RH SIPs addressing later planning periods and initiates the process of making Reasonable Progress toward the 2064 goal of natural visibility conditions. Washington's foundational RH SIP addresses the basic requirements of the RHR by:

- Determining baseline (2000-2004) visibility conditions in each of the state's 8 mandatory Class I Areas
- Providing inventories of visibility-impairing emissions from the state's sources
- Analyzing natural and human-caused sources of haze for the state's mandatory Class I Areas
- Establishing Reasonable Progress Goals for 2018 for the state's Class I Areas
- Developing a Long-Term Strategy for visibility improvement
- Determining and requiring Best Available Retrofit Technology (BART) for the 7 stationary point sources subject to BART

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# *Acronyms, Abbreviations and Terms*

| | |
|---|---|
| Anthropogenic | Caused or produced by humans |
| ARS | Air Resource Specialist, Inc. |
| BACT | Best Available Control Technology |
| BART | Best Available Retrofit Technology |
| Base02 | 2002 actual baseline emissions |
| Base18 | 2018 base case emissions |
| Btu | British thermal unit |
| CAA | Clean Air Act |
| CALMET | California Meteorological Model; a diagnostic 3-dimensional meteorological model |
| CALPUFF | California Puff Model; an air quality dispersion model |
| $CAM_x$ | Comprehensive Air Quality Model with Extensions |
| CCT | Clean Coal Technology |
| CENRAP | Central Regional Air Planning Association |
| CFR | Code of Federal Regulations |
| CGD | Cat Gasoline Desulfurizer |
| CIRA | Cooperative Institute for Research in the Atmosphere |
| CISWI | Commercial and Industrial Solid Waste Incinerators |
| CM | Coarse Matter |
| CMAQ | Community Multi-Scale Air Quality Model |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |

| | |
|---|---|
| COHA | Causes of Haze Assessment |
| COPD | Chronic Obstructive Pulmonary Disease |
| $DeSo_x$ | Desulfurization |
| DNR | Washington Department of Natural Resources |
| DOE | Washington State Department of Ecology |
| dv | Deciview; a measure of light extinction |
| EC | Elemental Carbon |
| ECAs | Emission Control Areas |
| EDMS | Emissions Data Management System |
| EGUs | Electric Generating Unit |
| EI | Emission Inventory |
| EPA | Environmental Protection Agency |
| ERG | Eastern Research Group |
| ESP | Electrostatic Precipitators |
| FCCU | Fluid Catalytic Cracking Unit |
| FEJF | Fire Emissions Joint Forum |
| FETS | Fire Emissions Tracking System |
| FGS | Flue Gas Scrubber |
| FIP | Federal Implementation Plan |
| FLM | Federal Land Manager |
| FS | Forest Service |
| GHG | Greenhouse Gas |
| Glidepath | The linear rate of improvement sufficient to attain natural conditions by 2064 |

| | |
|---|---|
| HAP | Hazardous Air Pollutant |
| HI | Haze Index |
| I-5 | Interstate 5 |
| IMO | International Maritime Organization |
| IMPROVE | Interagency Monitoring of Protected Visual Environments |
| IWG | Implementation Work Group |
| $LoTo_x^{TM}$ | Trademarked low temperature $NO_x$ removal system |
| LSFO | Limestone Forced Oxidation |
| LTS | Long Term Strategy |
| MACT | Maximum Achievable Control Technology |
| MANE – VU | Mid-Atlantic/Northeast Visibility Union |
| $Mm^{-1}$ | Inverse mega meter; a measure of particle extinction |
| MM | Million |
| MM5 | Meteorological Mesoscale 5 |
| MSL | Mean Sea Level |
| MW | Megawatt |
| NEDC | Northwest Environmental Defense Center |
| NESCAUM | Northeast States for Coordinated Air Use Management |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| $NH_3$ | Ammonia |
| $(NH_4)_2SO_4$ | Ammonium Sulfate |
| $NO_2$ | Nitrogen Dioxide |
| $NO_3$ | Ammonium Nitrate or $NH_4NO_3$ |

| | |
|---|---|
| $NO_x$ | Nitrogen Oxides |
| NPCA | National Parks Conservation Association |
| NPDES | National Pollutant Discharge Elimination System |
| NSPS | New Source Performance Standards |
| NPS | National Park Service |
| NSR | New Source Review |
| NTEC | National Tribal Environmental Council |
| NWCAA | Northwest Clean Air Agency |
| NWPPA | Northwest Pulp & Paper Association |
| $O_3$ | Ozone |
| OC | Organic Carbon |
| ODEQ | Oregon Department of Environmental Quality |
| OMC | Organic Mass Carbon |
| PG&E | Pacific Gas and Electric Company |
| Plan02 | 2000 through 2004 typical baseline emissions |
| PM | Particulate Matter |
| $PM_{2.5}$ | Fine Particles or Particulate Matter; with an aerodynamic diameter of 2.5 microns or less |
| $PM_{10}$ | Coarse Particle Matter or Particulate Matter; with an aerodynamic diameter of 10 microns or less |
| POA | Primary Organic Aerosol |
| ppm | parts per million |
| PRB | Powder River Basin |
| PRP | Preliminary Reasonable Progress |

| | |
|---|---|
| PRP18 (a or b) | 2018 Preliminary Reasonable Progress Emissions |
| PSAT | Particulate Matter Source Apportionment Technology |
| PSD | Prevention of Significant Deterioration |
| PTPC | Port Townsend Paper Corporation |
| RACT | Reasonable Available Control Technology |
| RAVI | Reasonably Attributable Visibility Impairment |
| RFO | Residual Fuel Oil |
| RH | Regional Haze |
| RHR | Regional Haze Rule |
| RICE | Reciprocating Internal Combustion Engine |
| RMC | WRAP's Regional Modeling Center |
| RPG | Reasonable Progress Goal |
| RPO | Regional Planning Organization |
| RRF | Relative Response Factors |
| SCR | Selective Catalytic Reduction |
| SIP | State Implementation Plan |
| SMOKE | Sparse Matrix Operator Kernel Emissions |
| SMP | Smoke Management Plan |
| SNCR | Selective Non-catalytic Reduction |
| SOIL | Fine Soil |
| $SO_2$ | Sulfur Dioxide |
| $SO_4$ | Ammonium Sulfate or $(NH_4)_2SO_4$ |
| $SO_x$ | Sulfur Oxides |

| | |
|---|---|
| SRU | Sulfur Recovery Unit |
| TGU | Tail Gas Unit |
| TIP | Tribal Implementation Plan |
| TSS | Technical Support System |
| URP | Uniform Rate of Progress |
| USDA | US Department of Agriculture |
| USDA – FS | US Department of Agriculture – Forest Service |
| USDI | US Department of the Interior |
| USDI – FWS | US Department of the Interior – Fish & Wildlife Service |
| USDI – NPS | US Department of the Interior – National Park Service |
| USGS | U.S. Geological Survey |
| VOC | Volatile Organic Compound |
| WA | Washington |
| WAC | Washington Administrative Code |
| WEP | Weighted Emissions Potential |
| WESTAR | Western States Air Resources Council |
| WGA | Western Governors Association |
| WGS | Wet Gas Scrubber |
| VIEWS | Visibility Information Exchange Web System |
| Visibility SIP | Visibility Protection |
| WRAP | Western Regional Air Partnership |

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# Chapter 1 Overview

## 1.1 Background

In 1977, Congress amended the Clean Air Act (CAA) to include provisions to protect scenic vistas in certain Class I Areas. In these amendments, Congress declared a national visibility goal:

> *"The prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution."* (CAA § 169A)

In 1979, the Environmental Protection Agency (EPA), in consultation with the Secretary of the Interior, promulgated a list of 156 mandatory Class I Areas in which visibility was determined to be an important factor. Eight areas in Washington were designated mandatory Class I Areas.

To address the national visibility goal, EPA promulgated regulations in 1980 to address Reasonably Attributable Visibility Impairment (RAVI). RAVI is distinct plumes (called "plume blight") caused by large stationary sources. RAVI regulations represented the first phase in addressing visibility impairment.

The Washington State Department of Ecology (Ecology) developed a revision to the State Implementation Plan (SIP) for the purpose of Visibility Protection (Visibility SIP) and submitted it to EPA in March 1985. EPA formally approved the Visibility SIP on May 4, 1987. Ecology has reviewed and revised the Visibility SIP several times since then. The most recent revisions were submitted to EPA on November 5, 1999 and approved by EPA on June 11, 2003.

Washington's phase I Visibility SIP targets both the distinct plumes from large stationary sources and prescribed burning. Although prescribed burning from forestry activities is not considered a stationary source, Washington addressed this source in its phase I Visibility SIP because of significant impacts on visibility from prescribed burn plumes.

EPA adopted phase II visibility rules, the Regional Haze Rule (RHR) in 1999. The RHR addresses visibility impairment from widespread haze caused by emissions from multiple sources. These emissions are often mixed and transported over long distances. The RHR established a comprehensive visibility protection program for the 156 mandatory Class I Areas.

## 1.2 Regional Haze Rule

The objectives of the RHR are to improve existing visibility in all 156 mandatory Class I Areas, prevent future impairment of visibility by man-made sources, and meet the national goal of natural visibility conditions by 2064. The RHR requires each state to adopt a Regional Haze (RH) SIP that focuses on improving the Most Impaired Days (the haziest or worst 20% of days) and protecting the Least Impaired Days (the clearest or best 20% of days). A state's RH SIP must provide a comprehensive analysis of natural and human-caused sources of haze in each mandatory Class I Area within the state and contain strategies to control and reduce emissions that contribute to haze. The SIP must also address mandatory Class I Areas outside of the state that are reasonably anticipated to be affected by emissions from the state.

The RHR breaks the RH Program into several planning phases extending from 2005 to 2064. This first RH SIP covers the initial (or foundational) planning period that extends from 2005 to 2018. The foundational SIP establishes the basis for RH SIP revisions addressing future planning periods and initiates the process of making reasonable progress toward the 2064 goal.

This foundational RH SIP integrates RAVI and RH through a comprehensive Long-Term Strategy that addresses both. This allows for coordinated review and revision of the SIP every five years in accordance with EPA's visibility requirements.

## 1.3 Organization of Washington's Foundational Regional Haze State Implementation Plan

Washington's RH SIP addresses the requirements specified in section 51.308 of the RHR. The RH SIP is organized as follows:

Chapter 2 addresses plan development. This includes the role of regional planning, the Western Regional Air Partnership (WRAP), and consultation with Federal Land Managers, Tribes, and other states.

Chapter 3 is a primer that provides information on basic plan elements and key concepts used in the RH SIP.

Chapter 4 describes Washington's eight mandatory Class I Areas and visibility monitoring for these areas.

Chapter 5 covers baseline and natural visibility conditions for each of Washington's eight mandatory Class I Areas. The uniform rate of visibility improvement for achieving the 2064 goal is also discussed here along with the uniform glide slope for each mandatory Class I Area.

Chapter 6 discusses the baseline and 2018 statewide emissions inventories that were developed and used to prepare this plan.

Chapter 7 describes the types of modeling used in the WRAP region and that Washington relied upon for this foundational SIP.

Chapter 8 discusses the significant in-state and regional sources of haze affecting Washington's mandatory Class I Areas and projected to affect visibility conditions in 2018. This chapter also presents which mandatory Class I Areas in adjacent states are significantly impacted by Washington emissions.

Chapter 9 defines the reasonable progress goal for each of the eight mandatory Class I Areas in Washington. Demonstrating reasonable progress towards the national visibility goal requires setting goals for the Most Impaired Days and Least Impaired Days for each mandatory Class I Area.

Chapter 10 describes the long-term strategy to address reasonably attributable and regional haze visibility impairment in Washington's mandatory Class I Areas and mandatory Class I Areas outside of the state that may be reasonably anticipated to be impacted by emissions originating in Washington.

Chapter 11 describes Best Available Retrofit Technology (BART) determinations for Washington. BART is a significant focus of the foundational RH SIP. BART applies to certain older industrial facilities that began operation before federal Prevention of Significant Deterioration rules were adopted to protect visibility in Class I Areas.

Chapter 12 addresses tracking progress towards the national visibility goal and performing plan reviews. The RHR requires commitments to monitoring, reporting, assessing visibility impacts, and revising the RH SIP.

Chapter 13 summarizes the national visibility goal, Washington's foundational RH SIP, and the long-term challenges and issues that must be and addressed to reach the national visibility goal in Washington.

# Chapter 2 Foundational Regional Haze State Implementation Plan Development

Just the term *regional haze* suggests the need for a *regional* approach to visibility impairment. This chapter provides background on regional planning to address Regional Haze (RH), the role of the Western Regional Air Partnership (WRAP) in the development of this first—foundational—RH State Implementation Plan (SIP), and Washington State's consultation with other states, tribes, and Federal Land Managers (FLMs) on foundational RH SIP development.

## 2.1 Regional Planning

The pollutants that lead to RH can originate from numerous sources located across broad geographic areas and be transported long distances. In recognition of the regional nature of haze, the Environmental Protection Agency (EPA) encouraged states to organize Regional Planning Organizations (RPOs) to coordinate regional activities related to the Regional Haze Rule (RHR). Ultimately states formed—and EPA funded—five RPOs, which collectively cover the 48 contiguous states, Alaska, and Hawaii (Figure 2-1).


**Figure 2-1 Regional Planning Organizations**

## 2.2 Western Regional Air Partnership

WRAP is a voluntary organization of western states, tribes, and federal agencies that work collaboratively to address visibility impairment in mandatory Class I Areas. The WRAP was formed in 1997 as the successor to the Grand Canyon Visibility Transport Commission (GCVTC). The 1990 Amendments to the Clean Air Act authorized the formation of visibility transport commissions and required EPA to establish the GCVTC.

The WRAP promotes, supports, and monitors the implementation of the GCVTC's June 1996 recommendations for improving visibility in the 16 national parks and wilderness areas on the Colorado Plateau. The recommendations developed by the GCVTC represent a significant milestone in the study of RH[1]. The GCVTC's technical analysis found the customary focus on mitigating visibility impairment from stack plumes associated with stationary-point sources was insufficient to address the wide range of pollutants and sources that caused or contributed to visibility impairment across the Colorado Plateau. The GCVTC's air quality monitoring and modeling showed that part of RH is caused by the long-range transport (more than 100 miles) of emissions from numerous and widespread sources.

The RHR expanded the focus of regional visibility planning processes in the West from the Colorado Plateau to all western Class I Areas. The WRAP embraced this geographic expansion by expanding its role to address RH in all 13 contiguous western states, Alaska, and Hawaii.

The focus of the WRAP for this foundational RH SIP is regional technical analysis. The WRAP has engaged in compilation of ambient monitoring, emission inventories, air quality modeling, and data analysis. The result is a regionally consistent body of technical data and analysis to address RH in the West. The WRAP also provides a forum for coordination and consultation between states, tribes and FLMs.

The WRAP accomplishes this work through committees, forums, and workgroups composed of states, tribes, FLMs, EPA, and environmental, industry, and public representatives. Staff-time for these activities is contributed by the organizations. The work is supported by WRAP staff from the Western Governors' Association and the National Tribal Environmental Council. The WRAP also contracts with environmental consulting firms for analysis of air pollution data, compilation and preparation of data, and analyses of natural and/or uncontrollable air pollution sources.

## 2.3 Consultation

Because of its very nature, addressing RH involves discussions between states, tribes, and FLMs. These discussions can be as informal in nature as a discussion within a WRAP forum, committee, or workgroup or they can be a structured, formal meeting. The RHR generally allows for both and one does not preclude the other. The RHR has formal requirements for a state's consultation with the FLMs administering mandatory Class I Areas within the state. This

[1] The Grand Canyon Visibility Transport Commission, *Recommendations for Improving Western Vistas*, June 10, 1996. http://www.wrapair.org/WRAP/reports/GCVTCFinal.PDF

section discusses the role of consultation between the state of Washington and other states, tribes, and FLMs in the development of this foundational RH SIP.

**Consultation with Other States**

The RHR requires consultation between states on the development of coordinated emission management strategies.[2] This requirement applies both to mandatory Class I Areas within Washington, where emissions from other states are reasonably anticipated to contribute to visibility impairment, and to mandatory Class I Areas outside Washington, where emissions from Washington are reasonably anticipated to contribute to visibility impairment.

Participation in the WRAP has fostered a regionally consistent approach to haze planning in the western states and provided a sound mechanism for consultation. Consultation among the fifteen western states within WRAP has occurred through meetings of WRAP committees, workgroups, and forums with participation by conference calls, face-to-face meetings, and workshops.

Through participation in the WRAP, the western states have agreed upon the overall goals set for 2018 and the appropriateness of the strategies to achieve these goals for all mandatory Class 1 Areas in the WRAP region. Coordination through WRAP resulted in resolution of technical tasks and policy decisions in such areas as monitoring, emissions, fire tracking, BART, source attribution, modeling, and control measures. Due to this extensive coordination, this foundational RH SIP reflects Washington's implementation of a regionally consistent approach to addressing visibility impairment in the West.

WRAP staff have compiled extensive documentation on WRAP meetings and work products (through October 2007) that provides an overview of the breadth of the coordinating role of the WRAP in the planning process for foundational RH SIPs (Appendix A).

In addition to consultation through the WRAP, Ecology met with the Oregon Department of Environmental Quality at its headquarters in Portland, Oregon on January 9, 2008 for a general discussion on RH planning.

**Consultation with Tribes**

The WRAP recognizes the unique legal status and jurisdiction of tribes and seeks to promote policies that ensure fair and equitable treatment of all participating members of the WRAP. The WRAP also recognizes the authority and responsibility of states and tribes to develop, adopt, and implement individual state and tribal implementation plans.

Ecology's consultation with tribes during the development of its foundational RH SIP has been solely through WRAP participation. Both EPA Region 10 and the National Tribal Environmental Council (NTEC) have offered assistance in making tribes aware of the Washington State's RH SIP. However NTEC, which made its offer of assistance in August 2007, has expended its federal RH funds and there is no EPA funding currently available to NTEC for the WRAP project. The RHR has no formal requirement for consultation with tribes.

[2] 40 CFR 51.308(d)(1)(iv) and 51.308(d)(3)(i)

**Consultation with Federal Land Managers**

The RHR requires consultation between the State of Washington and FLMs on development and implementation of the RH SIP. Ecology must provide FLMs with an opportunity to comment in person at least 60 days prior to holding a public hearing on this draft foundational RH SIP. The RHR specifies that the consultation must provide an opportunity for affected FLMs to comment on the state's assessment of visibility impairment in each mandatory Class I Area and provide recommendations on the reasonable progress goals and the development and implementation of visibility control strategies to address visibility impairment.

Formal consultation requirements do not preclude informal consultation. Ecology had a number of meetings with state and national representatives of the U.S. Department of Agriculture Forest Service (USDA-FS) and the U.S. Department of Interior National Park Service (USDI-NPS) between 2007 and 2009 (see Table 2-1). The major focus of these meetings was Ecology's Best Available Retrofit Technology (BART) determinations. These discussions were helpful to Ecology. Ecology used the discussions and informal written comments from FLMs to review and revise its draft BART determinations and associated draft compliance orders. A national representative of the U.S. Department of Interior Fish and Wildlife Service (USDI-FWS) participated in a number of the meetings as a representative of the U.S. Department of the Interior (USDI).

Ecology held a formal consultation with the USDA-FS, USDI-NPS and USDI represented by the USDI-FWS on May 18, 2010. Information on Ecology's formal consultation with the FLMs on this foundational SIP is found in Appendix B. Appendix B includes the formal written comments submitted to Ecology along with a synopsis of FLM comments accompanied by Ecology's response. This information was made available to the public as part of this foundational RH SIP when Ecology issued its public hearing notice for this foundational SIP.

The continuing role of the FLMs in RH planning is discussed in Chapter 12, Continuing Planning Process for RH.

**Table 2-1 Informal Ecology-Federal Land Managers Regional Haze State Implementation Plan Consultation**

| Date | FLMS | Arrangements | Topics |
|---|---|---|---|
| 1/18/07 | USDA-FS | Lacey, WA[3] meeting | • State BART activities<br>• Potential state involvement in the RH SIP and funding |
| 8/13/07 | USDA-FS<br>USDI-NPS | Lacey, WA meeting | • State plans for RH SIP and BART<br>• Informal consultation v. RHR consultation requirements |
| 11/16/07 | USDA-FS<br>USDI-NPS | Lacey, WA meeting | • BART-eligible sources – emission rates, exemption modeling, potential controls<br>• FLM-suggestions for future monitoring |
| 4/30/08 | USDA-FS<br>USDI-NPS | Lacey, WA meeting | • Baseline Washington Class I Areas IMPROVE monitoring<br>• BART status<br>• Alcoa Wenatchee primary aluminum plant exemption modeling<br>• Draft BART determination for Alcoa Intalco primary aluminum plant<br>• Draft BART technical analysis for Lafarge cement plant |
| 11/20/08 | USDA-FS<br>USDI-NPS<br>USDI-FWS | Lacey, WA meeting plus call-in | • Draft BART determinations:<br>R Lafarge cement plant<br>R Port Townsend Paper Corporation pulp & paper mill<br>R Alcoa Intalco primary aluminum plant |
| 2/13/09 | USDA-FS<br>USDI-NPS | Conference call | • Draft BART determination: TransAlta Centralia Generation coal-fired power plant |
| 3/16/09 | USDA-FS<br>USDI-NPS<br>USDI-FWS | Lacey, WA meeting plus call-in | • Revised draft BART determination for Alcoa Intalco primary aluminum plant<br>• Draft BART determinations:<br>R Weyerhaeuser Longview pulp & paper mill<br>R BP Cherry Point oil refinery |
| 3/23/09 | USDA-FS<br>USDI-NPS<br>USDI-FWS | Conference call | • Revised draft BART determination: TransAlta Centralia Generation coal-fired power plant |
| 8/12/09 | USDA-FS<br>USDI-NPS | Conference call | • Revised draft BART determination for Port Townsend Paper Corporation pulp & paper mill<br>• Draft BART determination for Tesoro oil refinery |
| 10/6/09 | USDA-FS<br>USDI-NPS<br>USDI-FWS | Conference call | • Revised draft BART determination: TransAlta Centralia Generation coal-fired power plant |
| 11/3/09 | USDA-FS<br>USDI-NPS<br>USDI-FWS | Lacey, WA meeting plus call-in | • Revised second draft BART determination: TransAlta Centralia Generation coal-fired power plant<br>• Cumulative visibility impacts<br>• Washington's BART process |

[3] The Washington State Department of Ecology is headquartered in Lacey, WA.

# Chapter 3 Primer on Visibility

In order to better understand the information presented in the document, this chapter describes basic plan elements and key concepts.

## 3.1 Natural Sources of Visibility Impairment

Natural sources of visibility impairment include anything not directly attributed to human caused emissions of visibility impairing pollutants.

Natural events (e.g. windblown dust, wildfire, volcanic activity, biogenic emissions) also introduce pollutants that contribute to haze in the atmosphere. Specific natural events can lead to high short-term concentrations of visibility impairing particulate matter and its precursors.

Natural sources, particularly wildfire and windblown dust, can be major contributors to visibility impairment. However, these emissions cannot be realistically controlled or prevented by the states, and therefore the focus of the Regional Haze (RH) strategies in this document are on human-caused (anthropogenic) sources, as described below. While current methods of analysis of monitoring data do not provide a clear distinction between natural and anthropogenic emissions, certain pollutant species, such as Sulfur Dioxide ($SO_2$) and Nitrogen Oxide ($NO_x$) are more representative of anthropogenic sources, while Organic Carbon (OC) and Coarse Particulate Matter ($PM_{10}$) are more representative of natural sources such as wildfire and dust, respectively.

Even when there is an absence of emissions, visibility can be degraded by the scattering of light by air molecules. This is called Rayleigh scattering and is affected by the air molecules' temperature and density.

Therefore, natural visibility conditions, for the purpose of the RH program, are represented by a long-term average of conditions expected to occur in the absence of emissions normally attributed to human activities. Natural visibility conditions reflect contemporary vegetated landscape, land use patterns, and meteorological/climatic conditions.

## 3.2 Human Caused Sources of Visibility Impairment

Anthropogenic, or human-caused, sources of visibility impairment include anything directly attributable to human-caused activities that produce emissions of visibility impairing pollutants. Some examples include industrial activities, transportation, agricultural activities, home heating, and managed outdoor burning. Anthropogenic sources can be local, regional, or international. Efforts to regulate anthropogenic emissions are mostly limited to inside the United States. Emissions from Mexico, Canada and off-shore marine shipping emissions in the Pacific Ocean are examples of anthropogenic sources that contribute to visibility impairment in Washington, but like natural sources, are beyond the scope of this planning document.

## 3.3 Emissions

Both natural sources and anthropogenic sources produce visibility impairing pollutants or emissions. Once particles and gases are emitted, they may go through chemical changes before they are captured by an air sampler. For this reason, the chemical species causing visibility impairment may not be the same species that are emitted by a pollution source.

## 3.4 The IMPROVE Program for Visibility Monitoring

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program is a cooperative effort with the primary purposes of protection of visibility in mandatory Class I Areas and characterization of RH. The objectives of IMPROVE program are to:

- Establish current visibility and aerosol conditions in mandatory Class I Areas
- Identify chemical species and emission sources responsible for existing man-made visibility impairment
- Document long-term trends for assessing progress towards the national visibility goal
- Provide RH monitoring representing all visibility protected Class I Areas where practical in support of the Regional Haze Rule (RHR)

The IMPROVE monitoring sites are operated and maintained through a formal cooperative relationship between Environmental Protection Agency (EPA), National Parks Service, Fish and Wildlife Service, Bureau of Land Management, and Forest Service. In addition, 4 inter-state agencies have joined the IMPROVE Steering Committee.

The IMPROVE monitor is designed to obtain a complete signature of the composition of the airborne particles affecting visibility. Each IMPROVE monitor collects a 24-hour sample of these particles onto a set of filters to determine the standard chemical components causing visibility impairment at that site.

In order to simplify the data analysis, some elemental particles and compounds are grouped together (based on scientific principles) into seven standard components. The seven standard components aerosol components of light extinction are listed in Table 3-1 along with the default color used in graphics throughout this document.

**Table 3-1 Interagency Monitoring of Protected Visual Environments Monitor Aerosol Composition**

| Aerosol Component | Abbreviation (Color) |
|---|---|
| 1. Ammonium Sulfate | $(NH_4)SO_4$ (yellow) |
| 2. Ammonium Nitrate | $NH_4NO_3$ (red) |
| 3. Organic Mass Carbon | OMC (green) |
| 4. Elemental Carbon | EC (black) |
| 5. Fine Soil | Soil (orange) |
| 6. Coarse Mass | CM (gray) |
| 7. Sea Salt | Sea Salt (light blue) |

The IMPROVE monitor consists of four independent modules with a common controller. Each module has a specific function though there is some redundancy between modules.

- Module A, the primary module, collects Fine Particles ($PM_{2.5}$) on a Teflon filter. The mass of $PM_{2.5}$ on the filter is determined from the difference in the filter's weight before and after use in the module. The filter is also analyzed for a long list of elements. The analyses are used to determine concentrations of sulfate, nitrate, fine soil, and sea salt.
- Module B collects $PM_{2.5}$ on a nylon filter for sulfate, nitrate, and chloride analyses. If sulfate, nitrate, or sea salt measurements from Module A are missing, the less accurate measurements from Module B may be used in their place.
- Module C collects $PM_{2.5}$ on a quartz filter for total OC and total elemental carbon analyses.
- Module D collects all $PM_{10}$ up to 10 µm in size on a Teflon filter. Coarse Mass is estimated by subtracting the $PM_{2.5}$ mass measured on Module A from the $PM_{10}$ mass measured on Module D.

The diagram of an IMPROVE monitor in Figure 3-1 shows the 4 modules, the size of particulates collected by each, the filter materials, and the analytical results..

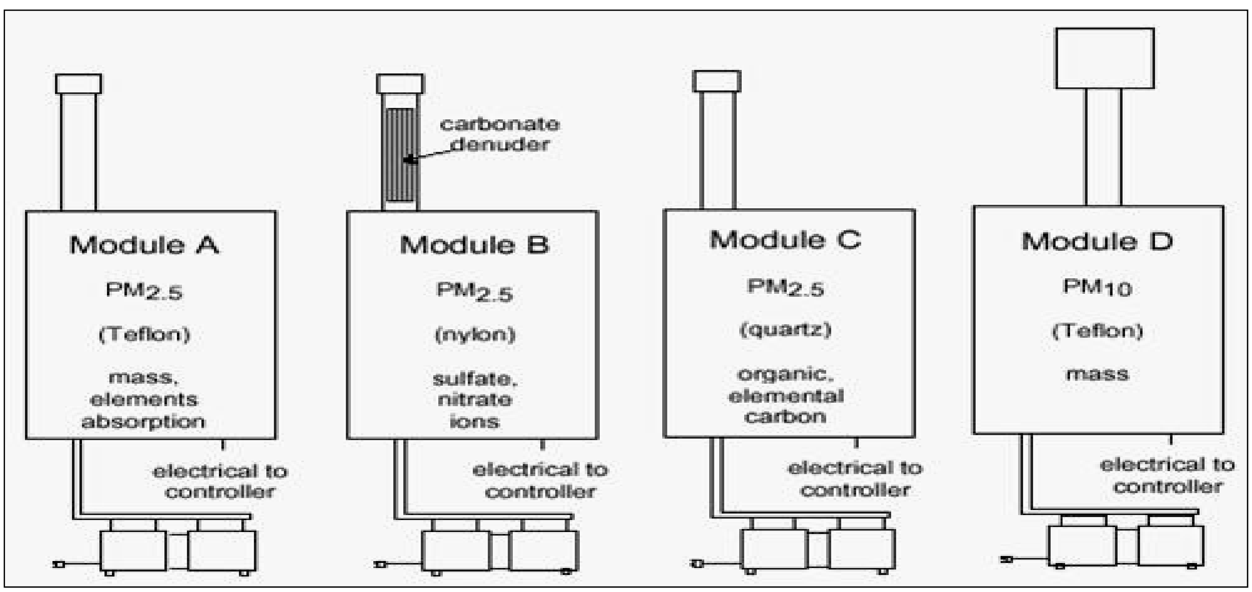



**Figure 3-1 Diagram of the Interagency Monitoring of Protected Visual Environments Monitor**

Detailed information regarding the IMPROVE program, including history, sampling protocols, standard operating procedures, and data availability can be found on the IMPROVE website (http://vista.cira.colostate.edu/improve/) and the Visibility Information Exchange Web System (VIEWS) website (http://vista.cira.colostate.edu/views/).

The data collected at the IMPROVE monitoring sites are used by land managers, industry planners, scientists, public interest groups, and air quality regulators to better understand and protect the visual air quality resource.

## 3.5 The Revised Interagency Monitoring of Protected Visual Environments Equation and Measuring Visibility Impairment

Some of the particles that compose aerosols absorb light, while others reflect or scatter light. Both absorption and scattering of light result in light extinction, the technical term for visibility impairment between the viewer and the light source.

Each of the key components of particulate aerosols has characteristics that differ in terms of ability to affect light extinction. For example, the same amount of pure sulfates or nitrates are about three times more effective than fine soil at impairing visibility. OC is about four times more effective than fine soil and elemental carbon about ten times more effective than fine soil at impairing visibility. Conversely, $PM_{10}$ is about half as effective as fine soil.

A complex calculation called the revised IMPROVE equation addresses the components' differing effects on light extinction (see Figure 3-2). The revised IMPROVE equation also accounts for site-specific Rayleigh scattering values based on altitude. Rayleigh scattering is the scattering of light by the molecules of air and causes the blue color of the sky.

| | |
|---|---|
| $b_{ext} \approx$ | 2.2 x $f_s$(RH) x [Small Sulfate] + 4.8 x $f_L$(RH) x [Large Sulfate] |
| | + 2.4 x $f_s$(RH) x [Small Nitrate] + 5.1 x $f_L$(RH) x [Large Nitrate] |
| | + 2.8 x [Small Organic Mass] + 6.1 x $f_L$(RH) x [Large Organic Mass] |
| | + 10 x [*Elemental Carbon*] |
| | + 1 x [*Fine Soil*] |
| | + 1.7 x $f_s$(RH) x [Sea Salt] |
| | + 0.6 x [*Coarse Mass*] |
| | + Rayleigh Scattering (site specific) |
| | + 0.33 x [$NO_2$ (ppb)] |

**Figure 3-2 Revised Interagency Monitoring of Protected Visual Environments Equation**

The result of the revised IMPROVE equation is referred to as the reconstructed light extinction (denoted as $b_{ext}$). It represents the light extinction due to the aerosol particulates measured at the IMPROVE monitor and is proportional to the mass measured at the monitor.

Additional information including characterization of the IMPROVE equation's performance and a summary of the rationale for the changes in the algorithm is available in the "Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data" report prepared by the IMPROVE Steering Committee's Technical Subcommittee for Algorithm Review.

Reconstructed light extinction is expressed in units of Inverse Megameters ($Mm^{-1}$). The RHR requires the tracking of visibility conditions in terms of the Haze Index (HI) metric expressed in the Deciview (dv) unit[1]. Generally, a one dv change in the HI is considered a humanly perceptible change under ideal conditions, regardless of background visibility conditions. The relationship between extinction $Mm^{-1}$, dv and visual range (mi) is shown in Figure 3-3.

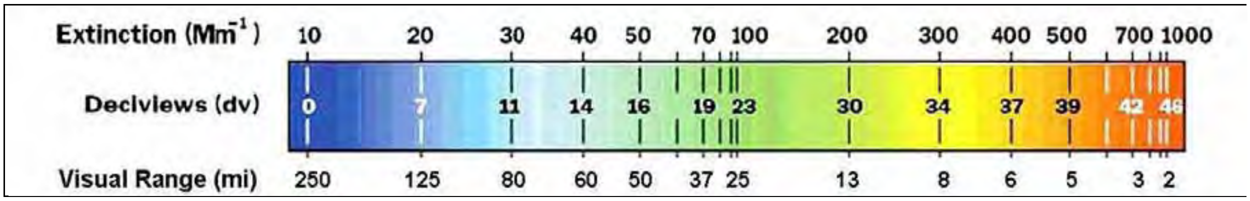



**Figure 3-3 Comparison of extinction, deciview, and visual range**
Source: William Malm, *Introduction to Visibility*, 1999.

## 3.6 Baseline Conditions

The RHR requires the calculation of baseline conditions for each mandatory Class I Area. Baseline conditions are defined as the five year average (annual values for 2000 - 2004) of IMPROVE monitoring data (expressed in dv) for the Most Impaired and the Least Impaired Days. For this first RH plan submittal, the baseline conditions are the reference point against which visibility improvement is tracked.

## 3.7 Natural Conditions

The visibility that would exist under natural conditions (absent any man-made impairment) would vary based on the contribution of natural sources and meteorological conditions on a given day. For that reason, natural conditions, as defined in this document, consists of a level of visibility (in dv) for both the Most Impaired and Least Impaired Days. Since no visibility monitoring data exists from the pre-manmade impairment period, these estimates of natural conditions are based on EPA guidance on how to estimate natural conditions (EPA Document: *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule*).

## 3.8 Uniform Rate of Progress

The Uniform Rate of Progress (URP) is the calculation of the uniform slope, or glide path, of the line between baseline visibility conditions and natural visibility conditions over the 60-year period. For the first RH plan, the first benchmark is the dv level that should be achieved in 2018 (Figure 3-4). This is the 2018 Milestone, and applies to both the Most Impaired and Least Impaired Days. The glide path is one of the indicators used to set reasonable progress goals for achieving natural visibility conditions.

[1] 40 CFR 51.308(d)(2)

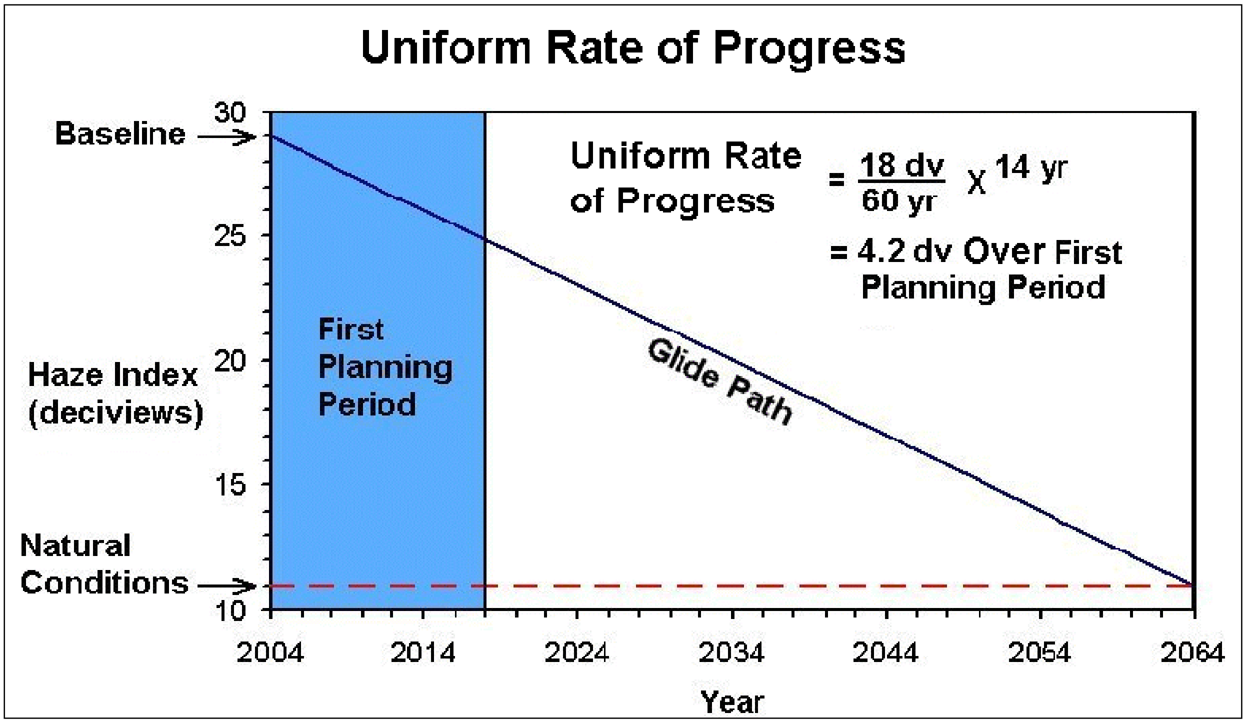



**Figure 3-4 Example of How Uniform Rate of Progress is Determined**
Source: EPA Guidance for Setting Reasonable Progress Goals under the Regional Haze Program

- Compare baseline conditions to natural conditions. The difference between these two represents the amount of progress needed to reach natural visibility conditions. In this example, the State has determined that the baseline for the Most Impaired Days for the mandatory Class I Area is 29 dv and estimated that natural background is 11 dv, a difference of 18 dv.
- Calculate the annual average visibility improvement needed to reach natural conditions by 2064 by dividing the total amount of improvement needed by 60 years (the period between 2005 and 2064). In this example, this value is 0.3 dv/yr.
- Multiply the annual average visibility improvement needed by the number of years in the first planning period (the period from 2005 until 2018). In this example, this value is 4.2 dv. This is the uniform rate of progress that would be needed during the first planning period to attain natural visibility conditions by 2064.

For the Most Impaired Days, the URP is expressed in dv per year (i.e. slope of the glide path) is determined by the following equation:

*URP = [Baseline Condition - Natural Condition] / 60 years*

The 2018 Progress Goal (i.e. the amount of reduction necessary for the first planning period) is determined by multiplying the URP by the number of years in the first planning period. The first planning period includes the 4 years between the baseline and the SIP submittal date plus the standard 10-year planning period.

*2018 Progress Goal = [Uniform Rate of Progress] x [14 years]*

# Chapter 4 Monitoring Visibility in Washington's Mandatory Class I Areas

The Regional Haze Rule (RHR) applies to mandatory Class 1 Areas. In 1979, the Environmental Protection Agency (EPA), in consultation with the Secretary of the Interior, promulgated a list of mandatory Class I Areas. The list contains 156 national parks and wilderness areas where visibility is an important value. Consultation with the Federal Land Managers (FLMs) on visibility values by EPA involved the U.S. Department of the Interior (USDI), U.S. Department of the Interior National Park Service (USDI-NPS), U.S. Department of the Interior Fish and Wildlife Service (USDI-FWS), the U.S. Department of Agriculture (USDA), and U.S. Department of Agriculture Forest Service (USDA-FS).[1]

This chapter identifies the mandatory Class I Areas located in the state of Washington, provides background on visibility monitoring for Class I Areas, and identifies the visibility monitoring sites associated with each of Washington's Class I Areas.

## 4.1 Washington's Mandatory Class I Areas

Washington has 8 mandatory Class I Areas: 3 national parks and 5 wilderness areas. Washington's 8 mandatory Class I Areas are shown in Figure 4-1 along with the locations of the visibility monitoring sites for the Class I Areas.

[1] 40 CFR 81.400

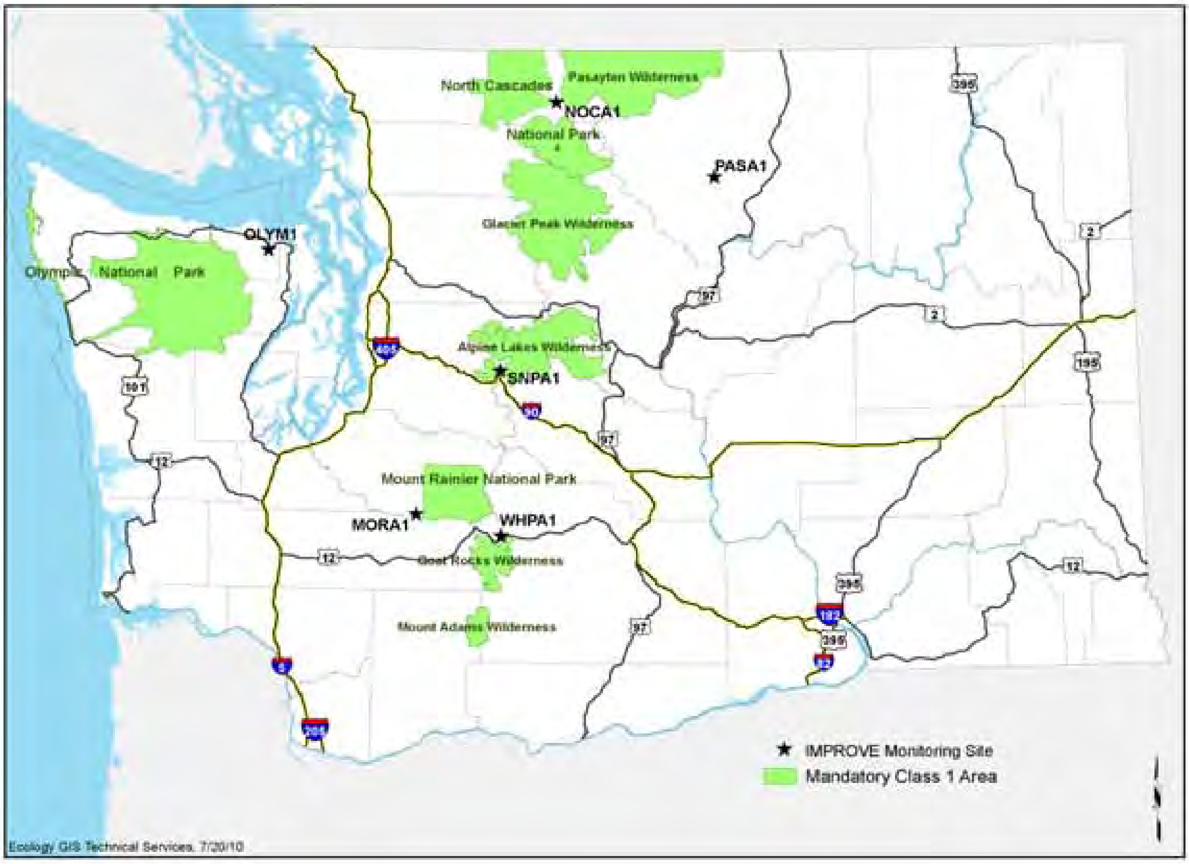



**Figure 4-1 Washington's Mandatory Class I Areas and Visibility Monitoring Sites**

Table 4-1 provides information on the size and FLM of each of the mandatory Class I Areas. The acreages may not match the current acreages of the national park or wilderness area for reasons including more accurate surveys or expansion of the area.

**Table 4-1 Washington's Mandatory Class I Areas**

| *Mandatory Class I Area* | *Acreage*[2] | *Federal Land Manager* |
|---|---|---|
| Olympic National Park | 892,578 | USDI-NPS |
| North Cascades National Park | 503,277 | USDI-NPS |
| Glacier Peak Wilderness | 464,258 | USDA-FS |
| Alpine Lakes Wilderness | 303,508 | USDA-FS |
| Mt. Rainier National Park | 235,239 | USDI-NPS |
| Goat Rocks Wilderness | 82,680 | USDA-FS |
| Mt. Adams Wilderness | 32,356 | USDA-FS |
| Pasayten Wilderness | 505,524 | USDA-FS |
| **Total Acres** | **3,019,420** | |

[2] Acreages listed in 40 CFR 81.434.

Washington's 8 mandatory Class I Areas are briefly described in the sections below; maps of these areas are included later in this chapter. The descriptions start with Olympic National Park followed by the 6 Class I Areas on the west side of the Cascade Range from the Canadian border south and ending with the Pasayten Wilderness which is largely on the east side of the Cascade Range.

### 4.1.1 Olympic National Park

Olympic National Park comprises a significant portion of the Olympic Peninsula in northwestern Washington. It is divided into two segments: the Olympic Mountains, which form the mountainous core of the Park, and a separate coastal strip, stretching for 90 km (56 mi) along the Pacific coast. The dominant aquatic feature is 13 major rivers flowing from the Olympic Mountains in all directions. Ninety-five percent of the Park is designated wilderness.

Elevations range from sea level along the coast to 2,428 m (7,965 feet) at the crest of Mt. Olympus near the center of the Peninsula. The area has the greatest precipitation gradient in the world for temperate latitudes. Annual precipitation is near 400 cm (150 inches) in the western valleys and 500 cm (200 inches) at the summit of Mt Olympus but as little as 41 cm (16 inches) on the northeast shore of the Peninsula in the rain shadow of the Olympic Mountains.

According to National Park Service statistics, there are approximately 3 million visitors to the Olympic National Park every year. [3]

### 4.1.2 North Cascades National Park

North Cascades National Park is set in the rugged mountains and the beautiful scenery of the Cascade Mountain Range in north-central Washington, about 80 km (50 miles) east of Bellingham. The area was set aside to preserve dramatic mountain scenery, alpine areas, and glaciers. Mountain summits rise abruptly 1,800-2,600 m (5,900-8,530 feet) above the valley floor. Approximately 93 percent of the Park is designated wilderness.

North Cascades National Park lies less than 150 km (95 miles) from major metropolitan areas, most notably, Seattle, Washington and Vancouver, British Columbia. According to USDI-NPS statistics, there are approximately 20,000 recreational visitors to the North Cascades National Park every year. [4]

### 4.1.3 Glacier Peak Wilderness

Glacier Peak Wilderness includes more than 200 lakes, many unnamed and tremendously difficult to access, in various cirques and hidden basins. The Wilderness straddles the northern Cascade Range roughly between Suiattle River on the west and Lake Chelan on the east. North Cascades National Park is adjacent to the northern border.

[3] National Park Service Public Use Statistics Office, http://www.nature.nps.gov/stats/
[4] National Park Service Public Use Statistics Office, http://www.nature.nps.gov/stats/

The dominant topographic feature is Glacier Peak, a 3,214 m (10,541 foot) high volcanic cone. Other mountain summits are 2,500 m (8,200 feet) or lower in elevation. Most terrain lies below 2,000 m (6,500 feet) elevation.

Glacier Peak Wilderness is drained on the west side of the Cascade crest by the Suiattle and Sauk Rivers, tributaries to the Skagit River, which flows into northern Puget Sound. East of the Cascade crest, streams flow to Lake Chelan and the Columbia River basin. The lowest elevations where streams exit the Wilderness on the west side are around 400 m (1,300 feet). The lowest elevations east of the Cascade crest are 350 to 400 m (1,200 to 1,300 feet), close to the 335 m (1,099 foot) elevation of Lake Chelan.

### 4.1.4 Alpine Lakes Wilderness

Alpine Lakes Wilderness was created when Congress passed the 1976 Alpine Lakes Wilderness Act to protect the area in its unique natural state. The name Alpine Lakes takes its origin from the nearly 700 small mountain lakes nestled among the high rock peaks and forested valleys of the region. The Wilderness is jointly administered by the Mt. Baker-Snoqualmie National Forest and the Okanogan-Wenatchee National Forest.

Alpine Lakes Wilderness is located in the rugged central Cascade Range. It is accessed by 47 trailheads and 990 km (615 miles) of trail on both sides of the crest of the Cascade Range between Stevens Pass (US Hwy 2) on the north and Snoqualmie Pass (I-90) on the south.

Its breathtaking beauty and proximity to the Seattle metropolitan area makes the Alpine Lakes one of the most popular natural areas in the Northwest. Over half of Washington State's population lives within a one-hour drive of the Wilderness.

### 4.1.5 Mount Rainier National Park

Mount Rainier National Park was established as the nation's fifth national park in 1899. The Park was set aside to protect timber, minerals, and other natural resources. One hundred kilometers (62 miles) southeast of Seattle, Mount Rainier is the highest of the chain of volcanoes comprising the Cascade Range. At 4,392 m (14,410 feet), Mount Rainier is the fifth tallest peak in the contiguous 48 states. The massive mountain occupies more than one-fourth of the Park's area. The 27 major glaciers on its slopes form the largest mass of year-round ice in the United States outside Alaska.

Mount Rainier National Park lies within 64 km (40 miles) of Puget Sound. The lowlands along the eastern shore of Puget Sound are the most of the populated and industrialized area of Washington. According to National Park Service statistics, there are more than 1 million recreational visitors to the National Park every year.[5]

[5] National Park Service Public Use Statistics Office, http://www.nature.nps.gov/stats/

### 4.1.6 Goat Rocks Wilderness

The Goat Rocks Wilderness is a portion of the volcanic Cascade Range in southwestern Washington located between Mount Rainier and Mount Adams. The Goat Rocks are remnants of a large volcano, which has been extinct for some two million years. The cluster of rocks and peaks in this area has become known as Goat Rocks because of the bands of mountain goats that live there. The Wilderness lies in both the Gifford Pinchot National and the Okanogan-Wenatchee National Forests.

Glaciation and erosion have worn away the terrain and left moderate summits east and west of the crest of the Cascades. Elevation in the Goat Rocks range from 900 m (3,000 feet) to 2,450 m (8,201 feet) at Gilbert Peak. The deep east-west drainages below the ridges often open into park-like alpine meadows dotted with small lakes and even smaller ponds.

### 4.1.7 Mount Adams Wilderness

Congress designated the Mount Adams Wilderness in 1964. The Wilderness lies in the Gifford Pinchot National Forest on the crest of the Cascade Range in southwestern Washington. Second in height only to Mount Rainier statewide, 3,742 m (12,276 feet) Mount Adams looms over at least 10 glaciers and a wilderness of forested slopes and subalpine meadows. The huge volcanic bulk of the mountain takes up a considerable portion of the Wilderness. Since the eruption of Mount St. Helens, Mount Adams has become a popular attraction for mountain climbers.

### 4.1.8 Pasayten Wilderness

The Pasayten Wilderness stretches across the crest of the Cascade Range in northern Washington. The Wilderness is bordered on the north by 80 km (50 mi) of the Canadian border and on the west by the Ross Lake National Recreation Area. The Pasayten Wilderness is located in both the Okanogan-Wenatchee and the Mount Baker-Snoqualmie National Forests.

The terrain of the western Wilderness area is a series of high ridges that flatten out in the eastern Wilderness area to high plateaus. Almost 150 peaks in the Wilderness have elevations above 2,300 m (7,500 feet). The western part of the wilderness area, west of the Cascade crest, is in the upper Skagit River basin and drains into Ross Lake and the Skagit River and thence into northern Puget Sound. From the eastern part of the Wilderness, streams flow north into British Columbia or southeast into the central Columbia Plateau. The lowest Wilderness elevations are around 1,000 m (3,000 feet) at the western boundary near Ross Lake and the southern boundary near Lost River Gorge.

## 4.2 Visibility Monitoring of Washington's Mandatory Class I Areas

Washington has 6 Interagency Monitoring of Protected Visual Environments (IMPROVE) sites that monitor the visibility of the state's 8 mandatory Class I Areas. Four of Washington's Class I Areas have been combined into two clusters and one monitor used to represent each cluster. Table 4-2 provides general information on the 6 sites. The sites are shown in Figure 4-2. Each site is discussed briefly below. The sites are discussed in the same order as the mandatory Class

I Areas earlier in the chapter where Olympic National Park was followed by the mandatory Class I Areas on the west side of the Cascade Range from the Canadian Border south and ending with Pasayten Wilderness on the east side of the Cascade Range.

**Table 4-2 Washington's Interagency Monitoring of Protected Visual Environments Monitoring Sites**

| *Site Name* | *Site Abbreviation* | *Site Sponsor* | *Monitored Mandatory Class I Area* |
|---|---|---|---|
| Olympic | OLYM1 | USDI-NPS | Olympic National Park |
| North Cascades | NOCA1 | USDI-NPS | North Cascades National Park & Glacier Peak Wilderness |
| Snoqualmie Pass | SNPA1 | USDA-FS | Alpine Lakes Wilderness |
| Mount Rainier | MORA1 | USDI-NPS | Mount Rainier National Park |
| White Pass | WHPA1 | USDA-FS | Goat Rocks Wilderness & Mt. Adams Wilderness |
| Pasayten | PASA1 | USDA-FS | Pasayten Wilderness |

### 4.2.1 Olympic Interagency Monitoring of Protected Visual Environments Site: OLYM1

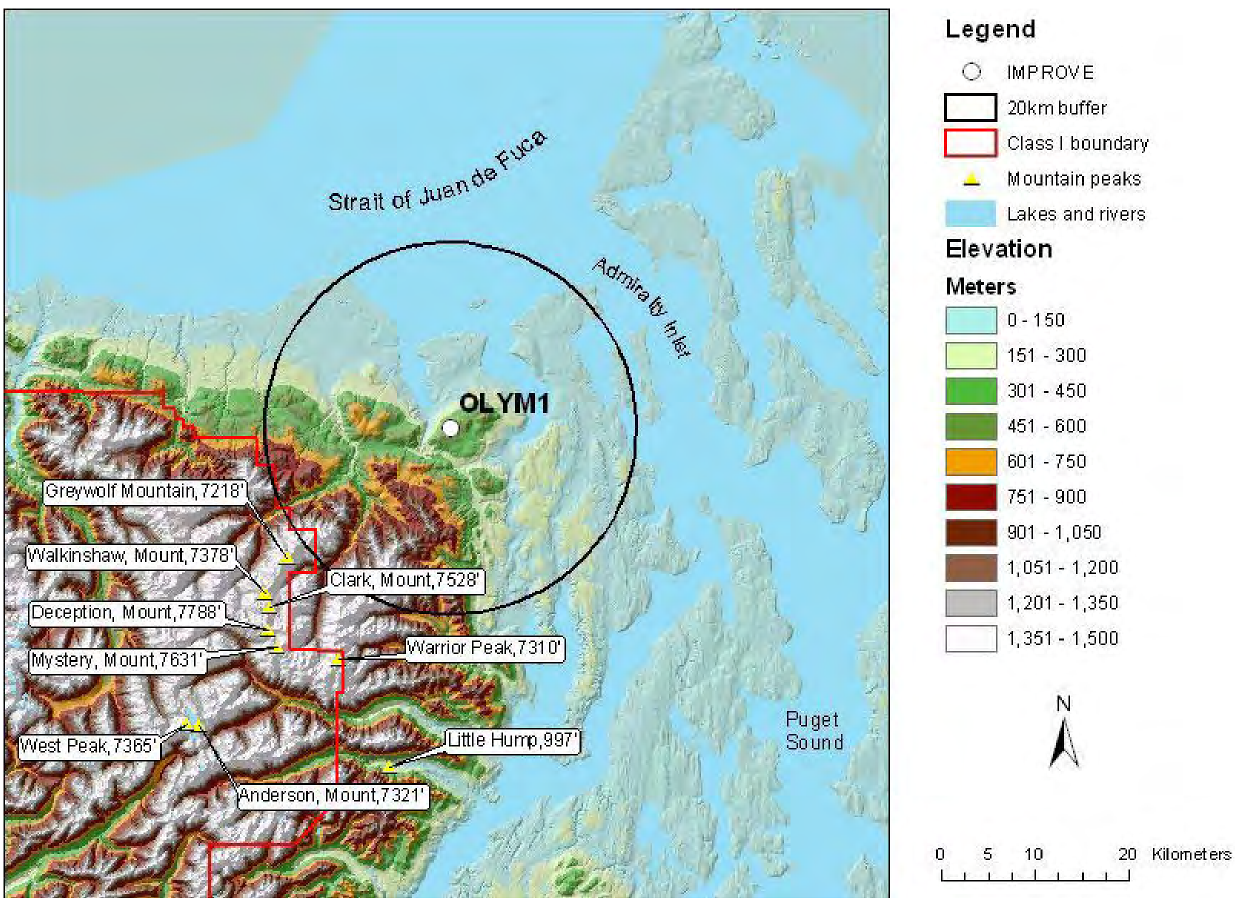



**Figure 4-2 Location of OLYM1 Interagency Monitoring of Protected Visual Environments Site**
Source: Causes of Haze Assessment Descriptive Maps

The IMPROVE site representing the Olympic National Park is OLYM1, located northeast of the Park boundary on an exposed hilltop (Blyn Lookout) near the northeastern extreme of the Olympic Peninsula at an elevation of 600 m (1,968 feet). See Figure 4-2. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

OLYM1 is on the northeast shore of the peninsula near Sequim. Sequim is in the rain shadow of the Olympics, with sea level precipitation less than 50 cm (20 inches) annually. The rain shadow effect may be less severe at the OLYM1 elevation of 600 m. OLYM1 should be representative of eastern National Park areas most of the time, although at this elevation there may be periods when it is above inversion height.

Because of the size of the Park, different areas may be affected by different sources. For the northeastern portion of the Olympic National Park, where the OLYM1 monitoring site is located, nearby industrial and urban emission sources that most immediately affect the area are in Port Angeles. For the western portions of the Olympic National Park including the coastal section, there are no additional large source areas, although there may be timber and shipping related industries.

## 4.2.2 North Cascades Interagency Monitoring of Protected Visual Environments Site: NOCA1

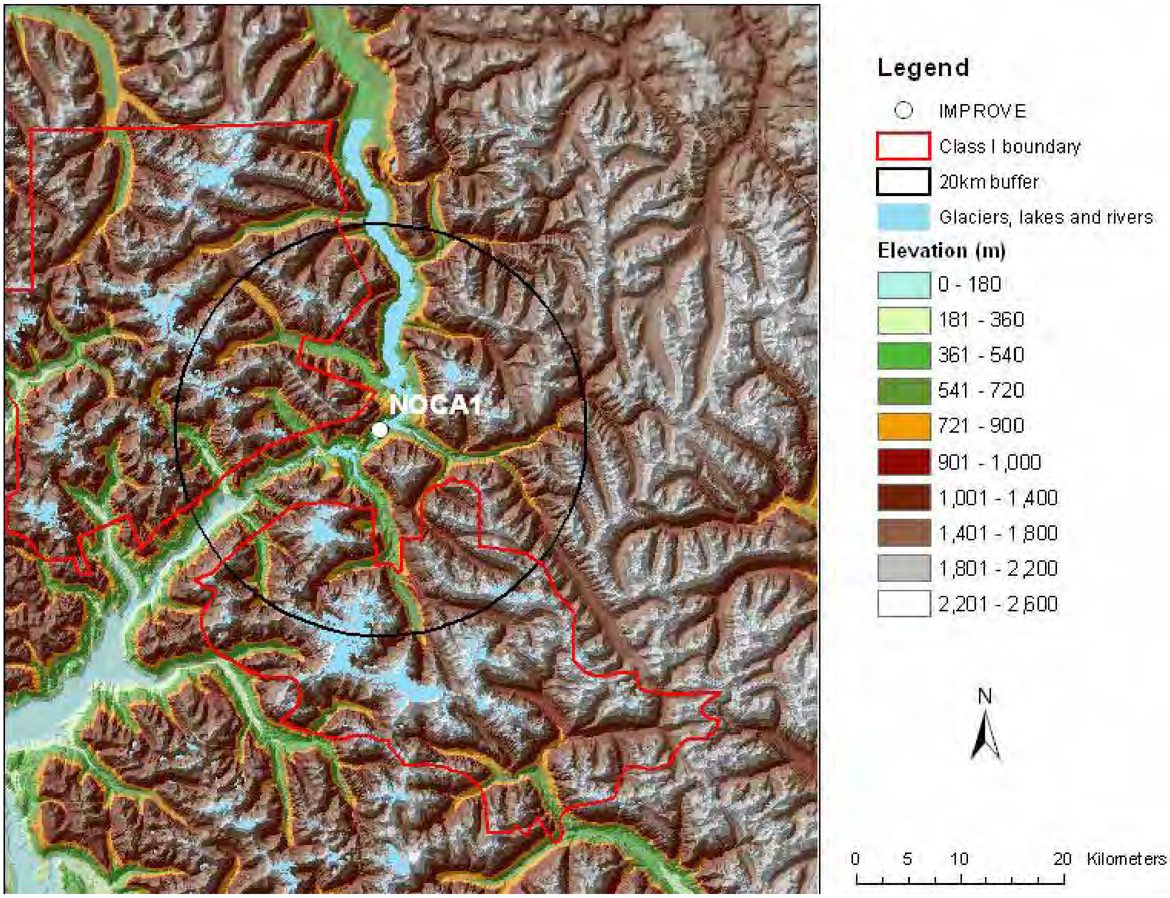



**Figure 4-3 Location of NOCA1 Interagency Monitoring of Protected Visual Environments Site**
Source: Causes of Haze Assessment Descriptive Maps

The NOCA1 IMPROVE site is the monitoring site for two mandatory Class I Areas, North Cascades National Park and Glacier Peak Wilderness. NOCA1 is located near Ross Lake on the upper reaches of the Skagit River just outside of the eastern boundary of the northern Park section, located north of the Skagit River. See Figure 4-3. The monitor is situated at an elevation of 576 m (1,889 feet) and is 87 m (285 feet) above the level of Ross Lake. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

The NOCA1 IMPROVE site is within the Skagit River Valley near Ross Lake, 87 m above lake level and about 200 m (650 feet) below the surrounding ridge tops. The NOCA1 site is in the lower slopes of a valley and may at times be within surface-based valley inversions. In the absence of valley inversions, the monitor should be representative of lower Park elevations at all times.

Similarly for Glacier Peak Wilderness, when NOCA1 is contained within surface-based valley inversions, it would not reflect visibility conditions at higher elevations. In the absence of valley inversions, the monitor should be representative of lower elevations of the Wilderness at all times.

### 4.2.3 Snoqualmie Pass Interagency Monitoring of Protected Visual Environments Site: SNPA1

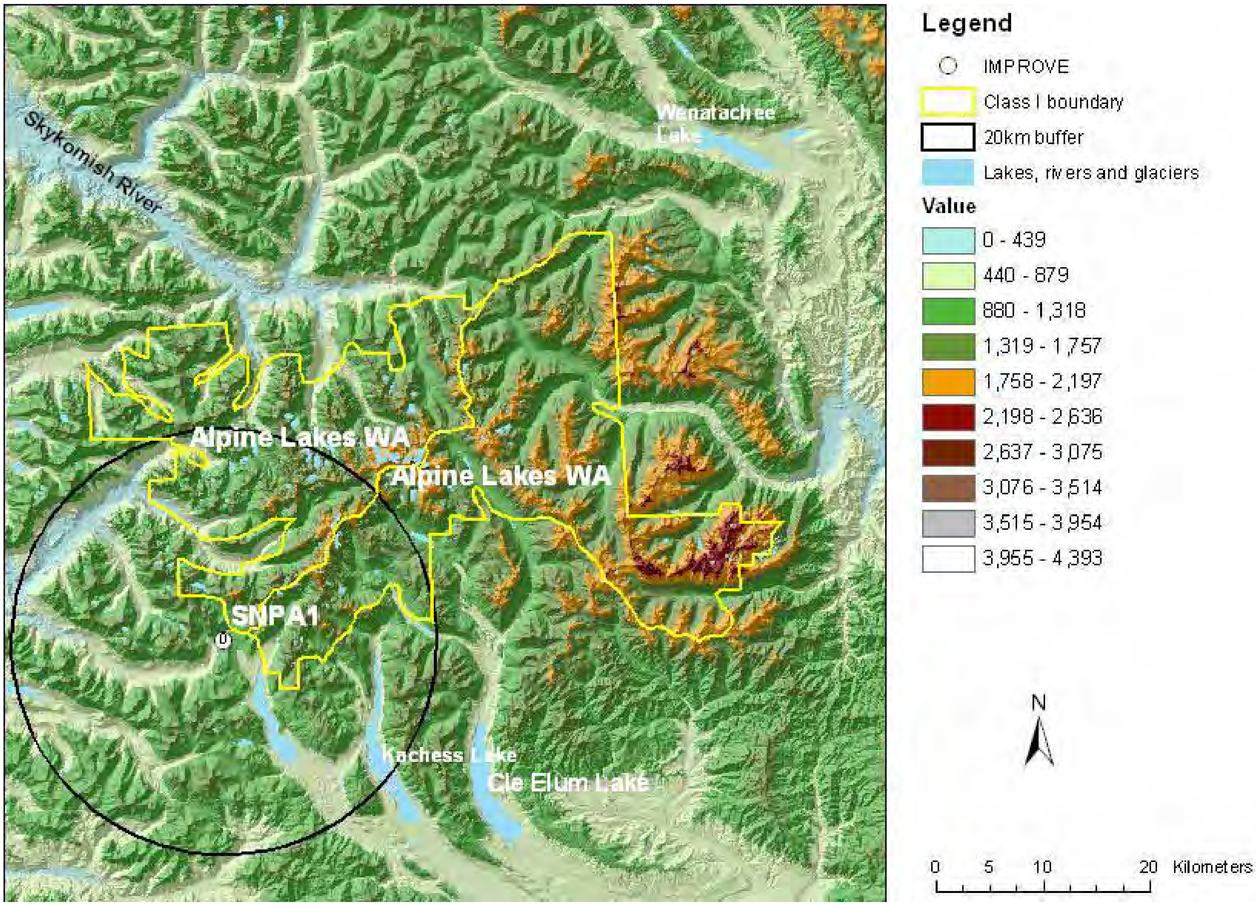



**Figure 4-4 Location of SNPA1 Interagency Monitoring of Protected Visual Environments Site**
Source: Causes of Haze Assessment Descriptive Maps

SNPA1 is the IMPROVE site representing the Alpine Lakes Wilderness. SNPA1 is located near the southwest boundary of the Wilderness in Snoqualmie Pass, a pass over the Cascade Range. The monitoring site elevation of 1,160 m (3,805 feet) is 239 m (784 feet) above the Snoqualmie Pass elevation of 921 m (3,022 feet). See Figure 4-4 SNPA1 is located near a ski area. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

SNPA1 is at a well-exposed ridge crest location and should be very representative of the particulate aerosol concentration and composition at similarly exposed locations in the Alpine Lakes Wilderness. The elevation of SNPA1 is at the lower end of the range of elevations of the Wilderness.

The mountain pass location of SNPA1 is representative of transport flow across the Cascade crest. Due to its location at a ridge crest, SNPA1 is probably above trapping inversions that may develop at valley bottom locations west and east of the Cascade crest.

### 4.2.4 Mount Rainier Interagency Monitoring of Protected Visual Environments Site: MORA1

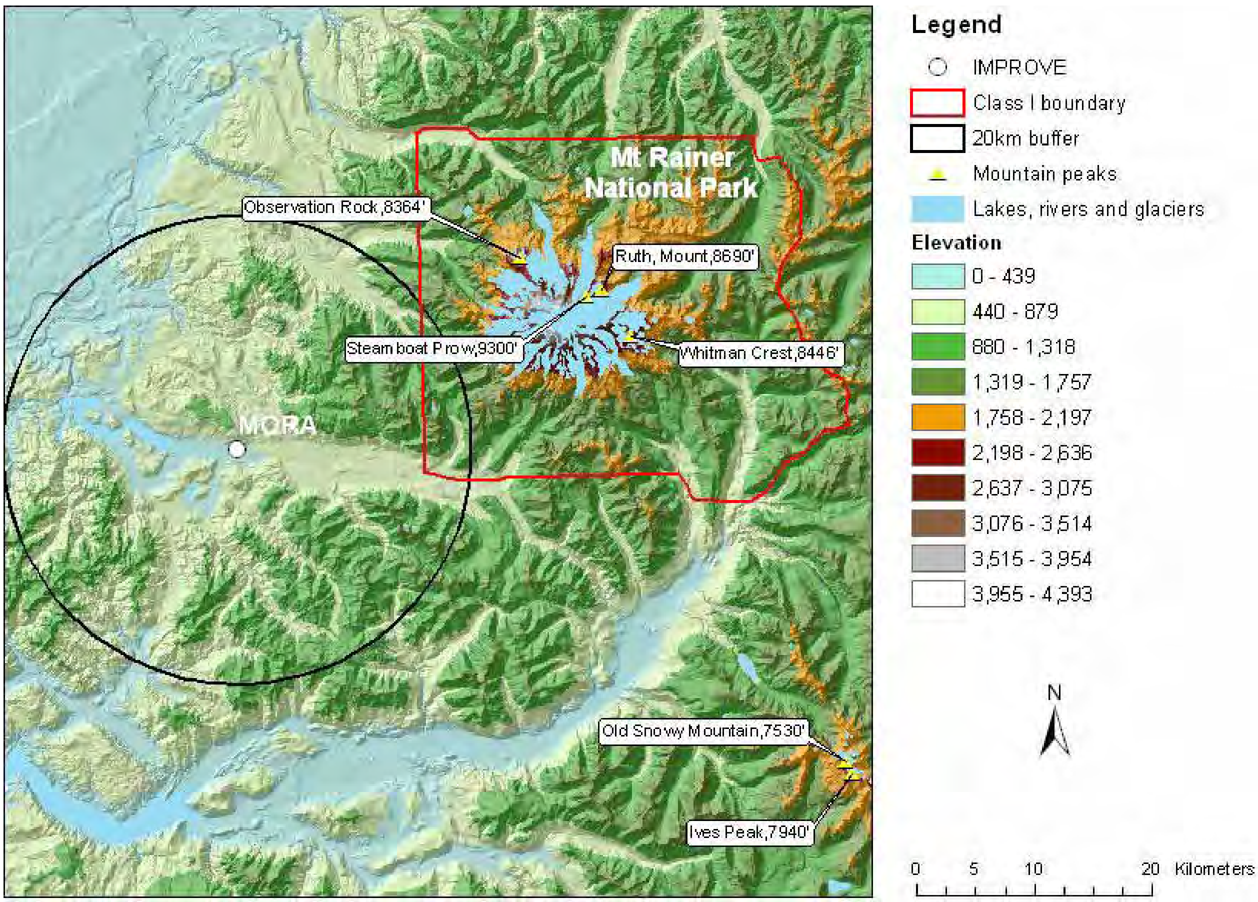



**Figure 4-5 Location of MORA1 Interagency Monitoring of Protected Visual Environments Site**
Source: Causes of Haze Assessment Descriptive Maps

The IMPROVE site representing Mount Rainier National Park, MORA1, is situated southeast of the Park at the Park headquarters at Tahoma Woods. MORA1 is located within the Nisqually River Valley at an elevation of 439 m (1,440 feet). The monitor is some 30 km (18.5 mi) west-southwest from the summit of Mount Rainer as shown above. See Figure 4-5.

The orientation of the drainage is east to west, with an elevation drop of about 60 ft/mile. Where the Nisqually River empties into Alder Lake reservoir (5 km or 3 miles) west of the site the river elevation is 367 m (1,204 feet).

The valley bottom at the monitoring site is about 1.5 km (0.9 mi) wide. The monitoring site is at the northern edge of the valley bottom. Elevations rise to 450 m (1,475 feet) at a distance of 2 km (1.25 mi) north and 3 km (1.9 mi) south from the monitoring site. Regional ground cover is predominantly fir and pine forest. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

The valley where the IMPROVE site is located may be subject to inversion and trapping of pollutants during periods of high pressure and stagnation. In those cases, the monitoring site, located at the bottom of the valley, would be contained within the trapped stable layer and would only be representative of the lower portions of the Park.

Generally, wind directions at MORA1 are channeled to an east/west direction with characteristic mountain/valley circulations of easterly nighttime drainage flow and westerly daytime upslope flow in the valley.

### 4.2.5 White Pass Interagency Monitoring of Protected Visual Environments Site: WHPA1

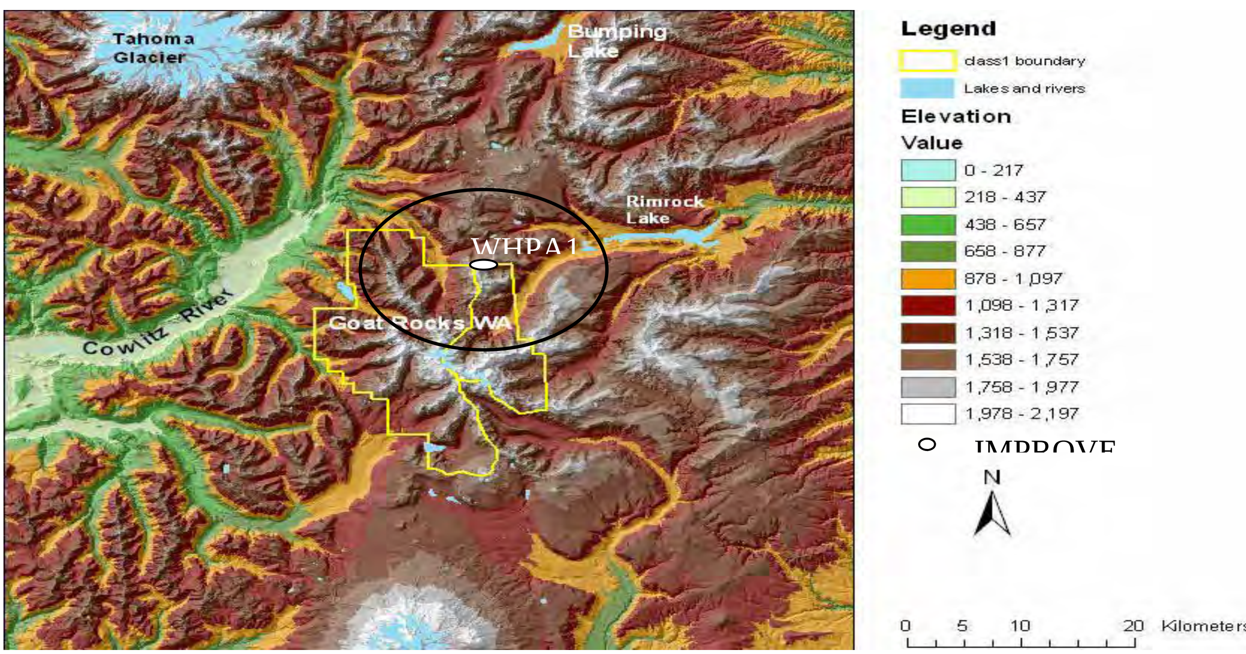



**Figure 4-6 Location of WHPA1 Interagency Monitoring of Protected Visual Environments Site**
Source: Causes of Haze Assessment Descriptive Maps

The IMPROVE site representing Goat Rocks and Mount Adams Wilderness Areas, WHPA1, is located on the crest of the Cascade Range at the northern Goat Rocks Wilderness boundary at White Pass Ski Resort near White Pass Washington. The monitoring site elevation is 1,830 m (6,002 feet). See Figure 4-6. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

WHPA1 is at a ridge crest location well-exposed to upper airflows and to aerosols transported aloft from upwind sources. WHPA1 should be very representative of aerosol concentration and composition at similarly exposed locations in the Goat Rocks and Mount Adams Wilderness Areas. Its elevation and exposure should also make it representative of regional characteristics and transport from distant source regions at pressure heights near 850 mb that are relatively unperturbed by terrain effects.

## 4.2.6 Pasayten Interagency Monitoring of Protected Visual Environments Site: PASA1

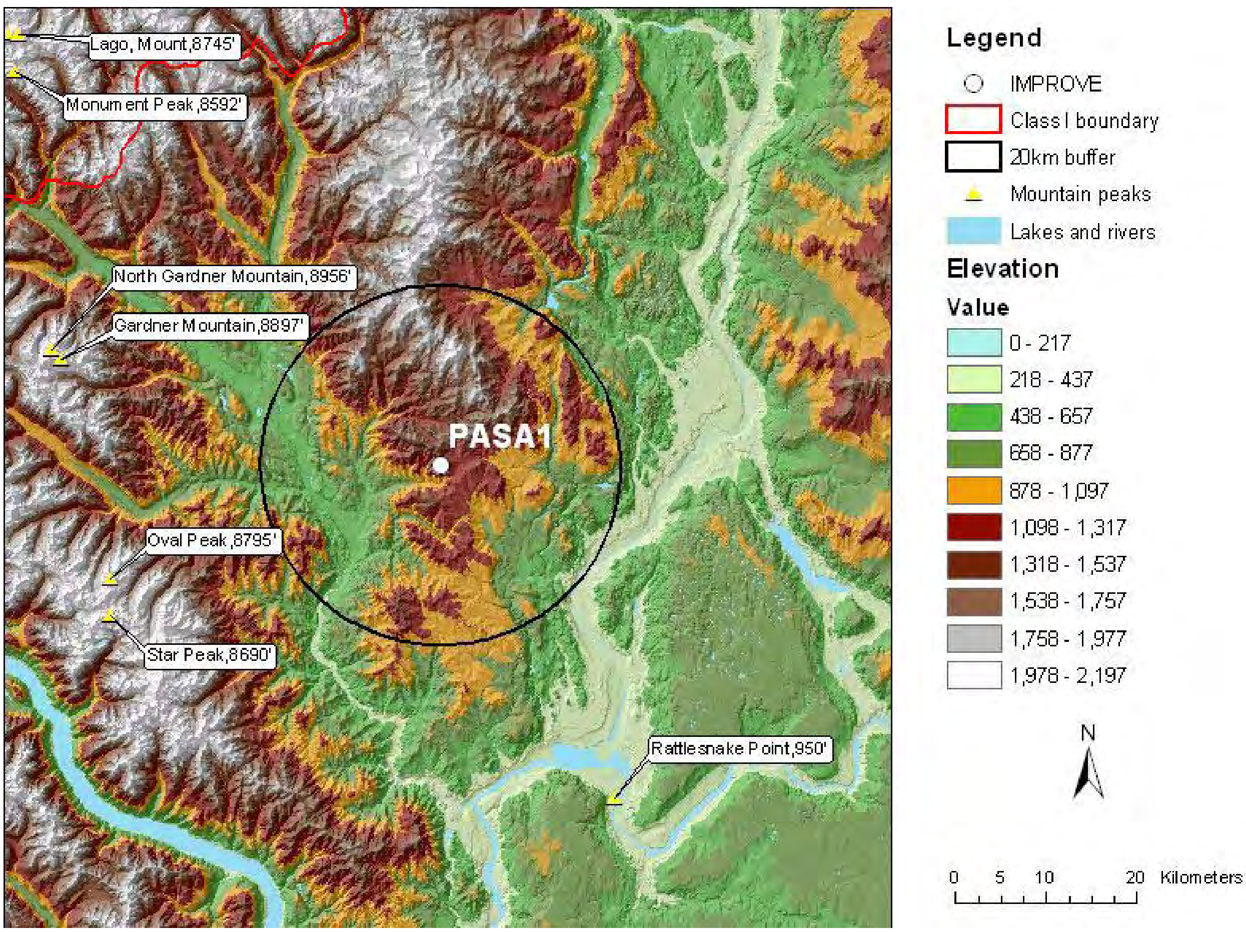



**Figure 4-7 Location of PASA1 Interagency Monitoring of Protected Visual Environments Site**
**Source: Causes of Haze Assessment Descriptive Maps**

The IMPROVE site representing Pasayten Wilderness, PASA1, is situated near the crest of Little Buck Mountain, 50 km (30 mi) south and east of the Wilderness boundary. PASA1 is located at an exposed elevation of 1,634 m (5,360 ft). See Figure 4-7. Additional information on nearby populations, industrial centers, and wind patterns can be found in Appendix C.

**Representativeness**

The PASA1 IMPROVE site is at a well-exposed ridge top location and should be very representative of regional conditions including high elevation locations in the Pasayten Wilderness. It is also representative of upper level (850 mb) aerosol characteristics of the central Columbia Plateau and Basin.

The North Cascades National Park IMPROVE site, NOCA1, may be better representative of low elevations of the Pasayten Wilderness east of the Cascade crest.

# Chapter 5 Baseline and Natural Conditions in Washington's Mandatory Class I Areas

This chapter covers the baseline and natural visibility conditions for each of Washington's 8 mandatory Class I Areas including the Uniform Rate of Progress (URP). The URP is the calculation of the uniform slope, or glide path, of the line between baseline visibility conditions and natural conditions over the 60-year period. The technical basis for this information was produced and compiled by the Western Regional Air Partnership (WRAP) for consistency in planning among western states.

Table 5-1 is shows a summary of the baseline conditions, natural conditions, the difference in these two conditions, and what the 2018 target would be for a URP for each of Washington's mandatory Class I Areas. More detailed information on light extinction and Deciviews (dv) for the Most Impaired and Least Impaired Days is found in Appendix E.

**Table 5-1 Summary of Baseline Conditions, Natural Conditions, and Difference**

| Washington's Mandatory Class I Areas | Most Impaired Days | | | | Least Impaired Days | | |
|---|---|---|---|---|---|---|---|
| | 2000-04 Baseline [deciviews] | 2064 Natural Conditions [deciviews] | Difference [deciviews] | 2018 Target Value for a Uniform Rate of Progress [deciview] | 2000-04 Baseline [deciview] | 2064 Natural Conditions [deciview] | Difference [deciviews] |
| Olympic National Park | **16.74** | **8.44** | **8.30** | **14.81** | **6.02** | **2.7** | **3.32** |
| North Cascades National Park and Glacier Peak Wilderness | **16.01** | **8.39** | **7.62** | **14.23** | **3.37** | **1.93** | **1.44** |
| Alpine Lakes Wilderness | **17.84** | **8.43** | **9.41** | **15.64** | **5.5** | **2.33** | **3.17** |
| Mount Rainier National Park | **18.24** | **8.54** | **9.70** | **15.98** | **5.47** | **2.56** | **3.91** |
| Goat Rocks Wilderness and Mount Adams Wilderness | **12.76** | **8.35** | **4.41** | **11.73** | **1.66** | **0.82** | **0.84** |
| Pasayten Wilderness | **15.23** | **8.25** | **6.98** | **13.6** | **2.73** | **1.16** | **1.57** |

## 5.1 Olympic National Park

Baseline visibility is determined from the from the OLYM1 monitoring site for the Most Impaired and Least Impaired Days for the years 2002 through 2004 as specified in the Regional Haze Rule (RHR)[1]. The baseline visibility for the Olympic National Park is calculated at 6.02 dv for the Least Impaired Days and 16.74 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experienced in the absence of human-caused impairment. Based on Environmental Protection Agency (EPA) guidance, the natural visibility for Olympic National Park is 2.7 dv for the Least Impaired Days and 8.44 dv for the Most Impaired Days. See Table 5-1 and Figure 5-1.

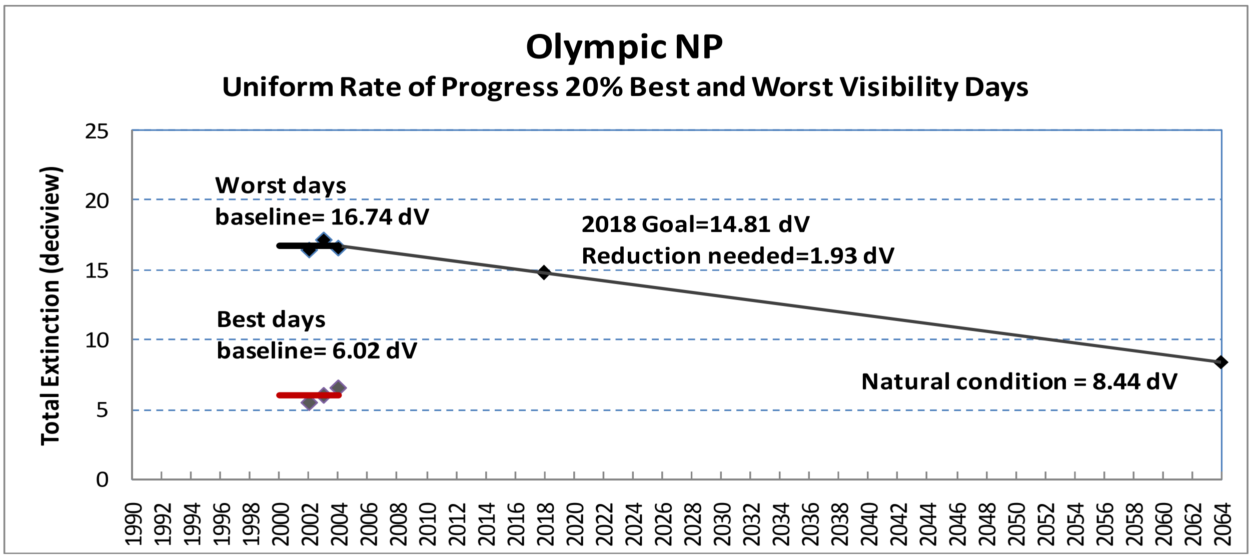



**Figure 5-1 Uniform Rate of Progress for Olympic National Park**

Figures 5-2 and 5-3 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the OLYM1 Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor site for the Most Impaired and Least Impaired Days, respectively. Overall, the year to year variability of annual Most Impaired and Least Impaired Days light extinction is very small (nearly 3 and 2 Megameter ($Mm^{-1}$), respectively). On average, sulfates are the predominant cause (39%) of haze on Most Impaired Days at this site, followed by Organic Compound (OC) (28%) and nitrates (19%). Elemental Carbon (EC), coarse mass and sea salt are much less significant and nearly equal contributors to visibility impairment on the Most Impaired Days for the baseline period. Compared to the Most Impaired Days, on the Least Impaired Days the proportional share attributable to sulfates, nitrates, and OC is nearly equal.

[1] 40 CFR §51.308(d)(2)(i)

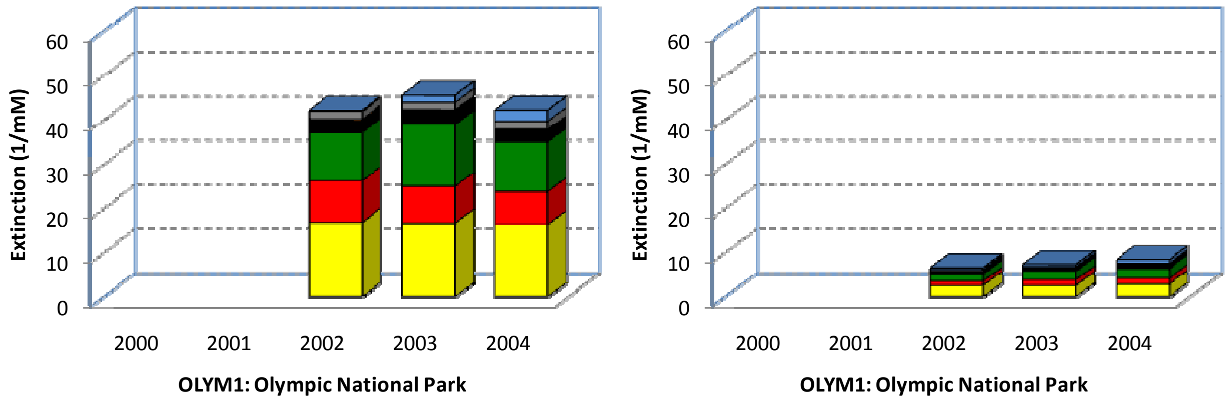



**Figure 5-2 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Olympic National Park**

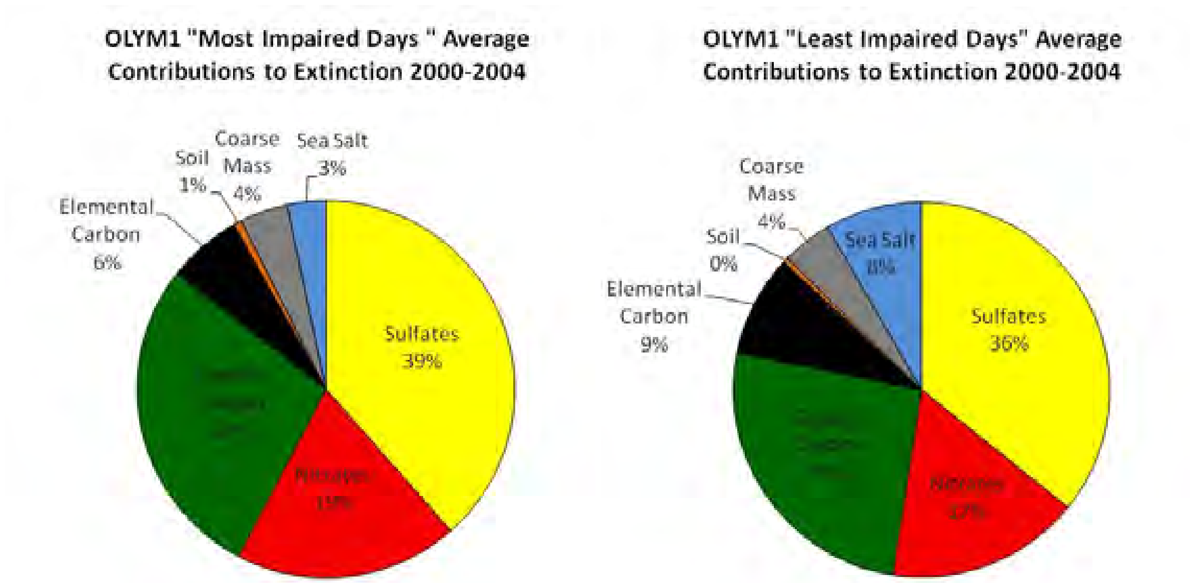



**Figure 5-3 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Olympic National Park**

Figure 5-4 illustrates monitoring data for all IMPROVE sampled days during the base years (2001-2004). These data are reinterpreted in Figures x through z for major haze species. A clear seasonal variation is observed for sulfates, with increases in summer months. OC and nitrates remain stable for much of the year with year-to-year variability in the late summer or fall throughout the year at this site.

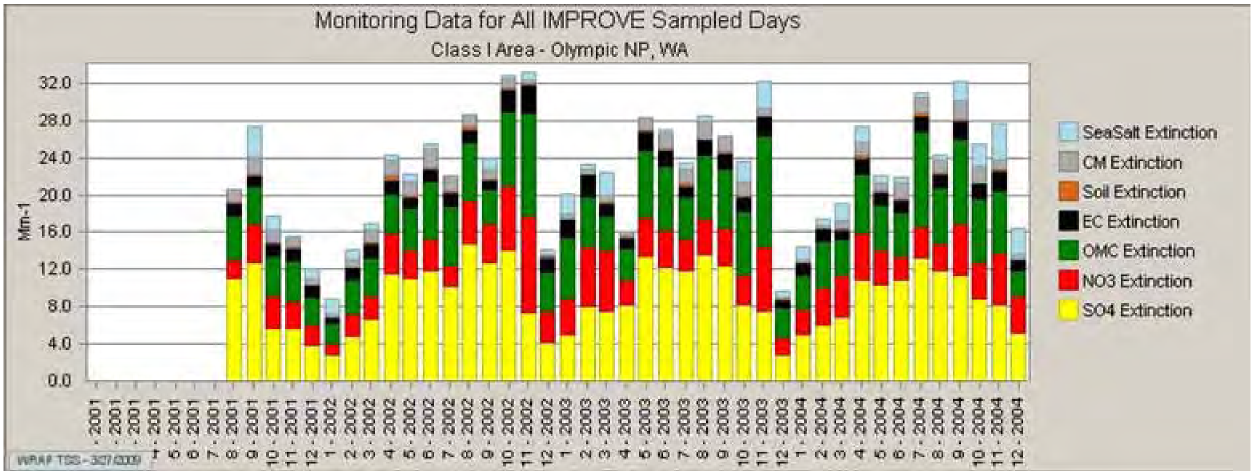



**Figure 5-4 Baseline Seasonal Variation in Haze Species at OLYM1 for 2001 through 2004**

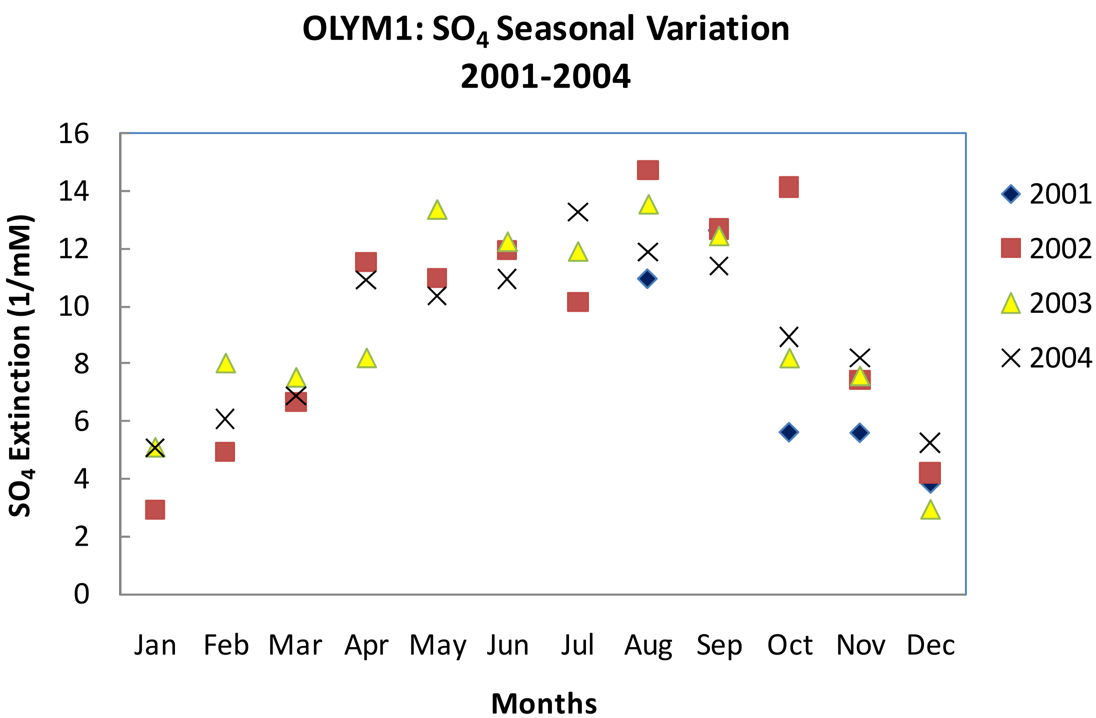



**Figure 5-5 Baseline Seasonal Variation by Month for $SO_4$ at OLYM1**

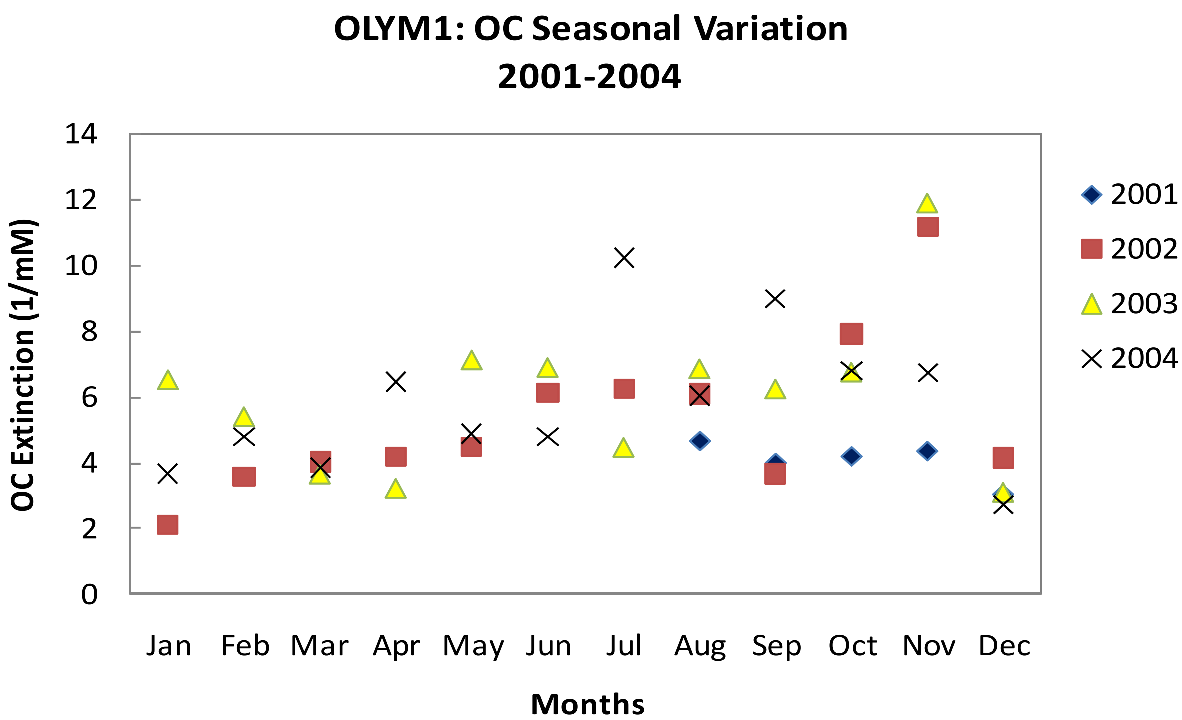



**Figure 5-6 Baseline Seasonal Variation by Month for OC at OLYM1**

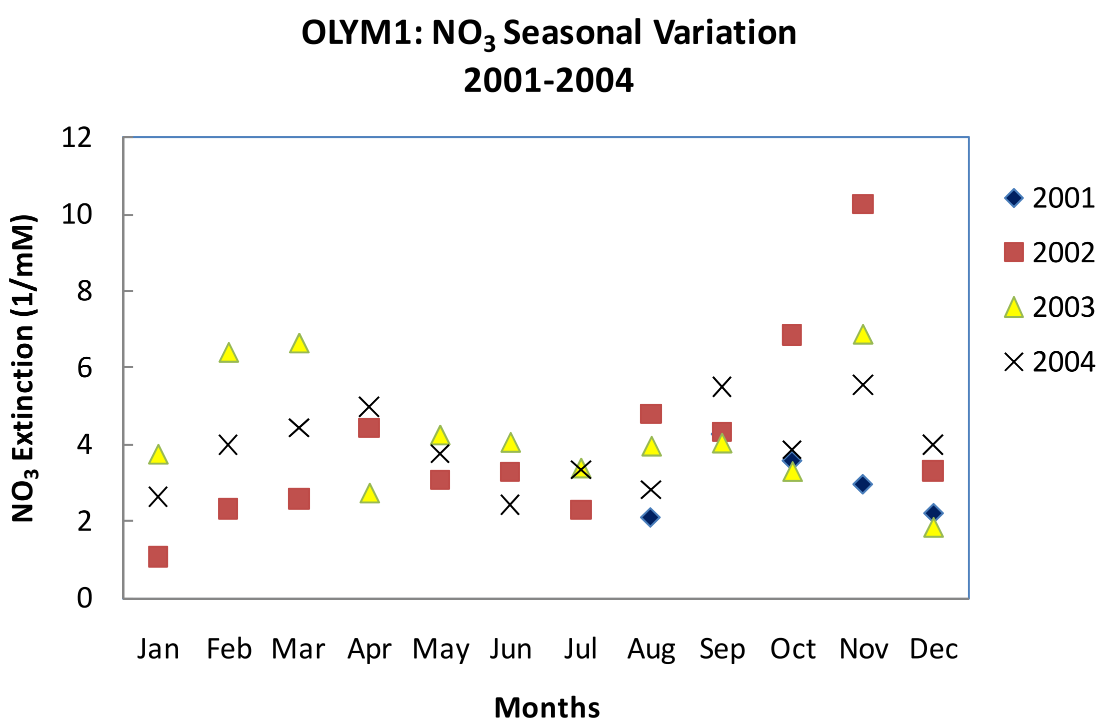



**Figure 5-7 Baseline Seasonal Variation by Month for $NO_3$ at OLYM1**

## 5.2 North Cascades National Park and Glacier Peak Wilderness

For the North Cascades National Park and Glacier Peak Wilderness, baseline visibility is determined from the NOCA1 monitoring site for the Most Impaired Days and Least Impaired Days. Data for years 2001 and 2002 met the data completeness requirements per the EPA document "Guidance for Tracking Progress under the RHR." Routine data substitutions per this guidance document were made for years 2003 and 2004. After these routine data substitutions were made, the NOCA1 site still failed to meet data completeness requirements for the baseline period. One reason was due to the site being inaccessible from mid-November 2003 to March 2004 due to snow.

WRAP performed additional data substitutions for years 2003 and 2004 to address the data completeness problems for this site. The SNPA1 IMPROVE site was used to complete the data substitution for years 2003 and 2004. The WRAP methods used were similar to methods used at IMPROVE sites with incomplete data records in other Regional Planning Organizations (RPOs). See Appendix D for additional information on the WRAP data substitutions for the NOCA1 site.

Using the now complete data set for 2001-2004, the baseline visibility for the North Cascades National Park and Glacier Peak Wilderness is calculated at 3.37 dv for the Least Impaired Days and 16.01 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experienced in the absence of human-caused impairment. The natural visibility for North Cascades National Park and Glacier Peak Wilderness is 1.93 dv for the Least Impaired Days and 8.39 dv for the Most Impaired Days. See Table 5-1 and Figure 5-8.

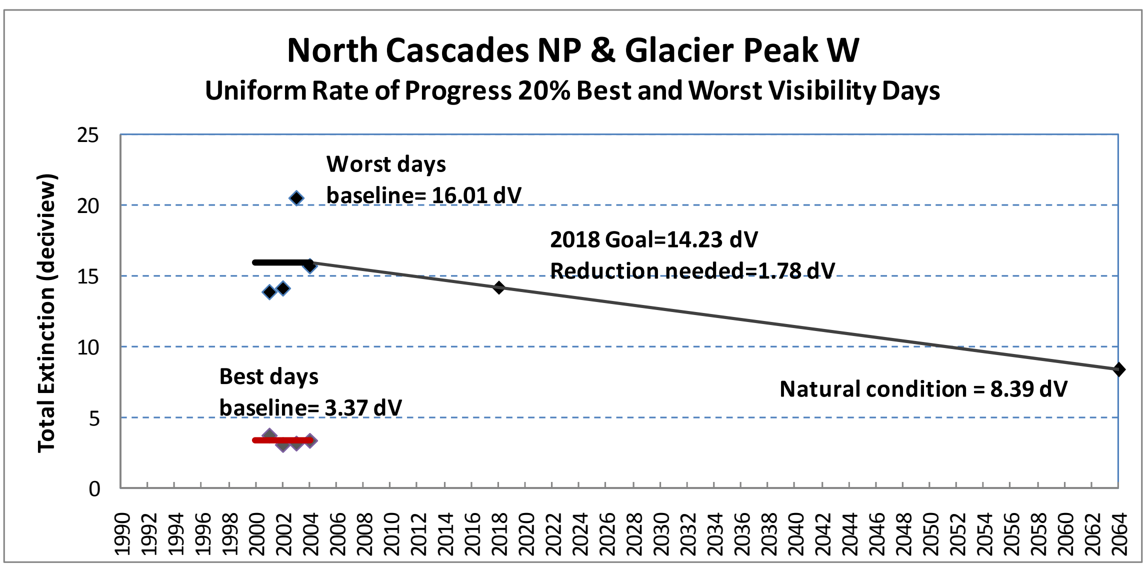



**Figure 5-8 Uniform Rate of Progress for North Cascades National Park and Glacier Peak Wilderness**

Figures 5-9 and 5-10 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the NOCA1 IMPROVE monitor site for the Most Impaired (left) and Least Impaired (right) Days, respectively. On average for the years 2001 to 2004, OC is the predominant cause (58%) of haze on the Most Impaired Days at this site. Sulfates (26%) produce the majority of the remaining visibility impairment. Compared to the Most Impaired Days, on the Least Impaired Days sulfates significantly increase their proportional share of the visibility impairment, the proportional share attributable to nitrates increases, OC significantly reduces its share, and EC stays about the same. The year to year variability of the average of the annual best days light extinction is very small. The principal chemical species that change between the annual average Most Impaired and Least Impaired Days are the OC, nitrates, and sulfates.

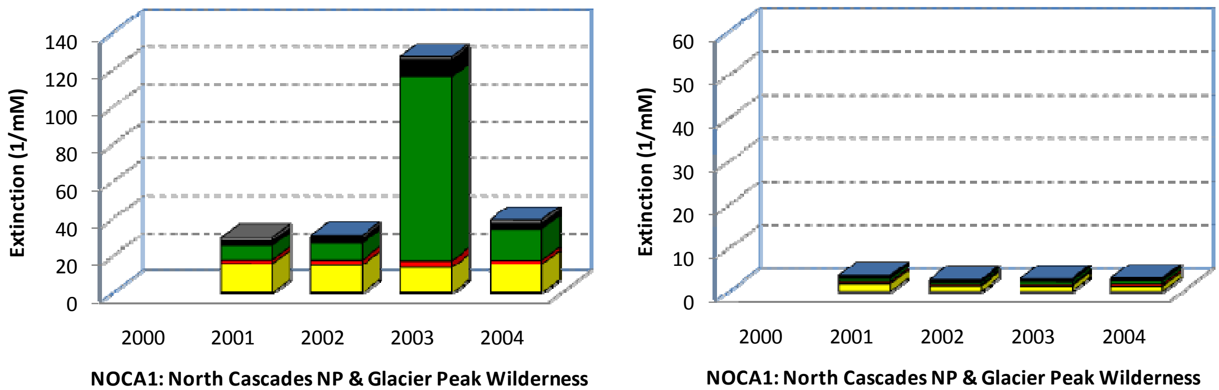



**Figure 5-9 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in North Cascades National Park and Glacier Peak Wilderness**

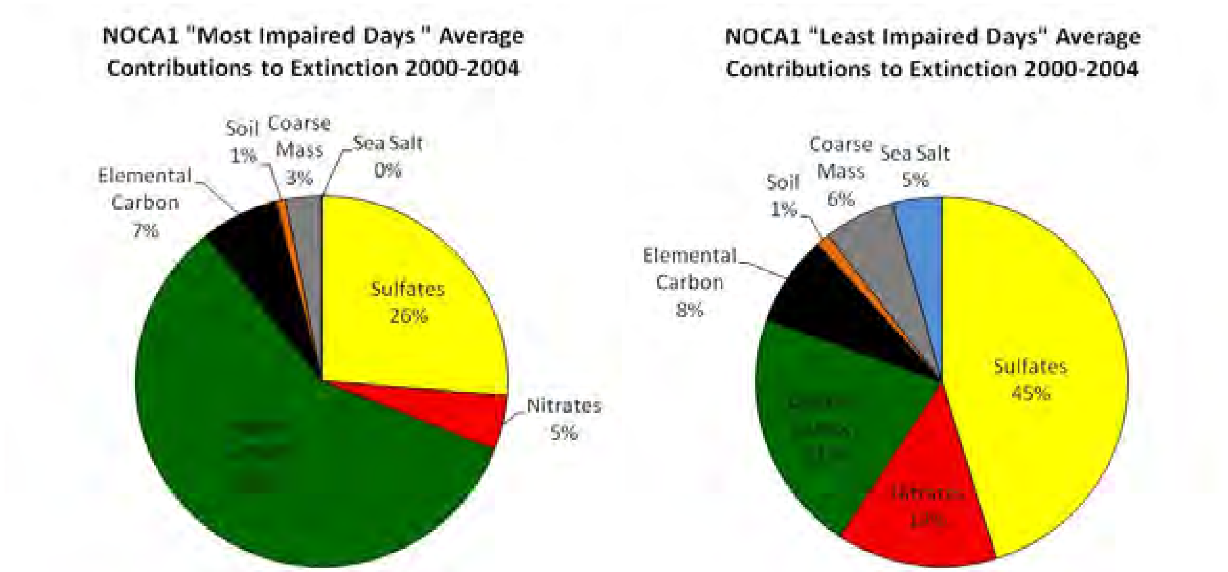



**Figure 5-10 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in North Cascades National Park and Glacier Peak Wilderness**

It is important to point that there is an abrupt emission increase for the Most Impaired Days in 2003, especially for organic and EC haze species. Figure 5-11 shows what the average contributions of haze species to light extinction on the Most Impaired Days would be at this site if the 2003 data were excluded. In this case, on average sulfates (46%) are the predominant cause of haze on the Most Impaired Days at this site. OC (34%) produces the majority of the remaining visibility impairment. The high levels of OC in September and October 2003 correspond with several large (over 1,000 acres) wildfires that occurred in or near the North Cascades Mountain Range. This will be discussed further in Chapter 8 when sources are discussed.

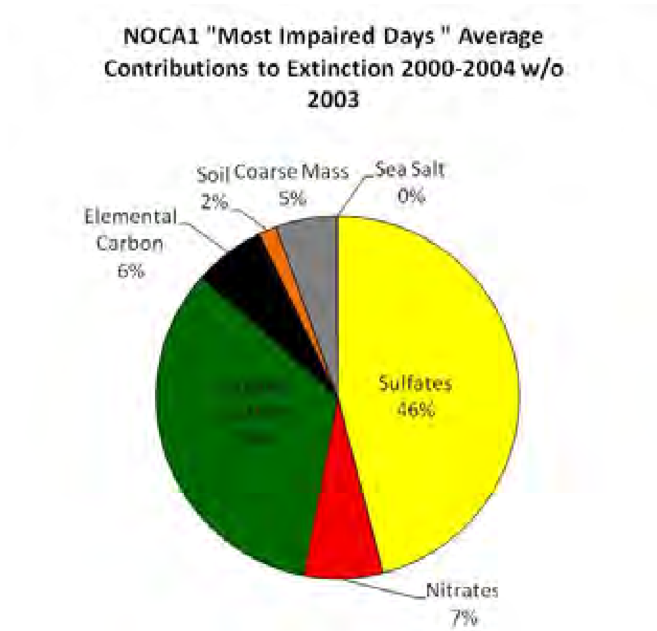



**Figure 5-11 Average Species Contributions to Most Impaired and Least Impaired Days in North Cascades National Park and Glacier Peak Wilderness excluding 2003 data**

Figure 5-12 illustrates monitoring data for all IMPROVE sampled days during the base years (2000-2004). These data are reinterpreted in Figures x through z for major haze species. A clear seasonal variation is observed for sulfates, OC, nitrates and EC. Sulfates and nitrates increase in summer months, and OCs and ECs increase in late summer and early fall. Some extreme values for EC and OC have been observed in September and October in 2003 due to natural fires. The highest nitrate levels of the baseline period were observed during the same months.

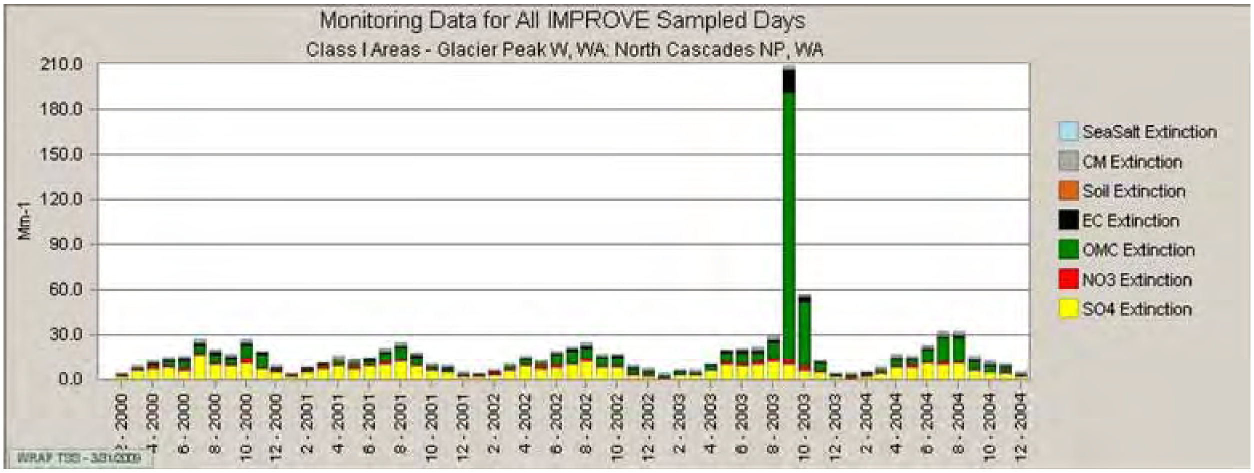



**Figure 5-12 Baseline Seasonal Variation in Haze Species at NOCA1 for 2000 through 2004**

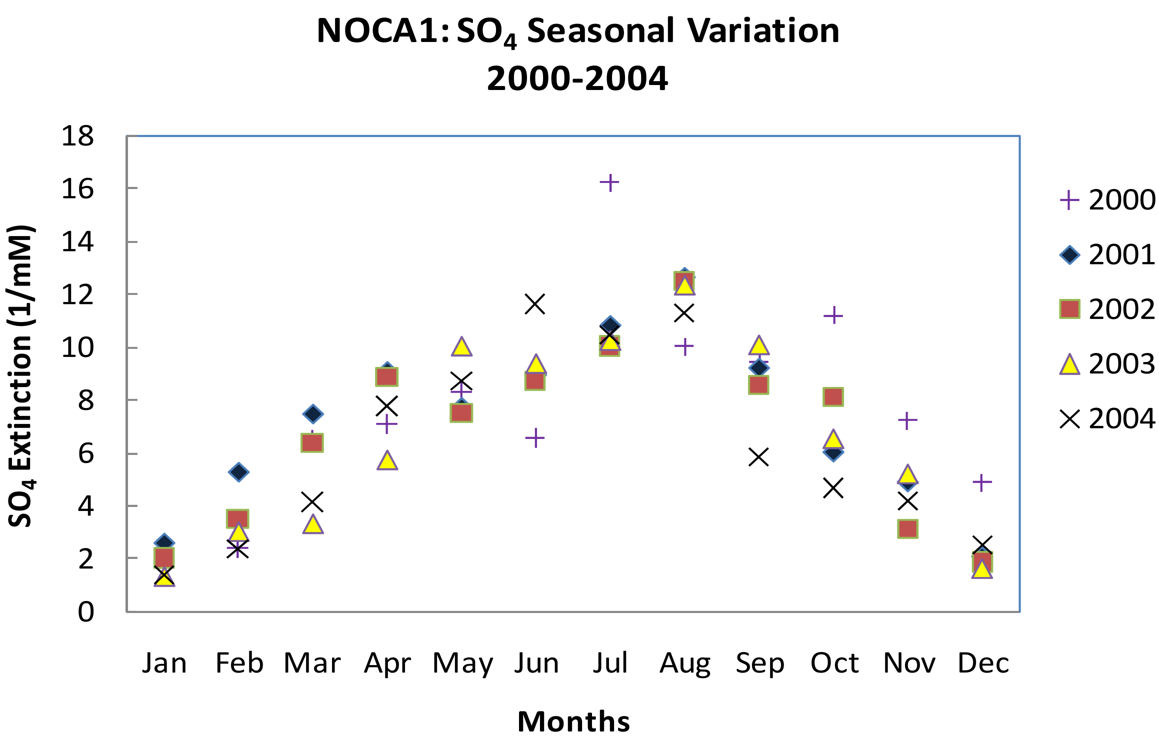



**Figure 5-13 Baseline Seasonal Variation by Month for $SO_4$ at NOCA1**

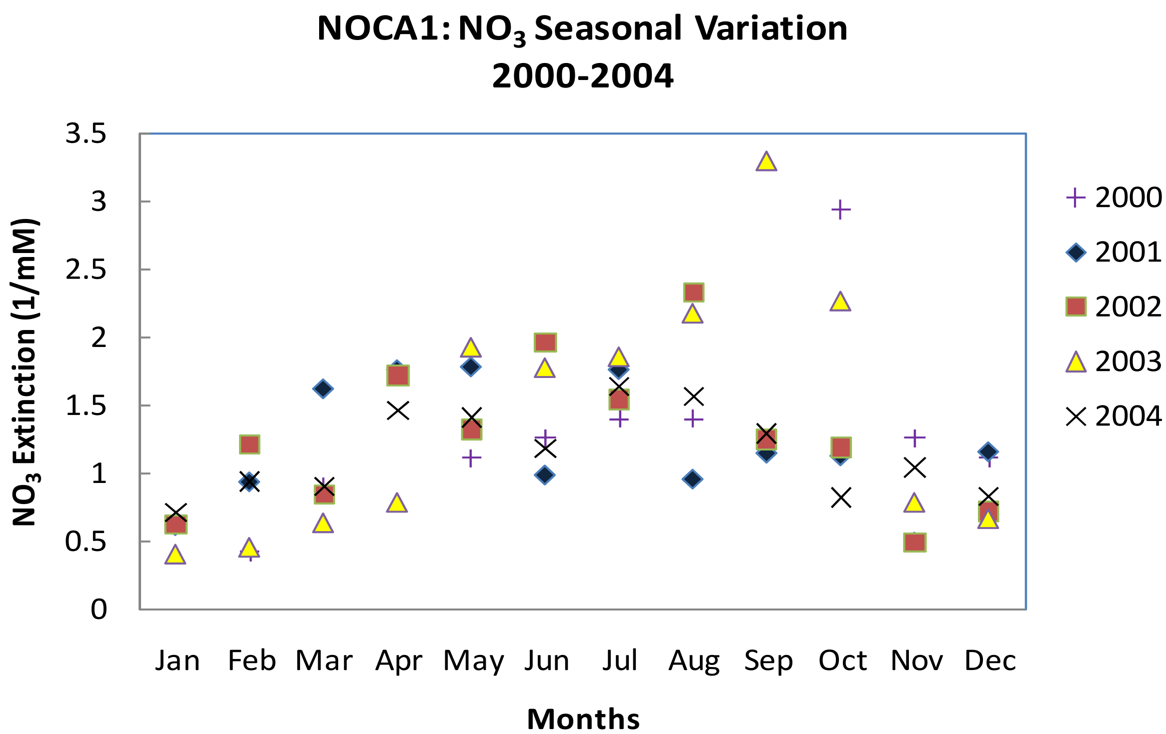



**Figure 5-14 Baseline Seasonal Variation by Month for $NO_3$ at NOCA1**

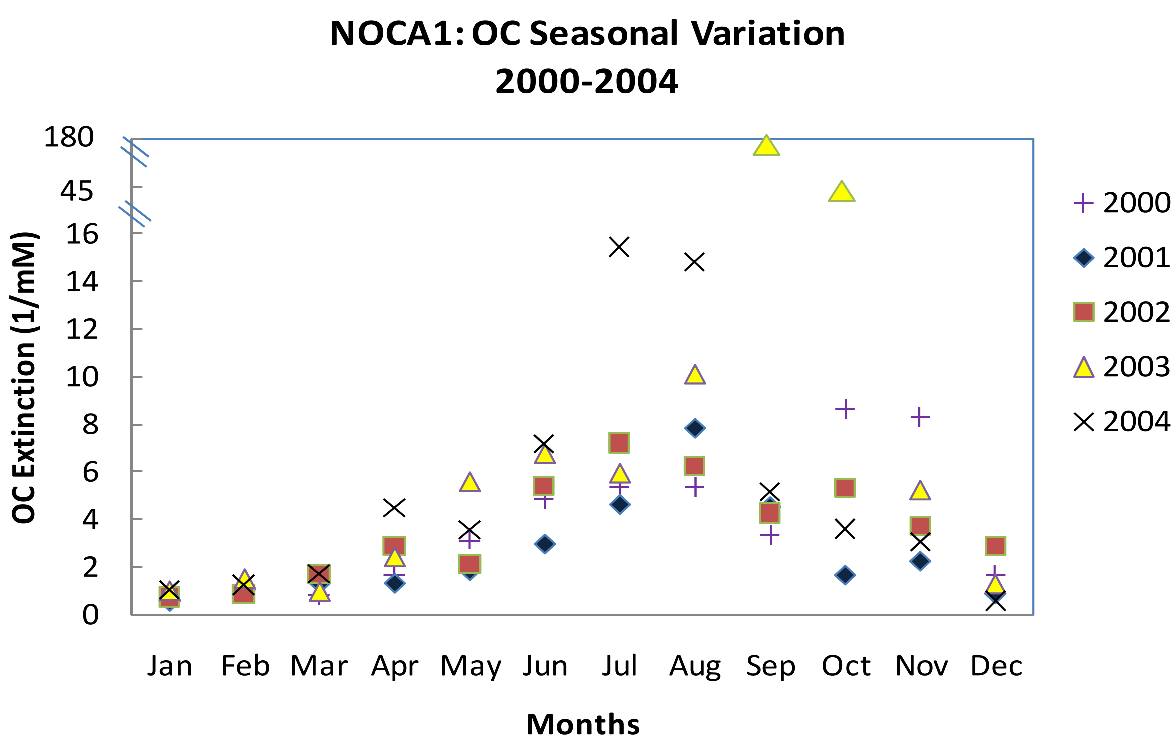



**Figure 5-15 Baseline Seasonal Variation by Month for OC at NOCA1**

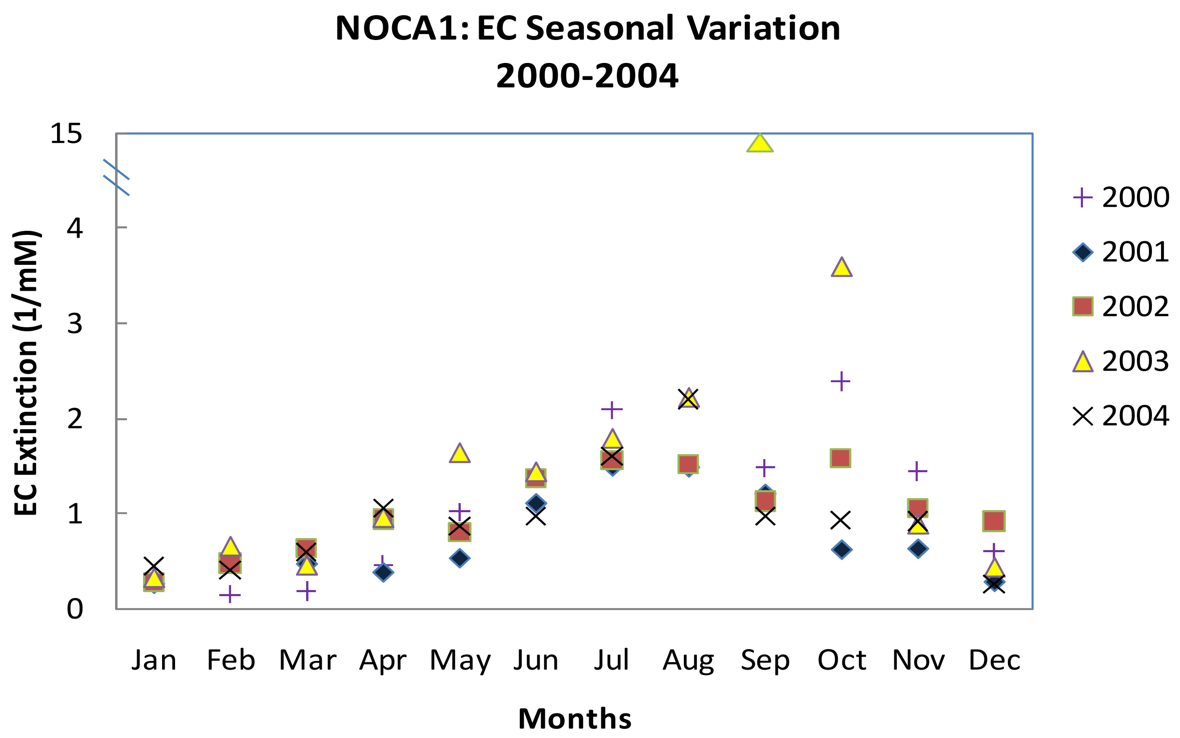



**Figure 5-16 Baseline Seasonal Variation by Month for EC at NOCA1**

## 5.3 Alpine Lakes Wilderness

Baseline visibility is determined from the SNPA1 monitoring site for the Most Impaired Days and Least Impaired Days for the years 2001 through 2004 as specified in the RHR under[2]. The baseline visibility for the Alpine Lakes Wilderness is calculated at 5.5 dv for the Least Impaired Days and 17.84 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experienced in the absence of human-caused impairment. Based on EPA guidance, the natural visibility for Alpine Lakes Wilderness is 2.33 dv for the Least Impaired Days and 8.43 dv for the Most Impaired Days. See Figure 5-17.

[2] 40 CFR §51.308(d)(2)(i)

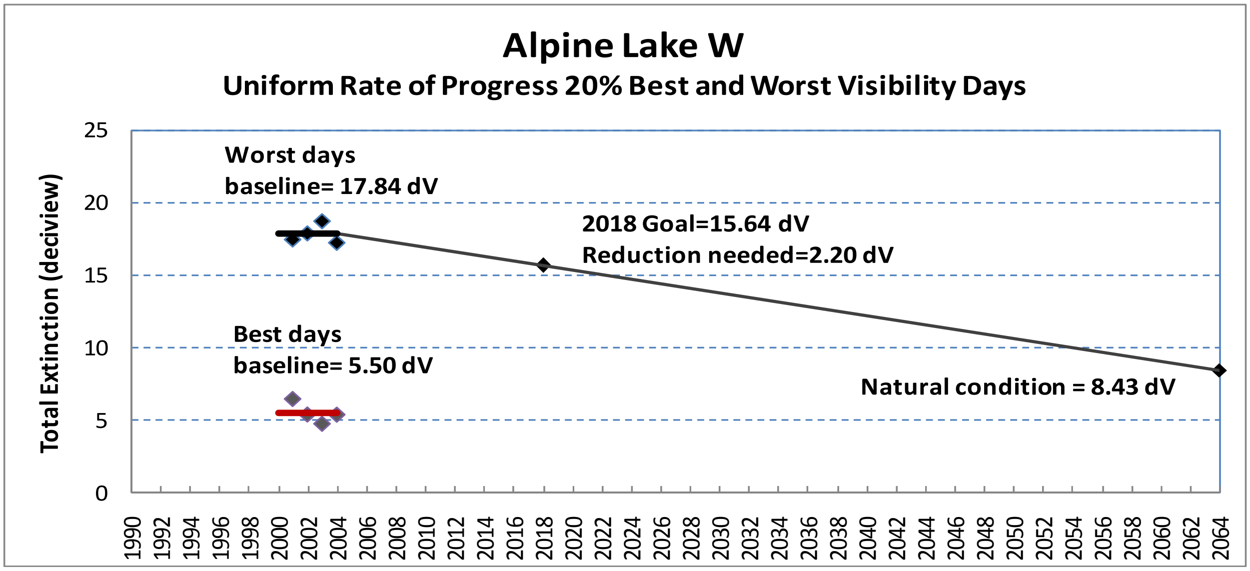



**Figure 5-17 Uniform Rate of Progress for Alpine Lakes Wilderness**

Figures 5-18 and 5-19 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the SNPA1 IMPROVE monitor site for the Most Impaired (left) and Least Impaired (right) Days, respectively. Overall, the year to year variability of the average of the annual Most Impaired and Least Impaired Days light extinction is small (nearly 10 and 3 $Mm^{-1}$, respectively). On average, sulfates (34%) and OC (30%) are the predominant cause of haze on the Most Impaired Days at this site. Nitrates (23%) produce the majority of the remaining visibility impairment. Compared to the Most Impaired Days, on the Least Impaired Days sulfates increase their proportional share of the visibility impairment, the proportional share attributable to nitrates remains about the same, OC reduces its share, and EC becomes relatively significant.

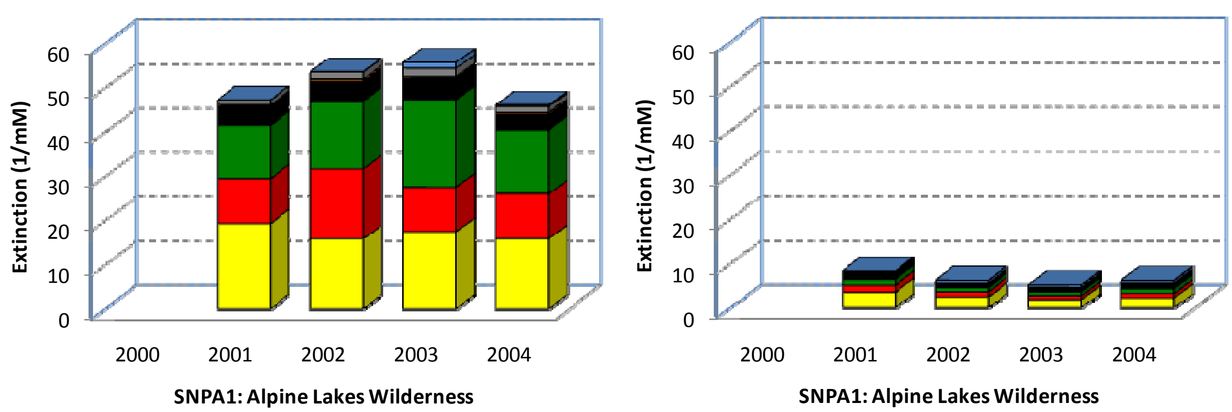



**Figure 5-18 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Alpine Lakes Wilderness**

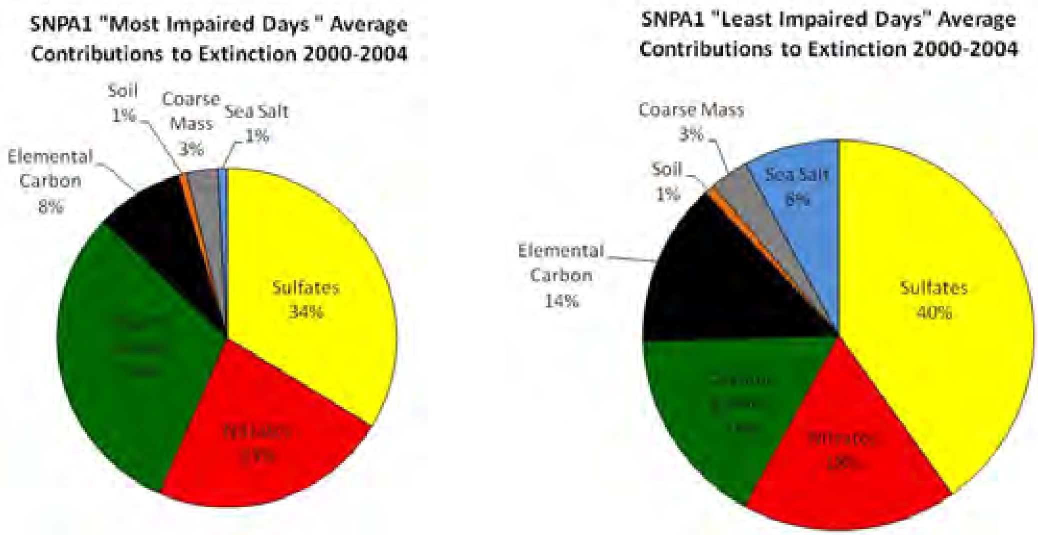



**Figure 5-19 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Alpine Lakes Wilderness**

Figure 5-20 illustrates monitoring data for all IMPROVE sampled days during the base years (2000-2004). These data are interpreted in Figures x through z for major haze species. A clear seasonal variation is observed for sulfates and OC, both of them increase during summer months. Nitrates remain relatively stable for much of the year with more year-to-year variability in the late fall and winter.

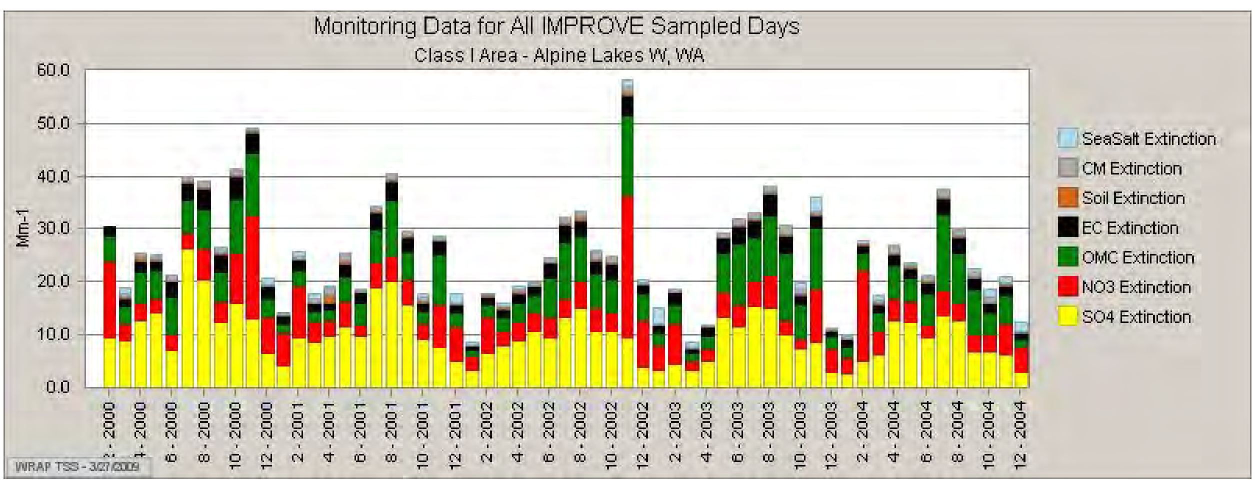



**Figure 5-20 Baseline Seasonal Variation in Haze Species at SNPA1 for 2000 through 2004**

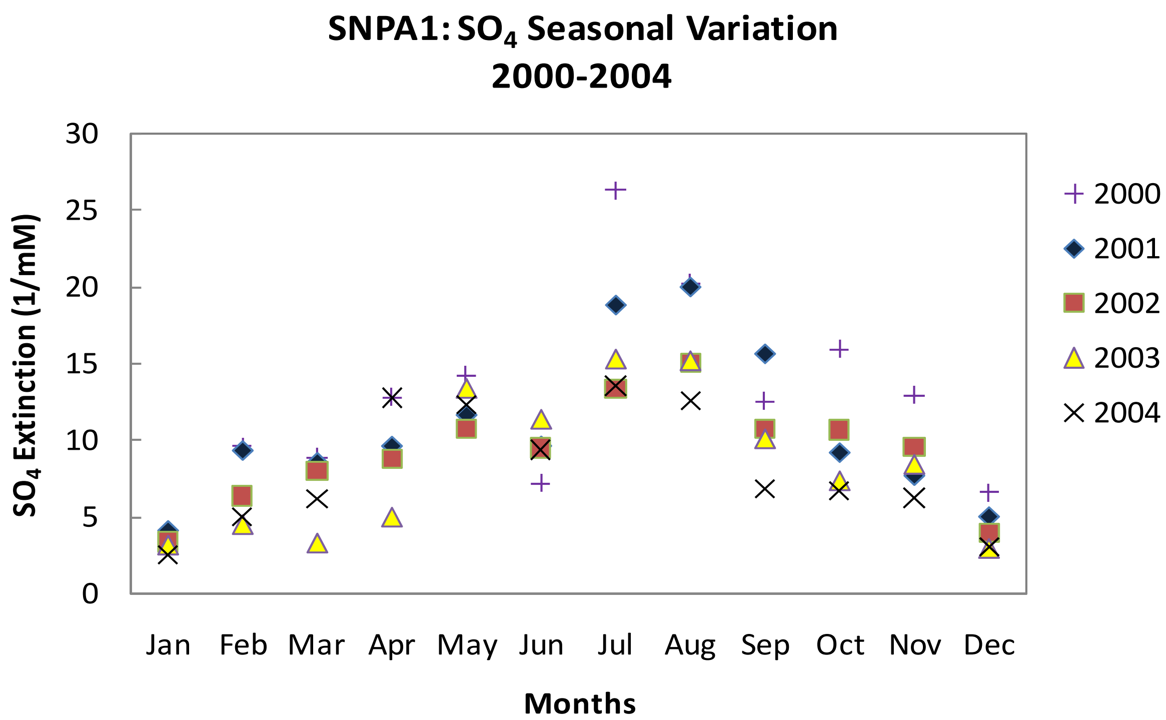



**Figure 5-21 Baseline Seasonal Variation by Month for $SO_4$ at SNPA1**

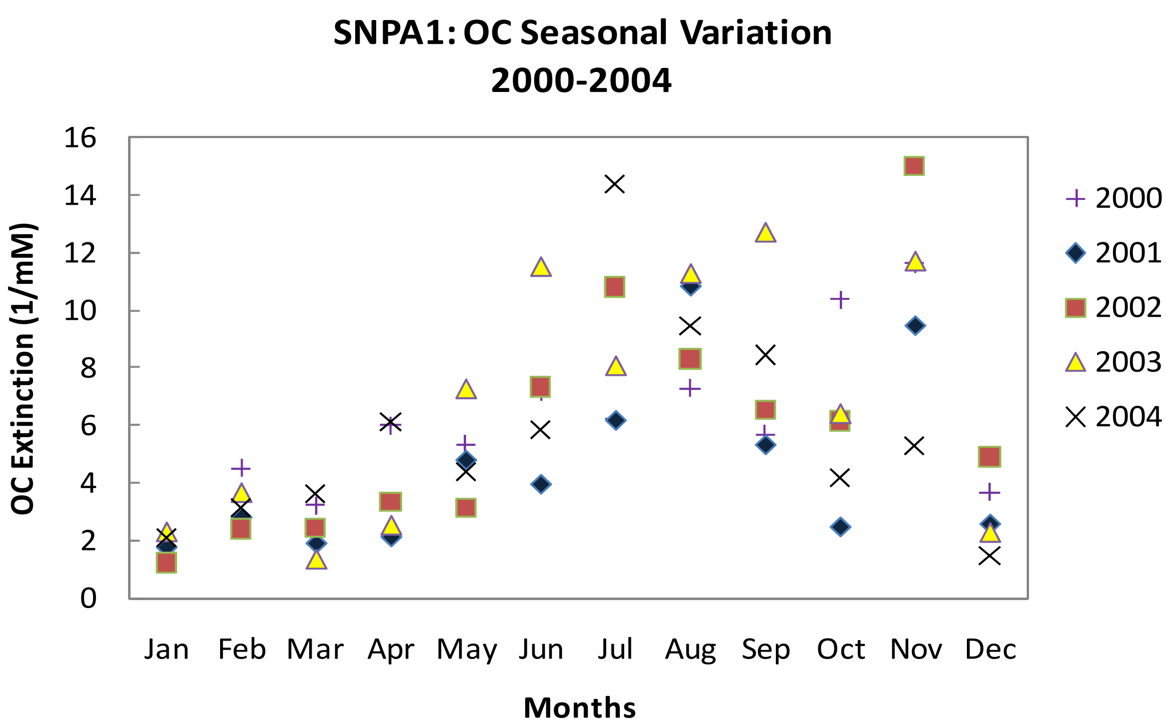



**Figure 5-22 Baseline Seasonal Variation by Month for OC at SNPA1**

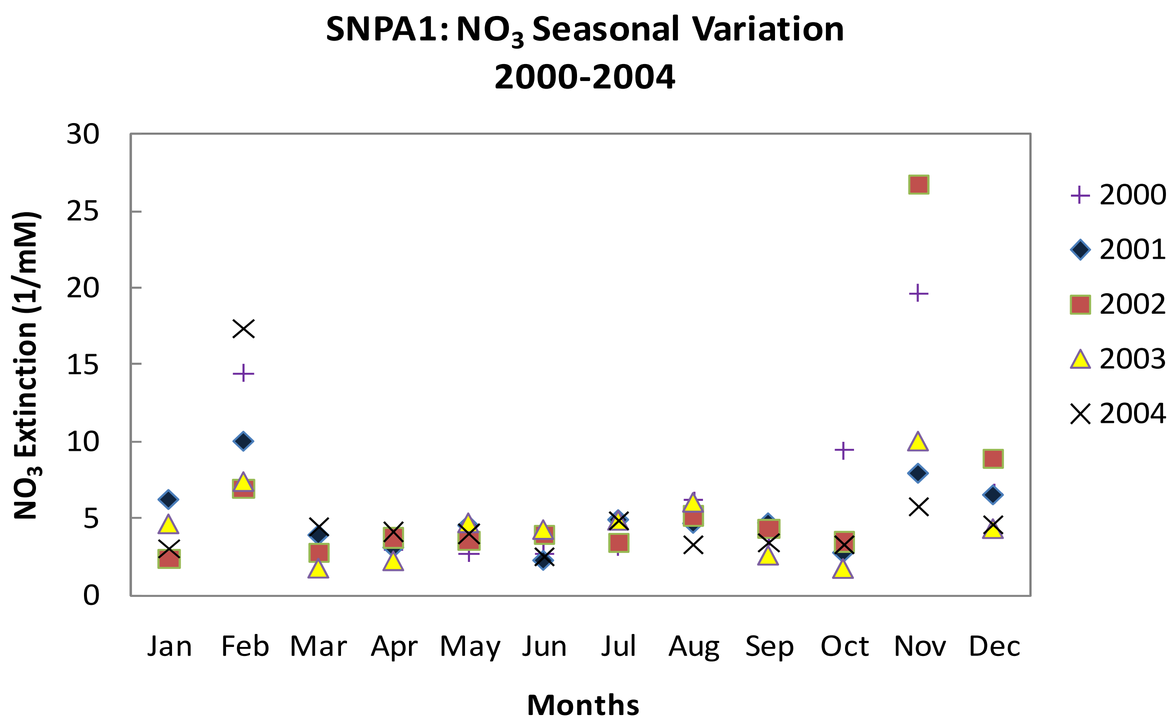



**Figure 5-23 Baseline Seasonal Variation by Month for $NO_3$ at SNPA1**

## 5.4 Mount Rainier National Park

Baseline visibility is determined from the MORA1 monitoring site for the Most Impaired and Least Impaired Days for the years 2000 through 2002 and year 2004 as specified in the RHR under[3]. The 2003 data from this site did not meet the data completeness requirements for the year and was not used to calculate baseline conditions. The baseline visibility for the Mount Rainier National Park is calculated at 5.47 dv for the Least Impaired Days and 18.24 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experienced in the absence of human-caused impairment. Based on EPA guidance, the natural visibility for Mount Rainier National Park is 2.56 dv for the Least Impaired Days and 8.54 dv for the Most Impaired Days. See Table 5-1 and Figure 5-24.

[3] 40 CFR §51.308(d)(2)(i)

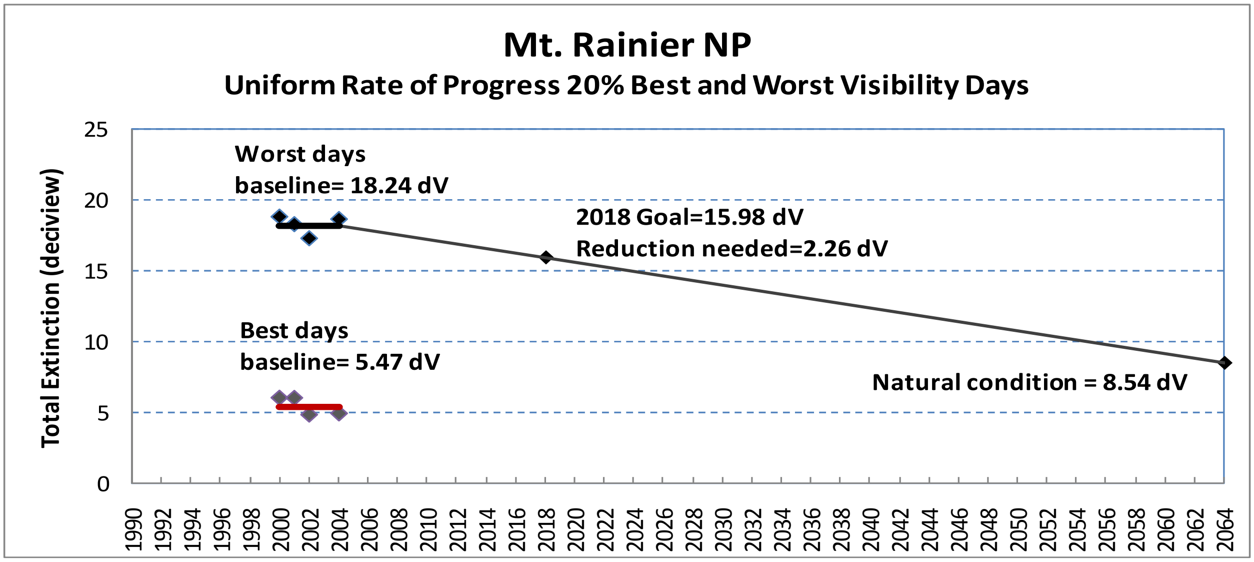



**Figure 5-24 Uniform Rate of Progress for Mount Rainier National Park**

Figures 5-25 and 5-26 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the MORA1 IMPROVE monitor site for the Most Impaired (left) and Least Impaired (right) Days, respectively. Overall, the variability of annual Most Impaired and Least Impaired Days light extinction is small (about 9 and 2 $Mm^{-1}$, respectively). On average, sulfates (46%) and OC (29%) are the predominant causes of haze on the Most Impaired Days at this site. Nitrates (10%) and EC (10%) are much less significant. Compared to the Most Impaired Days, on the Least Impaired Days sulfates decrease their proportional share to 40% and OC reduces to 23%. The proportional contribution of both nitrates and EC stays the same.

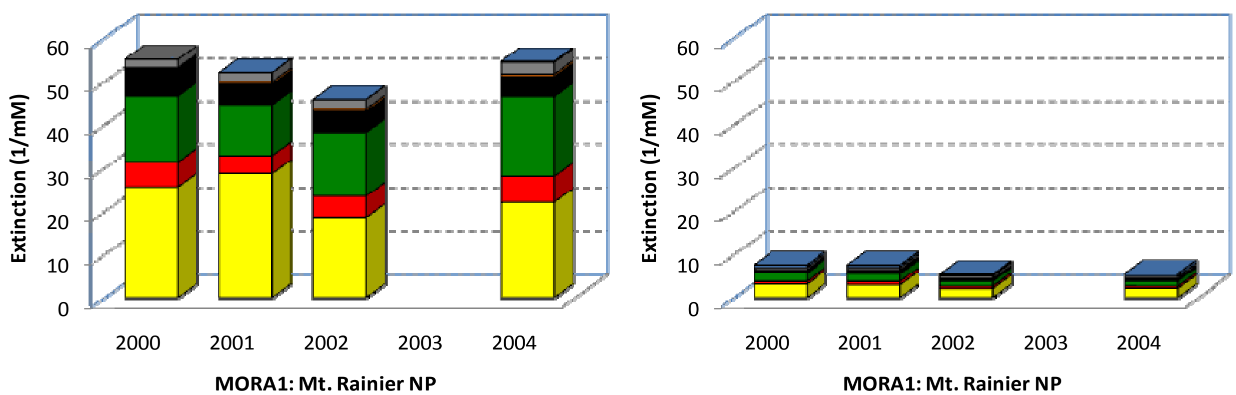



**Figure 5-25 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Mount Rainier National Park**

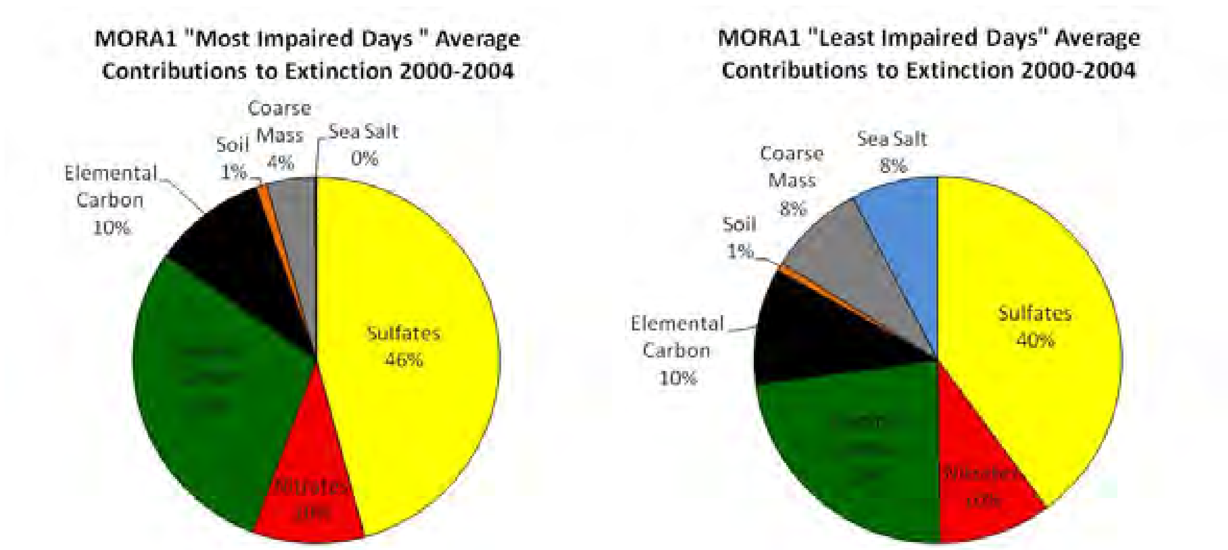



**Figure 5-26 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Mount Rainier National Park**

Figure 5-27 illustrates monitoring data for all IMPROVE sampled days during the base years (2000-2004). These data are reinterpreted in Figures x through z for major individual haze species. A clear seasonal variation is observed for sulfates, organic aerosols, EC and nitrates. Sulfates, OCs and EC increase in summer months, and nitrates decrease in winter months.

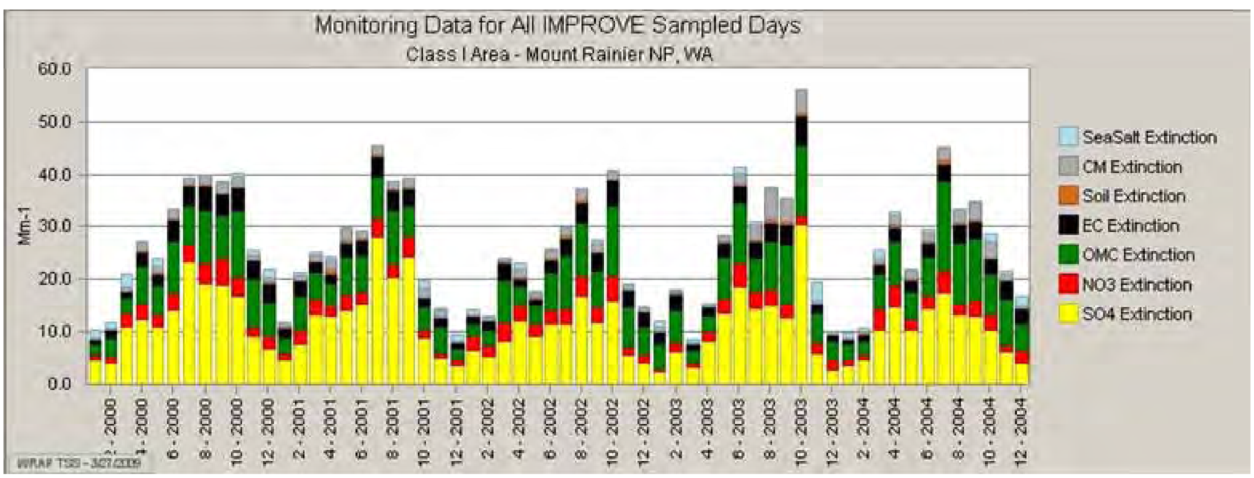



**Figure 5-27 Baseline Seasonal Variation in Haze Species at MORA1 for 2000 through 2004**

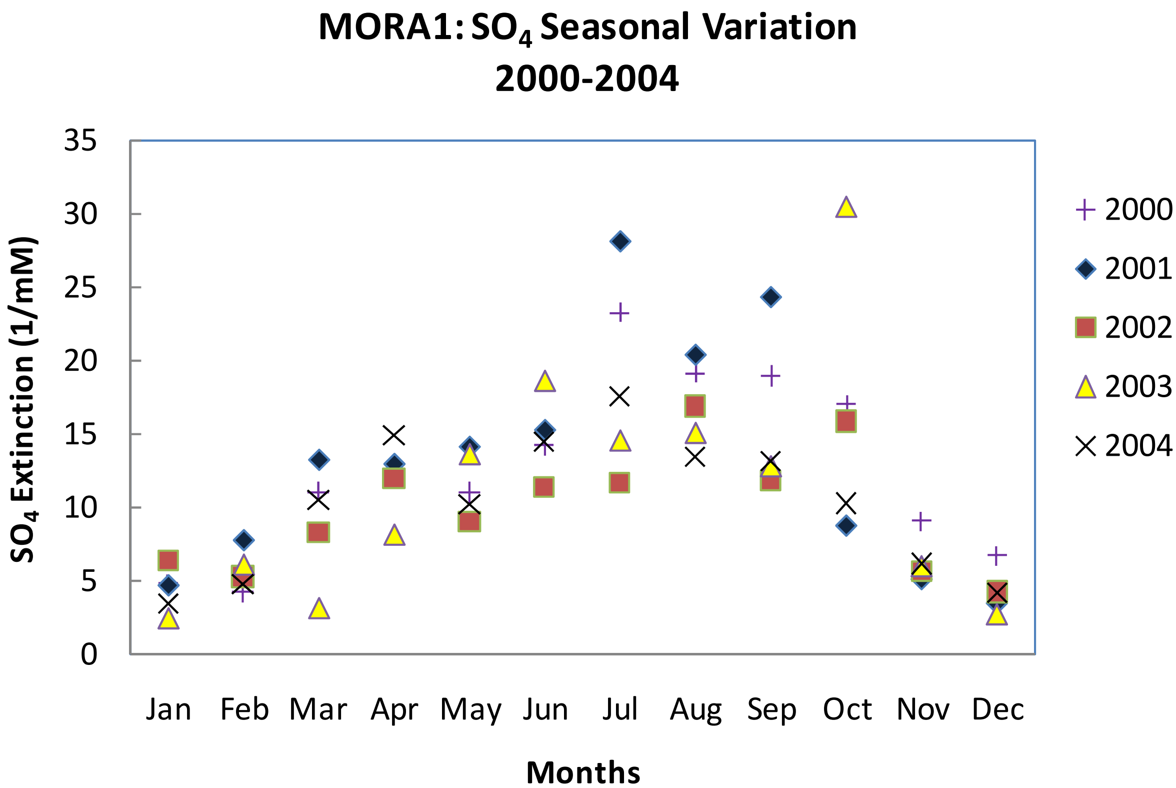



**Figure 5-28 Baseline Seasonal Variation by Month for $SO_4$ at MORA1**

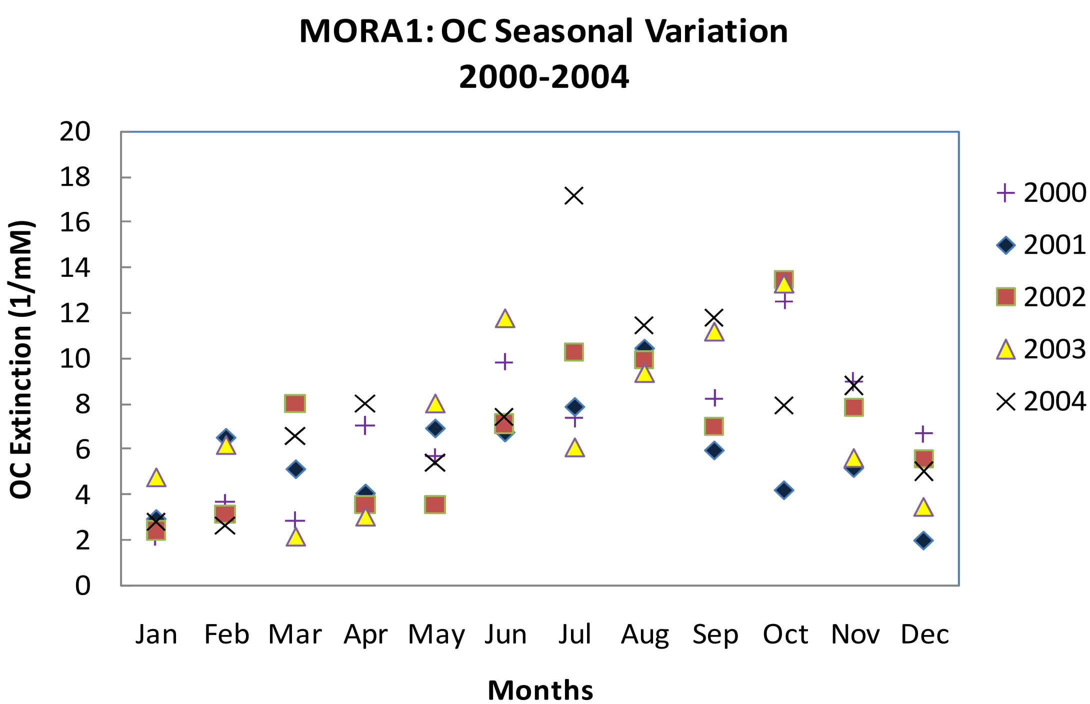



**Figure 5-29 Baseline Seasonal Variation by Month for OC at MORA1**

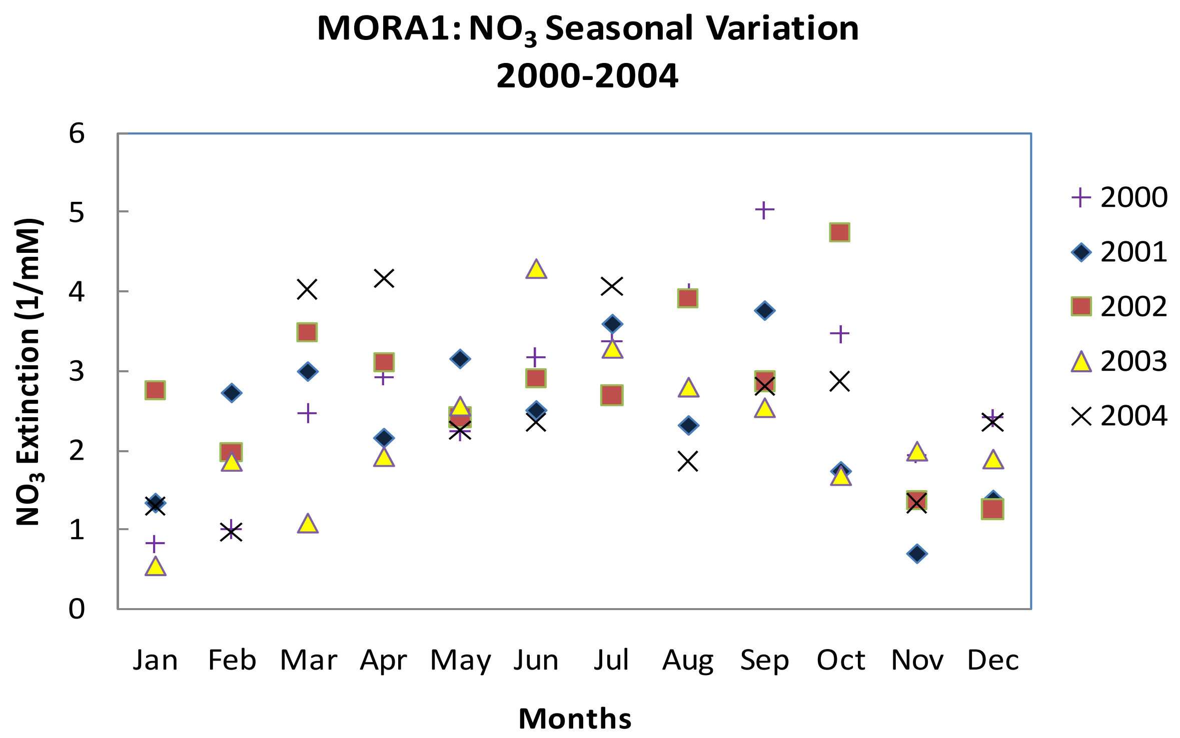



**Figure 5-30 Baseline Seasonal Variation by Month for $NO_3$ at MORA1**

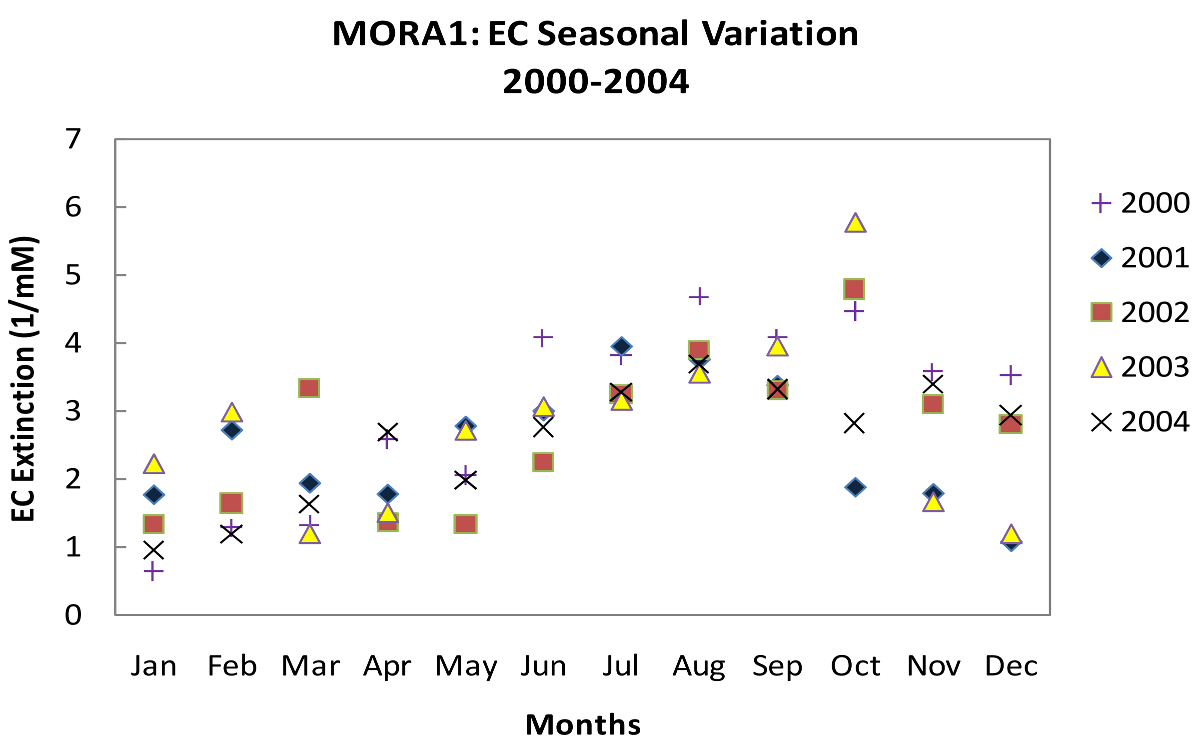



**Figure 5-31 Baseline Seasonal Variation by Month for EC at MORA1**

## 5.5 Goat Rocks Wilderness and Mount Adams Wilderness

For the Goat Rocks Wilderness and Mount Adams Wilderness baseline visibility is determined from the WHPA1 monitoring site for the Most Impaired Days and Least Impaired Days for the years 2001 through 2004 as specified in the RHR under[4]. The baseline visibility for the Goat Rocks Wilderness and Mount Adams Wilderness is calculated at 1.66 dv for the Least Impaired Days and 12.76 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experienced in the absence of human-caused impairment. Based on EPA guidance, the natural visibility for Goat Rocks Wilderness and Mount Adams Wilderness is 0.82 dv for the Least Impaired Days and 8.35 dv for the Most Impaired Days. See Table 5-1 and Figure 5-32.

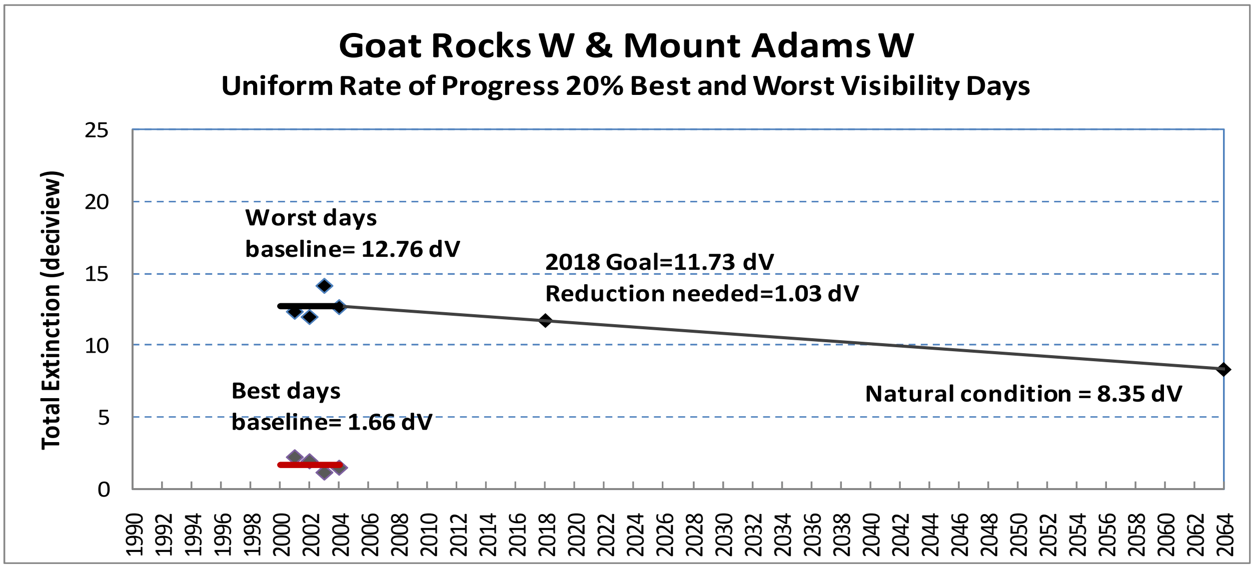



**Figure 5-32 Uniform Rate of Progress for Goat Rocks Wilderness and Mount Adams Wilderness**

Figures 5-33 and 5-34 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the WHPA1 IMPROVE site for the Most Impaired (left) and Least Impaired (right) Days, respectively. WHPA1 has the lowest light extinction among all Washington Class I areas for both Most Impaired and Least Impaired Days over the baseline period. There are some annual variations over the baseline period but overall, the year to year variability of the average of the annual Most Impaired and Least Impaired Days light extinction is relative small (nearly 10 and 1 $Mm^{-1}$, respectively). On average, sulfates (37%) and OC (36%) are the predominant causes of haze on the Most Impaired Days at this site. Compared to the Most Impaired Days, on the Least Impaired Days, sulfates increase their proportional share of the visibility impairment and the proportional share attributable to OC significantly decreases. OCs, nitrates, EC, coarse mass and sea salt are much less significant and contribute about equally to visibility impairment on the worst and the best days.

[4] 40 CFR §51.308(d)(2)(i)

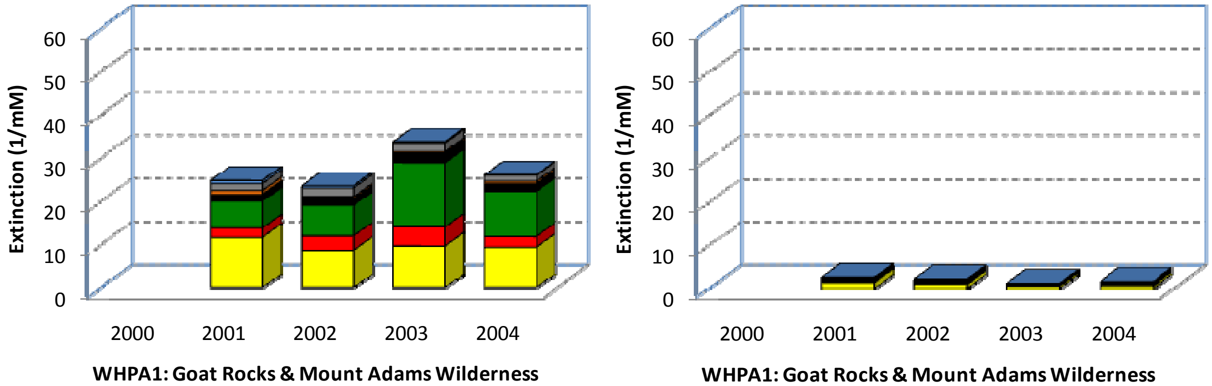



**Figure 5-33 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Goat Rocks Wilderness and Mount Adams Wilderness**

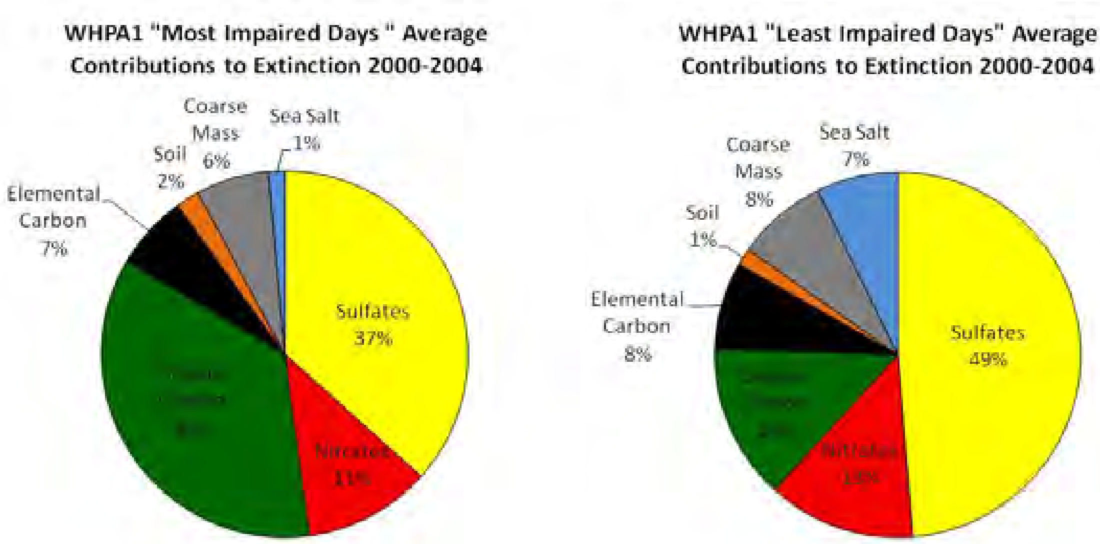



**Figure 5-34 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Goat Rocks Wilderness and Mount Adams Wilderness**

Figure 5-35 illustrates monitoring data for all IMPROVE sampled days during the base years (2000-2004). These data are interpreted in Figures x through z for major haze species. A clear seasonal variation is observed for sulfates and OCs, both of them increase during summer months. Nitrates remain stable for much of the year with more year-to-year variability in the winter months.

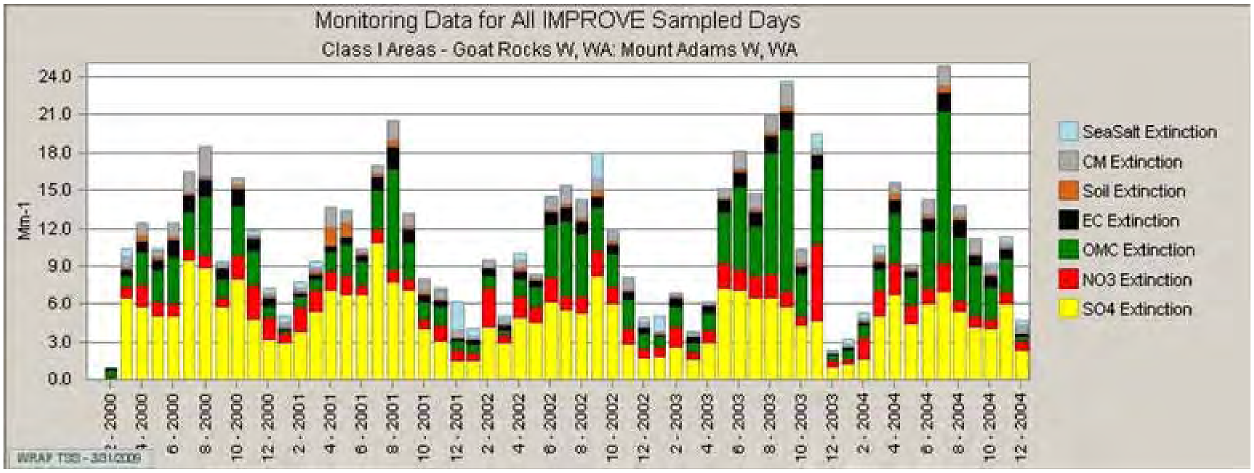



**Figure 5-35 Baseline Seasonal Variation in Haze Species at WHPA1 for 2000 through 2004**

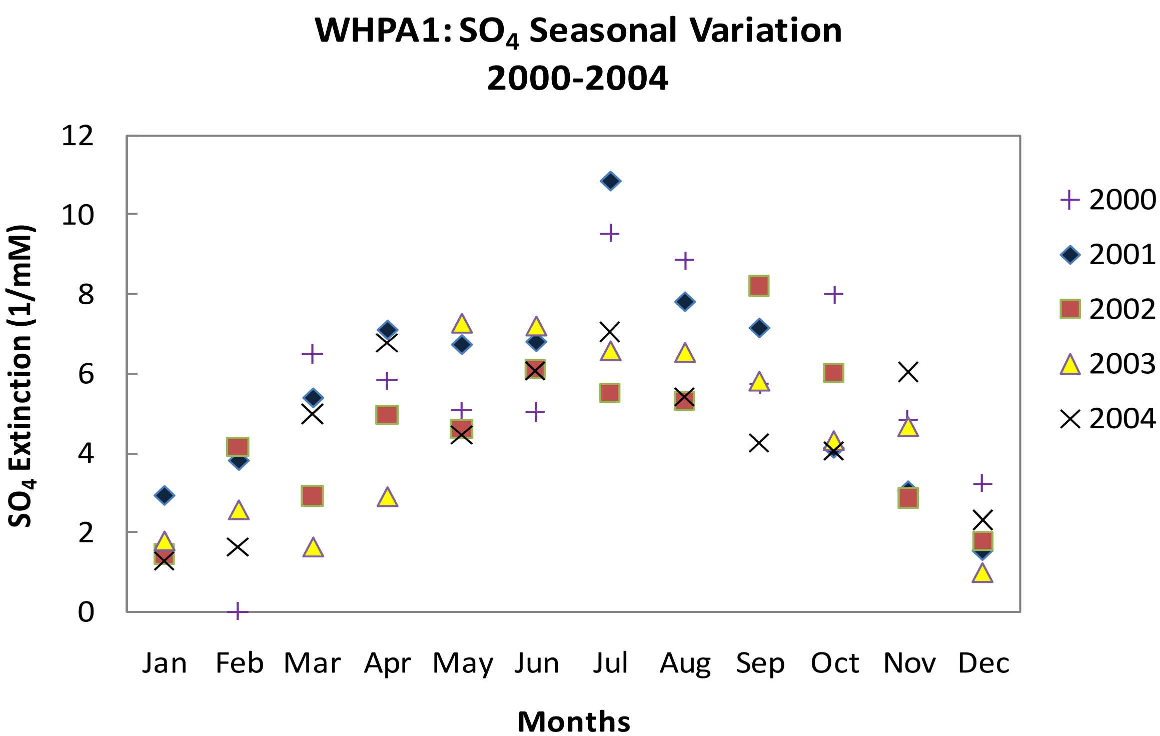



**Figure 5-36 Baseline Seasonal Variation by Month for $SO_4$ at WHPA1**

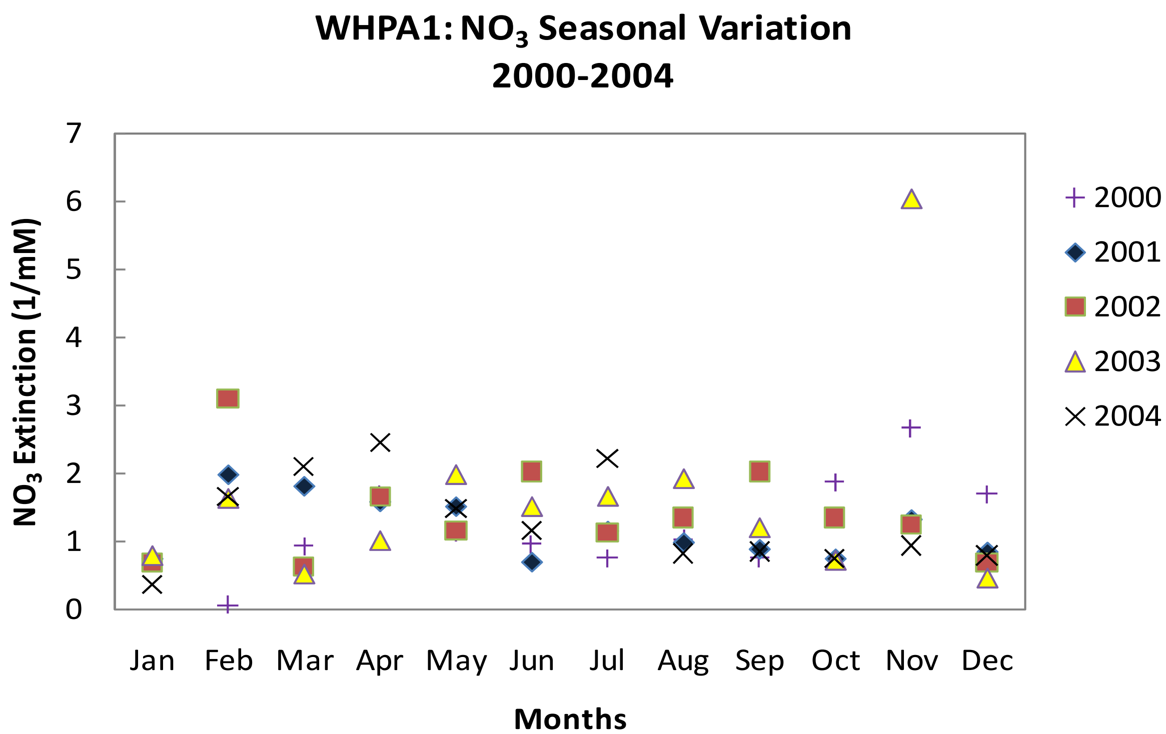



**Figure 5-37 Baseline Seasonal Variation by Month for $NO_3$ at WHPA1**

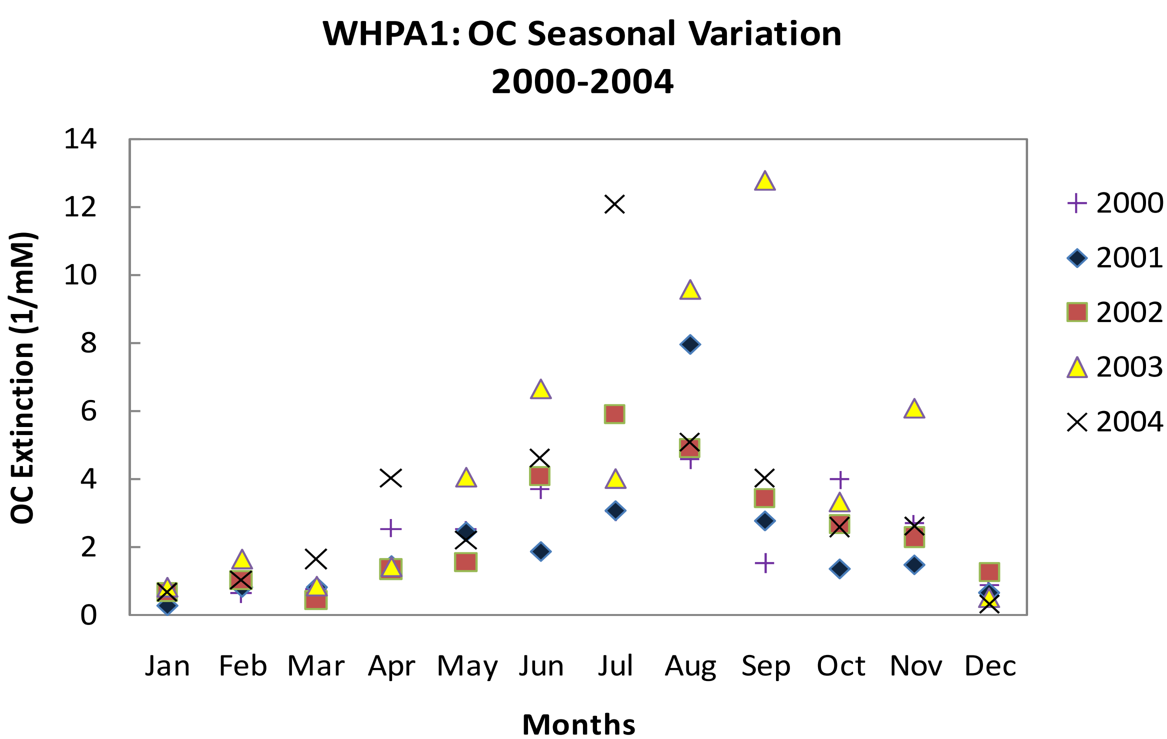



**Figure 5-38 Baseline Seasonal Variation by Month for OC at WHPA1**

## 5.6 Pasayten Wilderness

Baseline visibility is determined from the from the PASA1 monitoring site for the Most Impaired and Least Impaired Days for the years 2001 through 2004 as specified in the RHR under[5]. The baseline visibility for the Pasayten Wilderness is calculated at 2.73 dv for the Least Impaired Days and 15.23 dv for the Most Impaired Days.

Natural visibility represents the visibility conditions that would be experiences in the absence of human-caused impairment. Based on EPA guidance, the natural visibility for Pasayten Wilderness is 1.16 dv for the Least Impaired Days and 8.25 dv for the Most Impaired Days. See Table 5-1 and Figure 5-39.

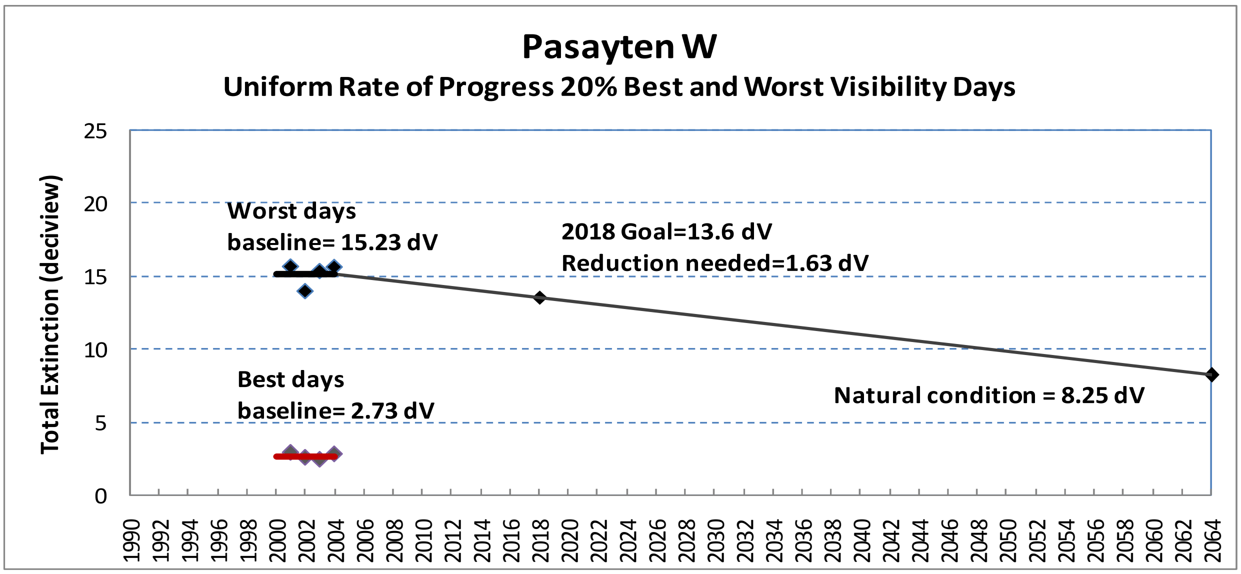



**Figure 5-39 Uniform Rate of Progress for Pasayten Wilderness**

Figures 5-40 and 5-41 show the annual and average contributions of haze species to light extinction over the baseline period based on data from the PASA1 IMPROVE monitor site for the Most Impaired (left) and Least Impaired (right) Days, respectively. Overall, the year to year variability of the average of the annual Most Impaired and Least Impaired Days light extinction is small (13 $Mm^{-1}$ and 1 $Mm^{-1}$, respectively). On average, OC (56%) is the predominant cause of haze on the Most Impaired Days at this site. Sulfates (20%) produce the majority of the remaining visibility impairment. Compared to the Most Impaired Days, on the Least Impaired Days sulfates significantly increase their proportional share of the visibility impairment, OC significantly reduces its share, and nitrates increase their share.

[5] 40 CFR §51.308(d)(2)(i)

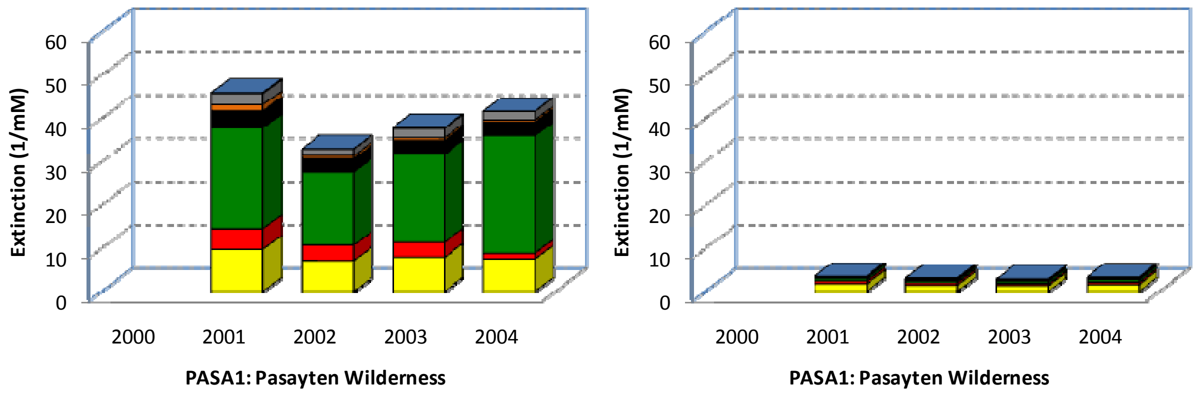



**Figure 5-40 Annual Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Pasayten Wilderness**

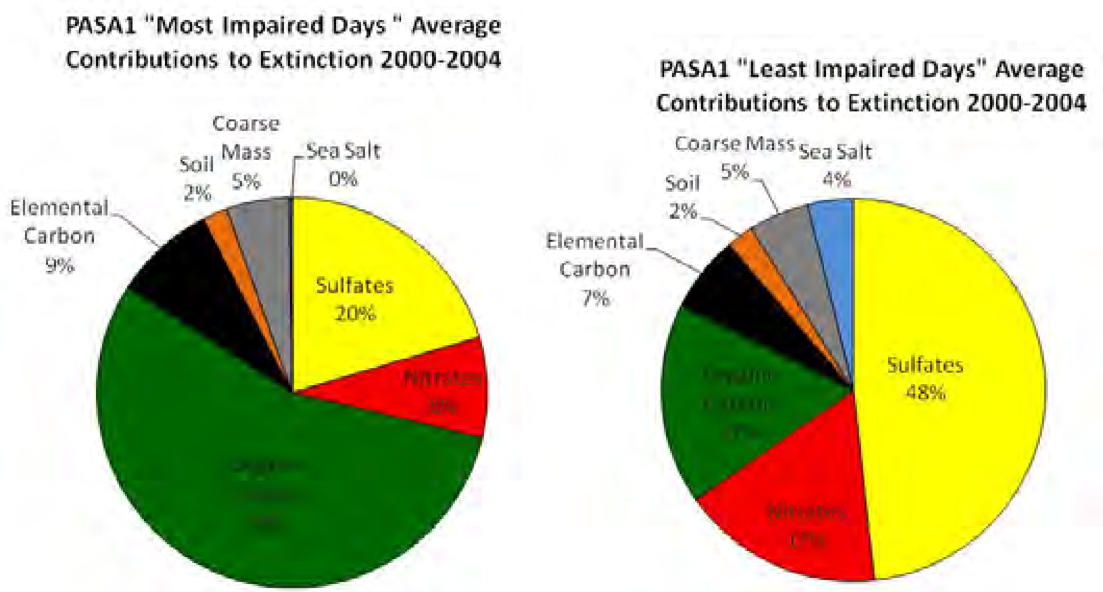



**Figure 5-41 Average Species Contributions to Most Impaired (left) and Least Impaired (right) Days in Pasayten Wilderness**

Figure 5-42 illustrates monitoring data for all IMPROVE sampled days during the base years (2001-2004). These data are reinterpreted in Figures x through z for major haze species. A clear seasonal variation is observed for OC which increases considerably in summer and fall months. A clear seasonal variation is observed for EC which increases in summer and fall months. A bimodal trend is observed for both $SO_4$ and $NO_3$, both of which seem to increase in the spring and fall.

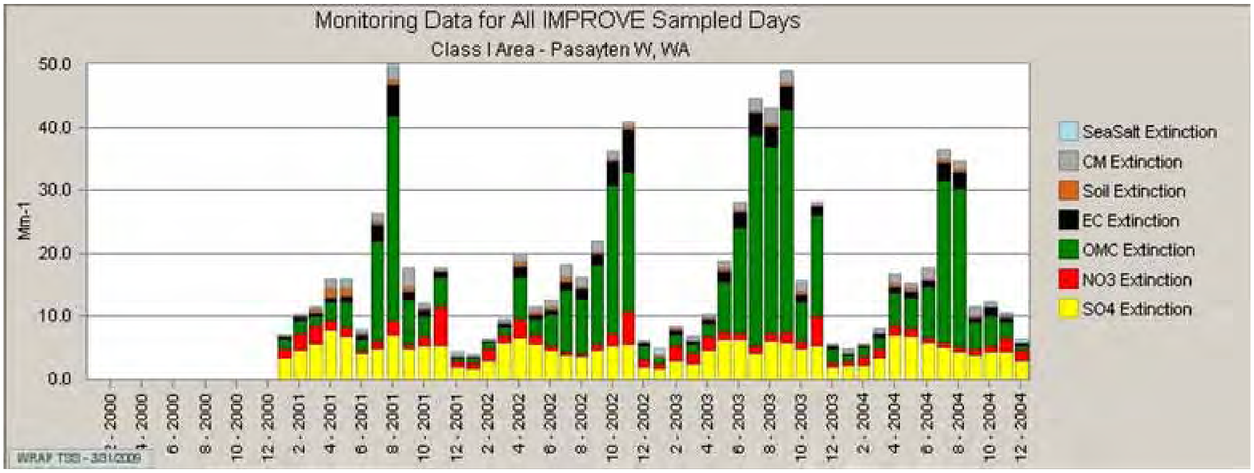



**Figure 5-42 Baseline Seasonal Variation in Haze Species at PASA1 for 2001 through 2004**

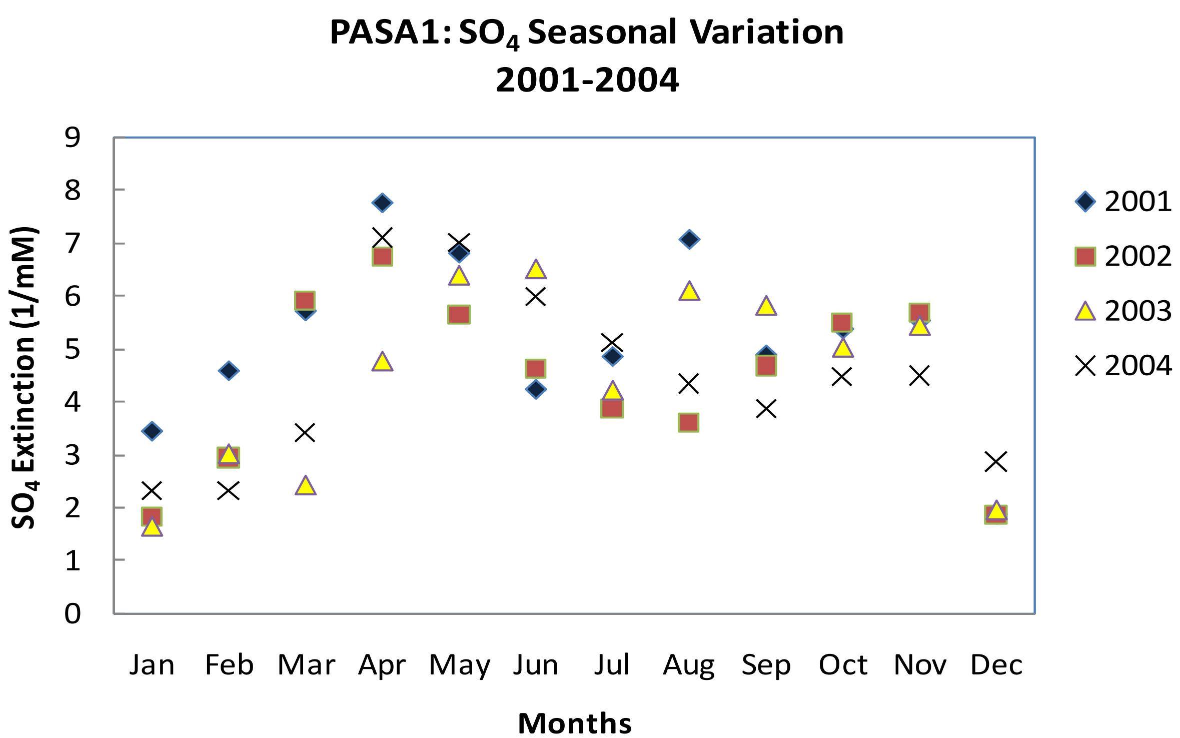



**Figure 5-43 Baseline Seasonal Variation by Month for $SO_4$ at PASA1**

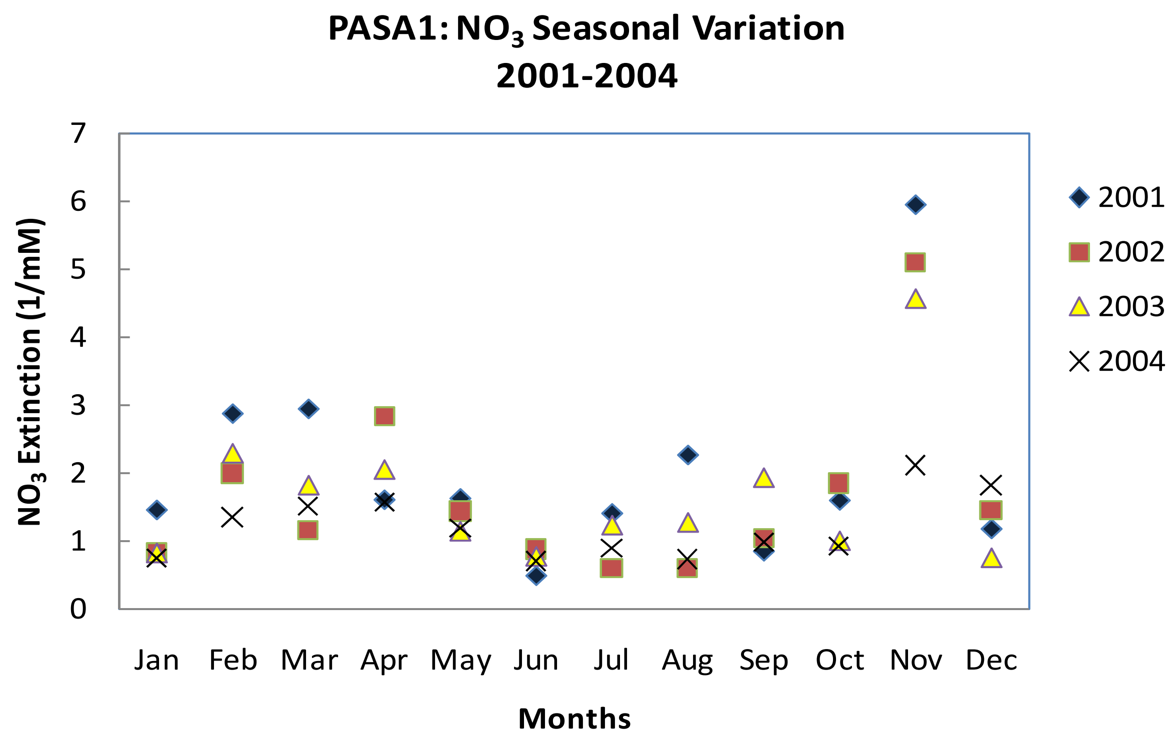



**Figure 5-44 Baseline Seasonal Variation by Month for $NO_3$ at PASA1**

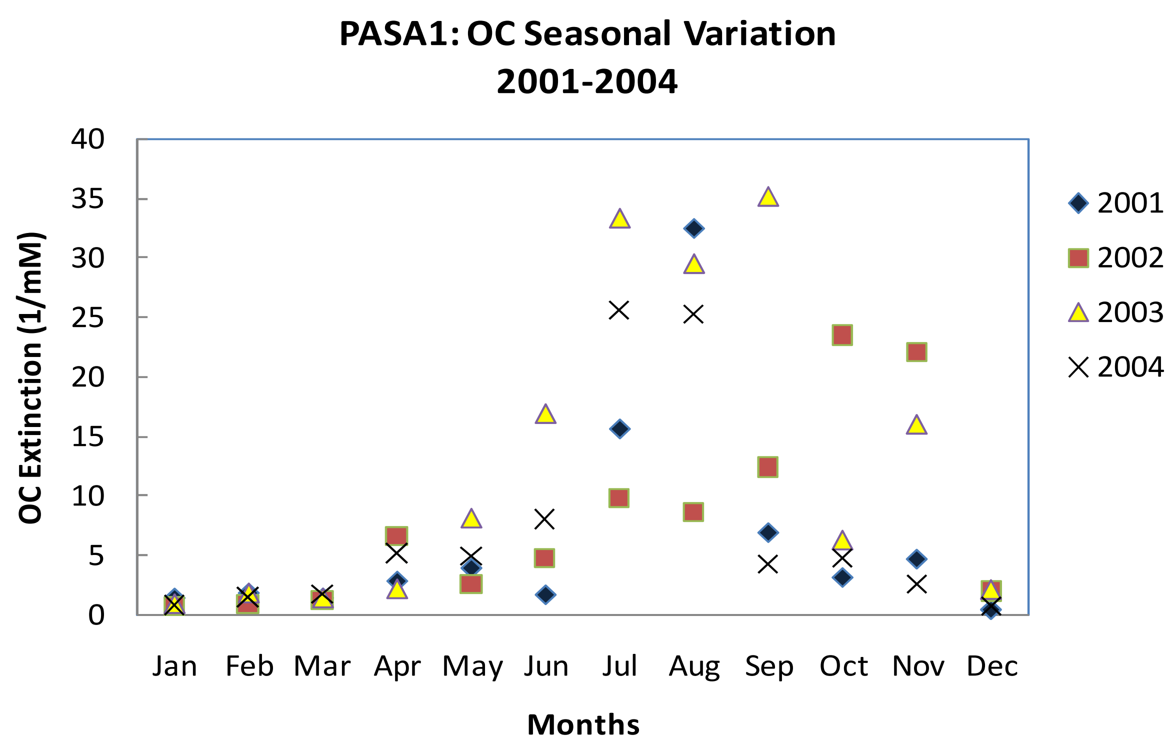



**Figure 5-45 Baseline Seasonal Variation by Month for OC at PASA1**

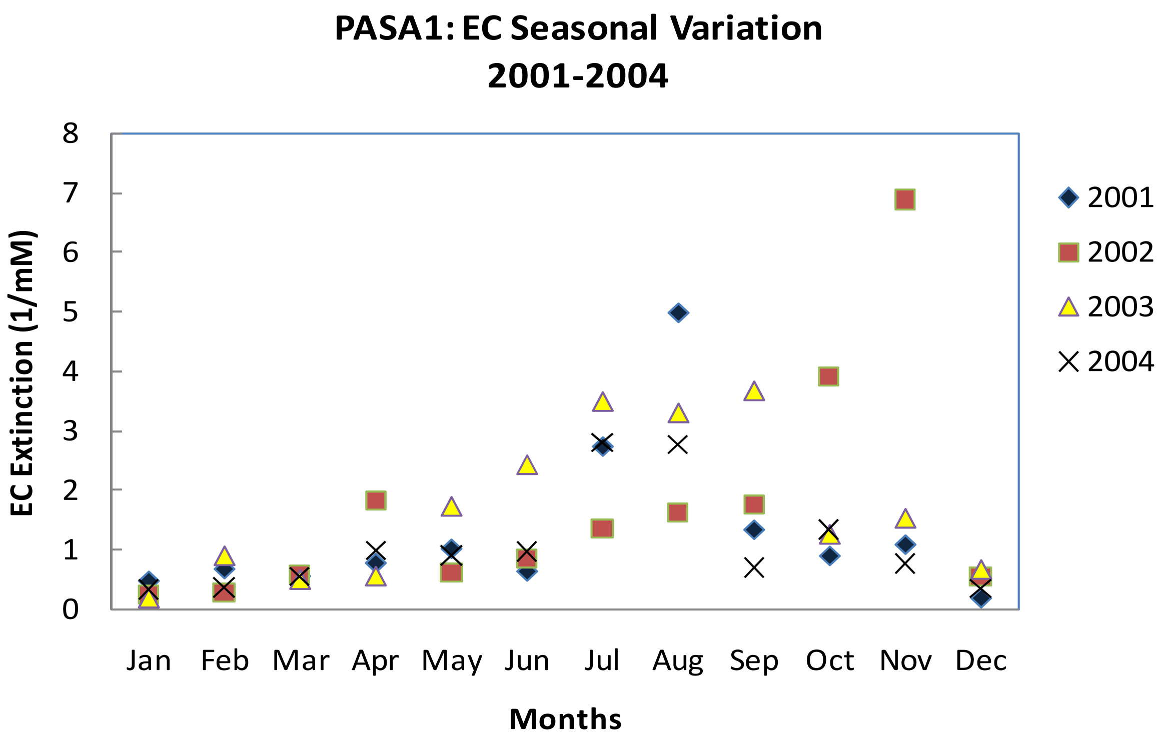



**Figure 5-46 Baseline Seasonal Variation by Month for EC at PASA1**

# Chapter 6 Emission Inventories

This chapter identifies emission source categories in Washington that could be affecting visibility in mandatory Class I Areas in Washington and other states impacted by Washington emissions. The Regional Haze Rule (RHR)[1] requires statewide emission inventories of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I Area.

## 6.1 Emission Inventory Development

Emission inventories play an important role in the identification and evaluation of sources that are reasonably expected to impact visibility. Most of the emissions data prepared and used in this foundational Regional Haze (RH) State Implementation Plan (SIP) were originally collected and reported in some form by state, local, and tribal air pollution control programs. Various Western Regional Air Partnership (WRAP) forums compiled these data for use in WRAP modeling and individual state analyses. as follows:

- The Stationary Sources Joint Forum and the Emissions Forum commissioned projects to obtain point source area source emissions.
- The Emissions Forum commissioned projects to obtain mobile source emissions.
- The Dust Emissions Joint Forum and the Modeling Forum commissioned projects to obtain ammonia, dust, and biogenic emissions.
- The Fire Emissions Joint Forum commissioned projects to obtain natural and anthropogenic fire emissions.

The Fire Emissions Joint Forum formed the Natural Background Task Team to develop a methodology to classify fire as either “natural” or “anthropogenic.” The resulting policy uses the following three classification criteria[2]:

1. Prescribed fire is an anthropogenic source, except where it is utilized to maintain an ecosystem that is currently in an ecologically functional and fire resilient condition, in which case it is classified as a “natural” source.
2. Wildfire that is suppressed by management action is a “natural” source. Wildfire, when suppression is limited for safety, economic, or resource limitations, remains a “natural” source. Wildfires managed for resource objectives are classified the same as prescribed fires.
3. Native American cultural burning for traditional, religious, and ceremonial purposes is a “natural” source.

The WRAP developed a central regional emissions inventory database to facilitate the data collection efforts. These emissions inventories are available from the WRAP Technical Support

[1] 40 CFR 51.308 (d)(4)(v)
[2] The Natural Background Task Team of the Fire Emissions Joint Forum, *Policy for Categorizing Fire Emissions*, November 15, 2001. http://www.wrapair.org/forums/fejf/documents/nbtt/FirePolicy.pdf

System (TSS) website (http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx). The TSS website has links to numerous references that describe in detail the emissions methods used in developing inventories for the foundation RH SIPs. Appendix G to this RH SIP, TSS Road Map, also contains information on inventories.

Along with the other WRAP states, Washington used the WRAP-developed emission inventories to develop the state's RH SIP as agreed to between Environmental Protection Agency (EPA), the states, and the WRAP.

## 6.2 Emission Inventory Scenarios

The WRAP focused on the development of the emission inventories for three scenarios:

(1) A base case emission inventory for 2002 for evaluation of model performance (referred to as "Base02")
(2) An inventory representing a typical year's emissions during the 2000-2004 baseline period ("Plan 02")
(3) A projected inventory for 2018 for evaluation of reasonable progress toward achieving the national visibility goal ("Base 18", later "PRP18")

Inventories for all three scenarios went through a series of revisions. Each revision refined the inventory by correcting errors and adding emission inventory improvements and updates. Each version of an inventory series is denoted by the addition of a letter to the inventory name. For example Base02b is the second version of the 2002 Base Case Inventory.

A general overview of the inventories developed for each of the three WRAP scenarios is provided below. Further information on modeling and source apportionment is found in Chapter 7.

## 6.3 Base Case Inventories

The purpose of the "2002 Base Case" or "Base02" inventory is to represent the actual emissions of pollutants causing or contributing to visibility impairment during calendar year 2002. Accordingly, the Base02 inventory is based on the best available data on actual 2002 emissions.

The WRAP used the Base02a inventory to model visibility for the calendar year 2002 and to evaluate model performance. The ability of the model to provide an adequate representation of air quality that occurred in 2002 would provide confidence that the model can adequately represent revised emissions in projected years. The WRAP decided model performance was acceptable.

The Base02b inventory was developed to correct errors and add emission inventory improvements. The WRAP considers the Base02b inventory to have the best estimates of actual 2002 emissions for all sectors for North America. The WRAP modeled the Base02b inventory to enable comparisons between the 2002 base case and the 2000-2004 typical-year modeling.

## 6.4 Typical-Year Baseline Inventories

The purpose of the 2000-2004 baseline period planning case emissions scenario is to represent emission patterns based on average or "typical" conditions during the 2000-2004 baseline period rather than emissions for any specific year. The inventory provides a basis for comparison with 2018 projected emissions and gauging reasonable progress. The WRAP refers to the Typical-Year Baseline Inventory as the "Plan02" inventory.

Versions of the Plan02 inventory were used for modeling visibility impairment and determining source apportionment. The WRAP also used the Plan02 inventory to develop information about the source areas of visibility impairing emissions impacting individual Class I Areas.

The WRAP used the third iteration of Plan02 inventory, the Plan02c inventory, to model baseline period visibility. The Plan02c inventory was also used with a different model and a source apportionment tool (discussed in Chapter 7) to identify the source regions and the contributions of major source categories to sulfate and nitrate at the Class I Areas.

The WRAP developed a Plan02d inventory that, among other revisions, included updates to source classification codes and source inventory codes along with source emissions corrections. This inventory was used for updated modeling of baseline period visibility impairment. The Plan02d inventory was also used for an analysis (discussed in Chapter 7) based on emissions and meteorology of potential source areas contributing visibility-impairing pollutants to the mandatory Class I Areas.

## 6.5 Reasonable Progress Inventories

The year 2018 represents the first milestone date for demonstrating reasonable progress toward the national visibility goal. The WRAP projected emissions to the year 2018 by taking into account growth, "on-the-books" (that is, adopted) controls and regulations, and application of RH strategies. The factors that were considered in projecting the inventory include the following:

- Presumptive Sulfur Dioxide ($SO_2$) Best Available Retrofit Technology (BART) for Electrical Generating Units (EGUs) in the WRAP region or current controls if lower
- Known BART controls in the WRAP region
- Mobile source controls
  - Heavy Duty Diesel (2007) Engine Standard
  - Tier 2 Tailpipe Standards
  - Large Spark Ignition and Recreational Vehicle Rule
  - Nonroad Diesel Rule
  - Low sulfur fuel requirements for gasoline engines, on-road diesel engines, off-road diesel engines, and locomotives
- Combustion Turbine and Industrial Boiler/Process Heater/Reciprocating Internal Combustion Engine (RICE) Maximum Achievable Control Technology (MACT)
- Post-2002 permits and state/EPA consent agreements

- Reductions in 2000-04 average fire emissions due to Emissions Reduction Techniques in Smoke Management Programs
- Ozone and Coarse Particulate Matter ($PM_{10}$) SIPs in place in the WRAP region
- State oil and gas emissions control programs

The WRAP did two series of 2018 projected emission inventories. The first series is referred to as "Base18" and the second, superseding series is referred to as "Preliminary Reasonable Progress" or simply "PRP18" inventories.

The second iteration of the Base18 inventory, the Base18b inventory, was modeled with the same model and source apportionment tool as the Plan02c inventory to identify the source regions and the contributions of major source categories to sulfate and nitrate at mandatory Class I Areas in 2018. The results can be compared with the earlier source apportionment modeling performed with the Plan02c inventory.

The WRAP modeled both the first and the second iterations of the PRP18 inventories, the PRP18a and the PRP18b inventories, and used the results to estimate 2018 visibility at mandatory Class I Areas. The PRP18a inventory included presumptive $SO_2$ BART for EGUs where BART had not been determined. The PRP18b inventory included known or projected BART for EGU and non-EGU sources along with presumptive $SO_2$ and Nitrogen Oxides ($NO_x$) BART for EGUs where BART was yet to be determined. These modeling runs were evaluated by various states in determining reasonable progress goals for mandatory Class I Areas and the emission reductions needed to achieve those goals.

The WRAP also developed a special version of the PRP18b inventory reflecting a more accurate inventory for commercial marine shipping off the Pacific coast. This PRP18cmv inventory was modeled to estimate 2018 visibility in mandatory Class I Areas.

The analysis based on emissions and meteorology of potential source areas contributing visibility impairing pollutants to mandatory Class I Areas was rerun with the PRP18a, PRP18b, and PRP18cmv projected 2018 emissions inventories. The results can be compared with the earlier analysis based on the Plan02d inventory. None of the PRP18 inventories include the projected affects of the recently adopted International Maritime Organization (IMO) Emission Control Area for the West Coast of the United States and Canada.

## 6.6 Emission Inventories for Washington's Regional Haze State Implementation Plan

While the various inventories developed for the three scenarios played a role in the development of the technical analysis for the WRAP region, Washington State's foundational RH SIP focuses on two emission inventories in particular:

- the Typical-Year Baseline Inventory referred to as "Plan02d"
- the inventory projected for 2018 specified by the WRAP as "Preliminary Reasonable Progress emissions inventory 2018 version a", but commonly referred to as "PRP18a".

These two inventories were the most recent, complete, and up-to-date inventories available through TSS when Washington State began doing its own analysis of the WRAP's technical basis for the state's RH SIP.

The visibility-impairing emissions examined in both inventories are $SO_2$, $NO_x$, Volatile Organic Compounds (VOC), Organic Carbon (OC), Elemental Carbon (EC), Fine Particulate Matter ($PM_{2.5}$), and $PM_{10}$ and Ammonia ($NH_3$). The emission tables show the primary source categories for each visibility impairing pollutant. The source categories vary by the type of pollutant. Source categories include: point, area, on-road mobile, off-road mobile, anthropogenic fire, natural fire, biogenic, road dust, fugitive dust and windblown dust.

Not included as an "in-state" emission source category is offshore marine vessel emissions, which are considered "regional" emissions. It should also be noted the PRP18a emissions for natural fire (wildfires) is based on historical rates of burning and does not take into account increased burning that may occur due to climate change or natural causes.

The emissions information for Washington is organized by visibility-impairing pollutant. Inventory information for each pollutant is provided by major source categories for both the Plan02d and the PRP18a inventories.

**Sulfur Dioxide Emissions**

Table 6-1 shows Washington $SO_2$ emissions for the baseline year and the end of the first planning period.

**Table 6-1 Washington Sulfur Dioxide Emission Inventories – 2002 and 2018**

| Washington Statewide $SO_2$ Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 52,885 | 37,444 | -15,441 | -29% |
| Area | 7,311 | 8,667 | 1357 | +19% |
| On-Road Mobile | 5,543 | 679 | -4,864 | -88% |
| Off-Road Mobile | 13,913 | 262 | -13,651 | -98% |
| Anthropogenic Fire | 1,411 | 1,043 | -368 | -26% |
| Natural Fire | 1,641 | 1,641 | 0 | 0% |
| **Total** | **82,703** | **49,736** | **-32,967** | **-40%** |

Gaseous $SO_2$ emissions are converted to sulfate particles, generally ammonium sulfate, in the atmosphere. Ammonium sulfate particles grow rapidly in size in the presence of water through water absorption and change from solid particles to solution droplets. The size of ammonium sulfate at high relatively humidity (>70%) makes it disproportionally responsible for visibility impairment compared to inorganic salts that do not take up water molecules.

Baseline year 2002 $SO_2$ emissions come primarily from point sources, including a coal-fired power plant, oil refineries, primary aluminum plants, pulp and paper mills, and a cement plant.

A 40% statewide reduction in $SO_2$ emissions is expected by 2018 due to planned controls on existing sources, especially due to on-the books rules for on-road and off-road fuels and a reduction of nearly 19,000 tons from the coal-fired power plant.

### Nitrogen Oxides Emissions

Table 6-2 shows Washington $NO_x$ emissions for the baseline year and the end of the first planning period.

**Table 6-2 Washington Nitrogen Oxides Emission Inventories – 2002 and 2018**

| Washington Statewide $NO_x$ Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 43,355 | 49,456 | 6,101 | 14% |
| Area | 17,587 | 22,746 | 5,159 | 29% |
| On-Road Mobile | 201,991 | 55,911 | -146,080 | -72% |
| Off-Road Mobile | 84,710 | 46,529 | -38,181 | -45% |
| Anthropogenic Fire | 6,821 | 4,971 | -1,850 | -27% |
| Natural Fire | 5,997 | 5,997 | 0 | 0% |
| Biogenic | 17,923 | 17,923 | 0 | 0% |
| **Total** | **378,384** | **203,533** | **-174,850** | **-46%** |

$NO_x$ emissions are generated during combustion processes from the reaction of oxygen with the nitrogen content of the fuel and at higher temperatures from the reaction of nitrogen and oxygen in the atmosphere. $NO_x$, similar to $SO_2$, reacts in the atmosphere to form nitrate particles such as Ammonium Nitrate ($NO_3$). Like Ammonium Sulfate ($(NH_4)_2SO_4$), $NO_3$ particles grow rapidly in the presence of water to reach a size that is disproportionately responsible for visibility impairment.

Baseline year 2002 $NO_x$ emissions come predominantly from on-road mobile sources. Of lesser importance are emissions from off-road mobile sources and point sources.

Point source emissions are projected to increase based on the increased utilization of existing units and new sources established between 2002 and 2008. Overall, $NO_x$ emissions in Washington are expected to decline 46% by 2018, primarily due to significant improvements in on-road and off-road mobile source emissions.

### Volatile Organic Compounds Emissions

Table 6-3 shows Washington VOC emissions for the baseline year and the end of the first planning period.

**Table 6-3 Washington Volatile Organic Compounds Emission Inventories – 2002 and 2018**

| Washington Statewide VOC Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 18,651 | 26,212 | 7,561 | 41% |
| Area | 151,680 | 253,703 | 102,023 | 67% |
| On-Road Mobile | 140,181 | 50,625 | -89,556 | -64% |
| Off-Road Mobile | 61,601 | 38,618 | -22,983 | -37% |
| Anthropogenic Fire | 14,858 | 10,532 | -4,325 | -29% |
| Natural Fire | 13,160 | 13,160 | 0 | 0% |
| Biogenic | 642,736 | 642,736 | 0 | 0% |
| **Total** | **1,042,867** | **1,035,587** | **-7,280** | **-1%** |

The dominant source of VOC emissions throughout the country is biogenic emissions. These emissions comprise 61% of total Washington VOC emissions in 2002. These are natural emissions mostly from forests, but also agricultural crops and urban vegetation. Among the other sources, most notably, on-road mobile sources, area sources, and off-road mobile sources, contribute to VOC loading in the atmosphere.

Significant VOC increases in area sources are primarily driven by population growth. Specific area sources expected to increase include residential wood combustion and solvent utilization.

Significant VOC reductions from mobile sources in the 2018 inventory are more than offset by increases in area sources due primarily to population growth. Use of solvents in paints, dry cleaning fluid, charcoal lighter fuel, windshield washer fluids, and many home use products shows up in the area source category and is linked to population growth.

From a RH perspective, there is less concern with VOCs emitted directly to the atmosphere and more with the formation of secondary organic aerosols. Secondary organic aerosols form after condensation and oxidation. VOCs also play a role in the photochemical production of ozone in the troposphere. Biogenic VOCs are uncontrollable and, therefore, there is a limit to the amount of visibility improvement that can be gained.

VOCs react with $NO_x$ to produce nitrated organic particles that impact visibility in the same series of chemical events that lead to ozone. Thus, strategies to reduce ozone in the atmosphere often lead to visibility improvements.

### Organic Carbon Emissions

Table 6-4 shows Washington OC emissions for the baseline year and the end of the first planning period.

**Table 6-4 Washington Organic Carbon Emission Inventories – 2002 and 2018**

| Washington Statewide Organic Carbon Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 763 | 941 | 178 | 23% |
| Area | 16,577 | 22,214 | 5637 | 34% |
| On-Road Mobile | 1,821 | 1,533 | -287 | -16% |
| Off-Road Mobile | 1,948 | 1,288 | -660 | -34% |
| Anthropogenic Fire | 10,305 | 7,349 | -2,955 | -29% |
| Natural Fire | 17,931 | 17,931 | 0 | 0% |
| Road Dust | 189 | 202 | 13 | 7% |
| Fugitive Dust | 739 | 992 | 253 | 34% |
| **Total** | **50,273** | **52,451** | **2,178** | **4%** |

OC is primarily the end product of combustion of organic material. Most of these emissions in Washington are from natural (nonanthropogenic) wildfire, which can fluctuate greatly from year to year. For instance, 2003 was an unusually high year for wildfires in Washington. Area sources are the largest anthropogenic contributor to the OC inventory, and these are expected to increase significantly (34%) from 2002 to 2018 mostly due to population increase. A variety of sources contribute to the area source category, but wood stoves are a particularly significant component.

### Elemental Carbon Emissions

Table 6-5 shows Washington EC emissions for the baseline year and the end of the first planning period.

**Table 6-5 Washington Elemental Carbon Emission Inventories – 2002 and 2018**

| Washington Statewide Elemental Carbon Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 144 | 206 | 62 | 43% |
| Area | 2,180 | 3,005 | 825 | 38% |
| On-Road Mobile | 2,003 | 481 | -1,522 | -76% |
| Off-Road Mobile | 4,213 | 1,696 | -2,517 | -60% |
| Anthropogenic Fire | 780 | 585 | -195 | -25% |
| Natural Fire | 3,717 | 3,717 | 0 | 0% |
| Road Dust | 14 | 15 | 1 | 8% |
| Fugitive Dust | 50 | 67 | 17 | 34% |
| **Total** | **13,102** | **9,773** | **-3,329** | **-25%** |

EC is black carbon, a product of incomplete combustion, which is emitted as soot. It is similar to OC, but EC represents more complete combustion of the fuel that produces carbon. The primary sources of EC are natural fires, off-road and on-road mobile sources, and area sources. EC emissions from mobile sources are estimated to decrease significantly by 2018 as new federal mobile source regulations are being implemented. Overall, EC emissions are estimated to decline by 25% by 2018.

**Fine Particulate Matter Emissions**

Table 6-6 shows Washington $PM_{2.5}$ emissions for the baseline year and the end of the first planning period.

**Table 6-6 Washington Fine Particulate Matter Emission Inventories – 2002 and 2018**

| Washington Statewide Fine Particulate Matter Emissions (tons/year) | | | | |
|---|---|---|---|---|
| Source Category | Plan02d | PRP18a | Net Change | % Change |
| | 2002 | 2018 | 2018 - 2002 | (2018-2002) / 2002 |
| Point | 2,257 | 2,625 | 368 | 16% |
| Area | 12,708 | 17,234 | 4,526 | 36% |
| Anthropogenic Fire | 3,869 | 2,691 | -1,178 | -30% |
| Natural Fire | 1,139 | 1,139 | 0 | 0% |
| Road Dust | 2,819 | 2,910 | 91 | 3% |
| Fugitive Dust | 12,957 | 17,366 | 4,408 | 34% |
| WB Dust | 5,401 | 5,401 | 0 | 0% |
| **Total** | **41,151** | **49,366** | **8,216** | **20%** |

$PM_{2.5}$ in the emissions inventory includes soil materials and other non-carbon, non-sulfate and non-nitrate particulate matter less than 2.5 microns in size. The primary sources are area and fugitive dust sources (agriculture, mining, construction, and unpaved and paved roads). Even though direct PM tailpipe emissions are relatively small they are accounted for as $PM_{10}$ under mobile sources. Overall, the PM fine emissions show an increase of 20% by 2018.

**Coarse Particulate Matter Emissions**

Table 6-7 shows Washington $PM_{10}$ emissions for the baseline year and the end of the first planning period. In the WRAP emission inventories $PM_{10}$ is defined as particles between 2.5-10 microns in size and may be referred to as $PM_{10}$.

**Table 6-7 Washington Coarse Particulate Matter Emission Inventories – 2002 and 2018**

| Washington Statewide Coarse Particulate Matter Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 6,244 | 5,742 | -502 | -8% |
| Area | 2,083 | 4,117 | 2,033 | 98% |
| On-Road Mobile | 1,079 | 1,089 | 10 | 1% |
| Anthropogenic Fire | 806 | 547 | -259 | -32% |
| Natural Fire | 3,856 | 3,856 | 0 | 0% |
| Road Dust | 26,044 | 26,642 | 598 | 2% |
| Fugitive Dust | 66,704 | 105,007 | 38,303 | 57% |
| WB Dust | 48,612 | 48,612 | 0 | 0% |
| **Total** | **155,430** | **195,613** | **40,184** | **26%** |

$PM_{10}$ emissions are significantly greater than $PM_{2.5}$ in Washington. Substantial increases in $PM_{10}$ emissions are seen in fugitive dust and area sources. This is due to the fact that construction and emissions from paved and unpaved roads are tied to population growth and vehicle miles traveled. Overall, $PM_{10}$ emissions are estimated to increase by 26% in 2018.

**Ammonia Emissions**

Table 6-8 shows Washington $NH_3$ emissions for the baseline year and the end of the first planning period.

**Table 6-8 Washington Ammonia Emission Inventories – 2002 and 2018**

| Washington Statewide Ammonia ($NH_3$) Emissions (tons/year) | | | | |
|---|---|---|---|---|
| **Source Category** | **Plan02d** | **PRP18a** | **Net Change** | **% Change** |
| | **2002** | **2018** | **2018 - 2002** | **(2018-2002) / 2002** |
| Point | 3,863 | 5,466 | 1,603 | 41% |
| Area | 45,218 | 47,769 | 2,551 | 6% |
| On-Road Mobile | 5,211 | 7,086 | 1,874 | 36% |
| Off-Road Mobile | 57 | 73 | 15 | 27% |
| Anthropogenic Fire | 3,439 | 2,398 | -1,040 | -30% |
| Natural Fire | 1,265 | 1,265 | 0 | 0% |
| **Total** | **59,054** | **64,057** | **5,003** | **8%** |

Emission estimates for $NH_3$ have a high degree of uncertainty associated with them, based on a high variability in emission factors, wide range of activities, and lack of a uniform emission methodology. However, $NH_3$ emissions are important in that they react with $SO_2$ and $NO_x$ to form sulfate and nitrate particles which are significant contributors to visibility impairment.

$NH_3$ emissions come from agricultural related activities, primarily livestock operations and farming fertilizer applications. WRAP has categorized these as either point or area sources.

The area source emission inventories for $NH_3$ have two components:

1. Emissions reported by the state and
2. Meteorologically driven fugitive emissions based on land use

Washington reported 4,470 tons/year of area source emissions in 2002. In 2018, the state reported portion is estimated to be 7,021 tons/year.

Based upon the work done by the Modeling Forum, WRAP estimated 40,748 tons/year of meteorologically driven fugitive emissions based on land use. This number was held constant in 2002 and 2018. Some of the fugitive emissions may have already been accounted for in the state reported portion resulting in double counting of $NH_3$ emissions.

Improvements in developing ammonia inventories are needed in the near future to develop more effective RH strategies. Along with an improved emission inventory, a better understanding of the chemistry in forming $SO_4$ and $NO_3$ is needed for RH planning.

# Chapter 7 Western Regional Air Partnership Modeling

This chapter describes the types of models used by the Western Regional Air Partnership (WRAP) to characterize its region. Washington relied upon WRAP modeling for this foundational Regional Haze (RH) State Implementation Plan (SIP). Results from these models are presented in subsequent chapters.

## 7.1 Overview

Visibility impairment occurs when air borne particles in the atmosphere scatter or absorb light to create haze. Particulates can be directly emitted into atmosphere as primary particulates. Particulates may also be produced in the atmosphere as secondary particulates by photochemical reactions and condensation. Pollutants can also remain suspended for long periods, be transported long distances, and be lost from the atmospheric suspension through wet and dry deposition.

As a result emission inventories alone are not sufficient to determine which pollutants should be controlled to improve visibility at mandatory Class I Areas. Computer air quality models provide a better understanding of the sources of fine particulates by simulating emissions, meteorological processes, atmospheric chemical transformations, transport, and deposition. The WRAP used air quality models to analyze baseline period visibility, identify significant source areas and source categories of visibility-impairing emissions, and project future visibility impairment and potential visibility improvement from emissions reduction strategies.

## 7.2 Regional Haze Modeling

The primary tool relied upon by the WRAP for modeling visibility was the Community Multi-Scale Air Quality (CMAQ) model. The modeling was conducted by the Regional Modeling Center (RMC) at the University of California Riverside under the oversight of the WRAP Modeling Forum. All WRAP states are using this modeling.

The CMAQ model was designed as a "one atmosphere" modeling system to encompass modeling of multiple pollutants and issues, including ozone, Particulate Matter (PM), visibility, and air toxics. This is in contrast to many earlier air quality models that focused on single pollutants. The CMAQ model takes into account emissions, advection and dispersion, photochemical transformation, aerosol thermodynamics and phase transfer, aqueous chemistry, and wet and dry deposition of trace species.

The CMAQ model requires inputs of three-dimensional gridded wind, temperature, humidity, cloud/precipitation, and boundary layer parameters. The version of CMAQ used for the WRAP modeling utilized gridded meteorological data from the Meteorological Mesoscale 5 (MM5) model for its meteorological inputs. The MM5 model was developed as a state-of-the-science model that has been proven useful for air quality applications. MM5 has been used extensively for local, state, regional, and national modeling efforts. MM5 has undergone extensive peer-review and all of its components have undergone continual development and scrutiny by the weather prediction and modeling communities.

The RMC developed the air quality modeling inputs including annual meteorology and emissions inventories for a 2002 actual emissions base case, a planning case to represent the 2000-04 RH baseline period using averages for key emissions categories, and 2018 projected cases representing base case projected emissions and emissions from preliminary reasonable progress scenarios. The modeling emissions inputs were developed from the emission inventories using the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system.

CMAQ modeling of the WRAP region required other emission inventories besides those developed for the WRAP region. The RMC developed Pacific offshore commercial marine vessel inventories from a variety of sources. The RMC also gathered the latest and best representative emission estimates from the Central Regional Air Planning Association (CENRAP), the eastern United States, Mexico, and Canada. Results can be found on the WRAP Technical Support System (TSS) website at http://vista.cira.colostate.edu/TSS/Results/HazePlanning.aspx

The CMAQ model also requires that the concentrations of visibility-impairing pollutants at the 4 lateral boundaries of the modeling domain be specified. These boundary conditions represent visibility-impairing pollutants reaching North America from the rest of the world. Boundary conditions were developed from the GOES-CHEM global chemical transport model by a project commissioned by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) regional planning organization on behalf of all five regional planning organizations implementing the Regional Haze Rule (RHR).

Visibility projections for 2018 were developed from projected concentrations of visibility-impairing pollutants at Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites representing mandatory Class I Areas through the use of the revised IMPROVE equation. Projected concentrations were calculated by applying a Relative Response Factor (RRF) to the measured baseline period concentration at the IMPROVE site. The RRF is the ratio of the future-year modeling results to the current-year modeling results. The RRFs were developed from modeling the Plan02d baseline period and PRP18a projected 2018 emission inventories.

## 7.3 Model Performance

The WRAP's RMC evaluated the performance of the CMAQ model for modeling visibility in the WRAP region. The objective of the model performance evaluation was to compare CMAQ model-simulated concentrations with 2002 ambient monitoring data from a large number of sites to determine whether the CMAQ model's performance was sufficiently accurate to justify use of the model for simulating future conditions. The RMC used the Base02a emissions inventory for the simulation. The CMAQ model was evaluated for both the Most Impaired Days and the Least Impaired Days. The "Final Report for the WRAP 2002 Visibility Model Performance Evaluation" (Tonnesen, et al, 2006) discusses the model performance evaluation in detail.

The key finding of the RMC's model performance evaluation is that CMAQ modeling can be used in combination with the RRF approach to evaluate the benefits of emission reduction strategies for all particulate matter species except for coarse mass and project visibility changes at Class I Areas for RH planning purposes.

The RMC model performance evaluation dealt the with entire WRAP region. Ecology decided to do a further evaluation of model performance specifically for mandatory Class I Areas in the state of Washington. Ecology performed a 3-step process. As the first two steps, Ecology examined two sets of graphics for mandatory Class I Areas in Washington:

(1) Time-series concentrations of visibility-impairing pollutants from IMPROVE monitoring of each of the mandatory Class I Areas in Washington for the 2000-2004 baseline period
(2) IMPROVE monitoring data and CMAQ modeling results for each of the mandatory Class I Areas in Washington for 2002

Finally, Ecology performed a basic analysis of the modeling results in comparison to the monitored data at the mandatory Class I Areas. Details on the 3 steps and their results are described in Appendix M.

Ecology drew the following conclusions about the acceptability of CMAQ modeling results. CMAQ modeling results are acceptable for the following visibility-impairing pollutants and, where noted, visibility conditions:

- Ammonium Sulfate ($SO_4$) especially on the Most Impaired Days
- Organic Matter Carbon (OMC) on the Most Impaired Days
- Elemental Carbon (EC)
- Coarse Matter (CM) for the Least Impaired Days (with the caveat that the RMC found model performance for CM to be unacceptable in its model performance evaluation)

CMAQ modeling results are unacceptable for the following visibility-impairing pollutants and, where noted, visibility conditions:

- Ammonium Nitrate ($NO_3$)
- OMC on the Least Impaired Days
- Soil
- CM on the Most Impaired Days

Ecology is using the WRAP results to forecast changes to concentrations of visibility-impairing pollutants and resultant visibility with the understanding that the CMAQ modeling results are the best tool available to forecast concentrations of visibility-impairing pollutants and projected visibility in 2018, the end of the first control period covered by the state of Washington's RH SIP. Pollutant concentrations and hence visibility are likely to be over predicted on the Least Impaired Days. The impact of modeling is not so clear for the Most Impaired Days. CMAQ modeling results for sulfate and OMC, 2 of the most important pollutants affecting visibility, are generally expected to be acceptable, but concentrations of nitrate, the other important pollutant affecting visibility are likely to be over predicted.

## 7.4 Source Apportionment Analysis Using Particulate Matter Source Apportionment Technology and Weighted Emissions Potential

In order to determine the significant sources contributing to haze in Washington's mandatory Class I Areas, Washington has relied upon source apportionment analysis techniques provided by the WRAP for this RH plan. This information can be found on the WRAP TSS website at http://vista.cira.colostate.edu/TSS/Results/HazePlanning.aspx .

There were two techniques used for source apportionment of RH. One was the Particulate Matter Source Apportionment Technology (PSAT) tool, used only for the attribution of sulfate and nitrate sources. The other was the Weighted Emissions Potential (WEP) tool which was used for attribution of sources of sulfate, nitrate, organic carbon, EC, fine particles ($PM_{2.5}$), and coarse particle matter ($PM_{10}$).

### 7.4.1 Particulate Matter Source Apportionment Technology

The PSAT tool is used with the Comprehensive Air Quality Model with Extensions ($CAM_X$). Like the CMAQ model, the $CAM_X$ model is a state-of-the-science, one atmosphere model. The $CAM_X$/PSAT model system simulates nitrate-sulfate-ammonia chemistry and applies this chemistry to a system of tracers or "tags" to track the emissions, chemical transformations, transport, and removal of Nitrogen Oxides ($NO_x$) and Sulfur Dioxide ($SO_2$). The tracer analysis used the Plan02c baseline period and Base18b projected 2018 emission inventories to identify source regions and source categories of sulfate and nitrate.

WRAP did not regenerate PSAT results for updated baseline period or projected 2018 emission inventories because of the time and resources that running $CAM_X$/PSAT requires. Nonetheless, because later revisions to the WRAP inventory were relatively minor as was the projected impacts on visibility in mandatory Class I Areas, the PSAT source apportionment still serves as a reliable, relative guide to source regions and source categories of sulfate and nitrate.

Sulfate and nitrate are important because not only do they usually originate from anthropogenic (human-caused) sources but they have major impacts on visibility at mandatory Class I Areas. The results from the PSAT analysis can be useful in determining contributing sources that may be controllable within Washington and in identifying potentially controllable sources, or the need for controls, in other jurisdictions (neighboring states, Canada, and Pacific offshore). While the PSAT results show contributions in terms of mass ($\mu g/m^3$), these do not directly represent actual sulfate and nitrate measurements, nor can they accurately be transformed into extinction values.

Examples of PSAT analysis are shown below in Figures 7-1 and 7-2. The PSAT analyses for each of Washington's mandatory Class I Areas are discussed in Chapter 8.

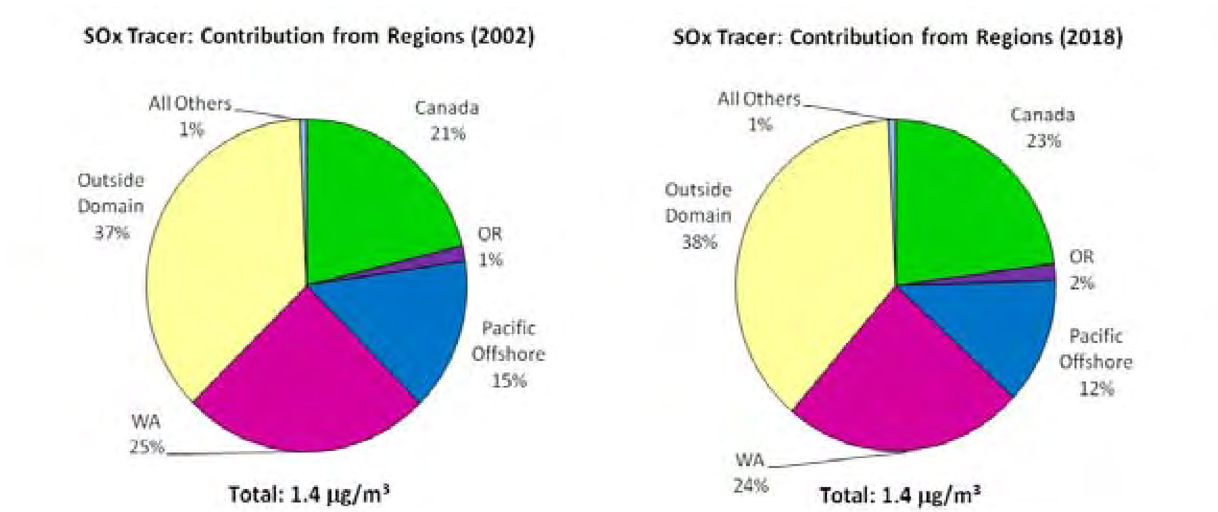



**Figure 7-1 Example of Particulate Matter Source Apportionment Technology Tool Identification of Source Regions**

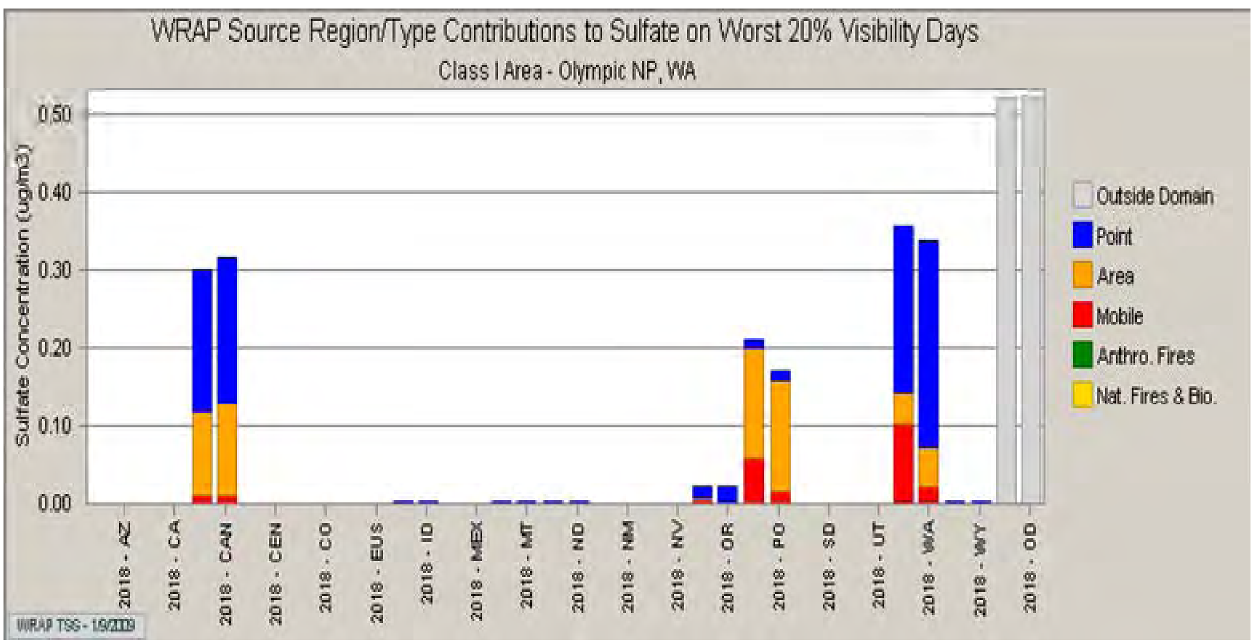



**Figure 7-2 Example of Particulate Matter Source Apportionment Technology Tool Identification of Source Regions and Source Categories**

### 7.4.2 Weighted Emissions Potential

WEP is a screening tool that helps to identify source regions that have the potential to contribute to haze formation at specific mandatory Class I Areas. Unlike PSAT, this method does not account for chemistry or deposition and thus is more qualitative. WEP combines emission inventories, wind patterns, and residence time of an air mass over each meteorological model grid cell, to estimate the potential for a visibility-impairing pollutant to affect a specific mandatory Class I Area. The WEP tool was used to estimate source areas for Sulfur Oxides ($SO_x$), $NO_x$, Primary Organic Aerosol (POA), EC, $PM_{2.5}$, and $PM_{10}$.

Similar to PSAT, the WEP tool evaluates contributing source areas for both the 2000-2004 baseline period and the 2018 projection. The WEP tool is available in TSS for various combinations of the baseline period Plan02d inventory and projected 2018 inventories. This foundational RH SIP used Plan02d and PRP18a inventories.

An example of WEP analysis is shown below in Figure 7-3. Selected WEP analyses for Washington's mandatory Class I Areas are discussed in Chapter 8.

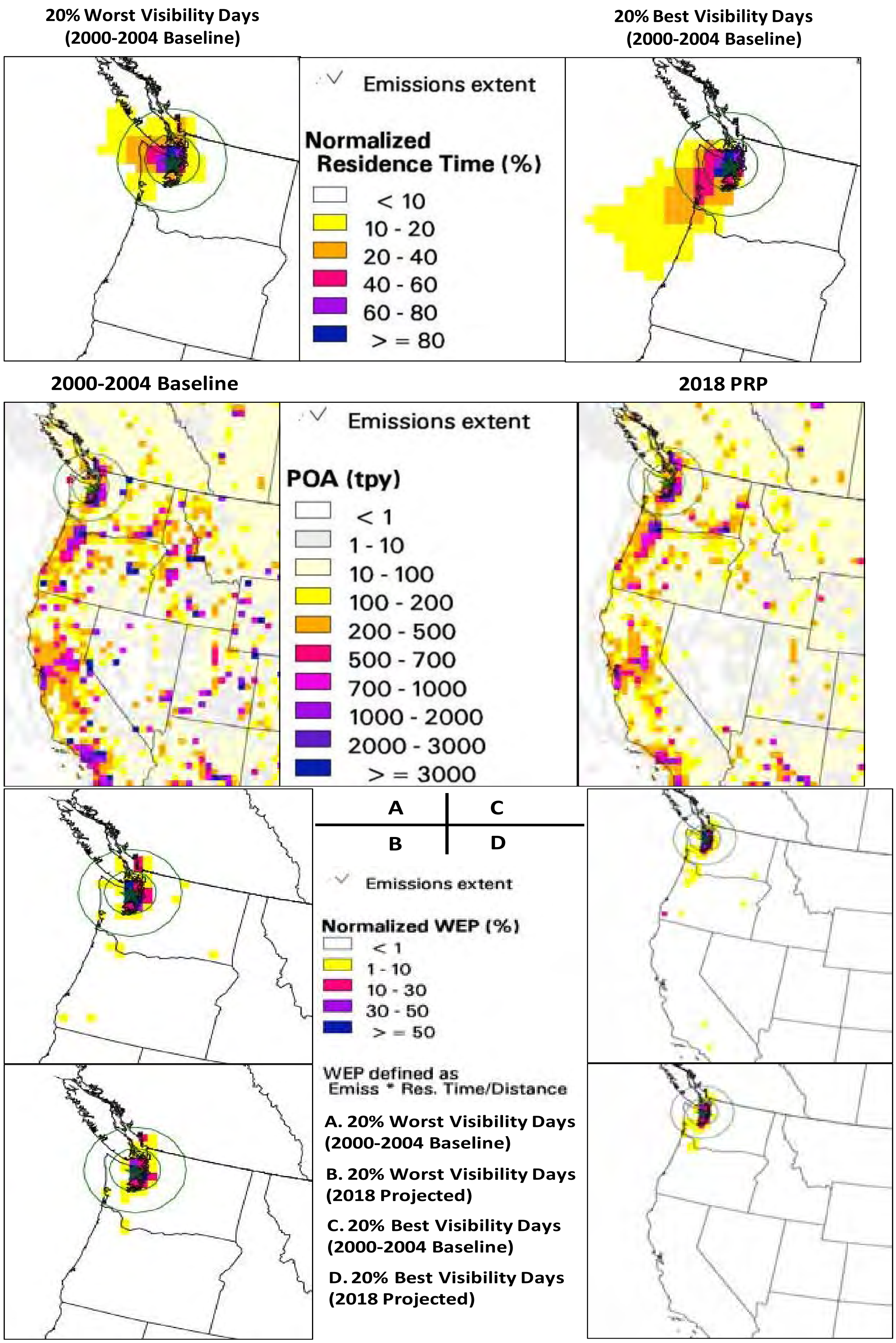



**Figure 7-3 Example of Weighted Emission Potential Results for Primary Organic Aerosol**

## 7.4.3 Differences between the Two Source Apportionment Tools

The PSAT tool was used to identify source regions and sources categories of sulfate and nitrate emissions. The PSAT modeling used the $CAM_X$ model to account for chemistry, transport, and deposition of sulfate and nitrate. The PSAT results estimate contributions from all regions, including the WRAP states, Canada, Pacific offshore, and "outside the domain". PSAT results also estimate contributions for various source categories within the source regions.

The PSAT tool identified three geographic source regions of particular interest to the state of Washington. The three regions are outside the domain, Pacific offshore, and Canada. Outside the domain consists of the background air concentrations of visibility-impairing pollutants contributed by the rest of the world. It cannot be controlled by Washington State.

Pacific offshore emissions consist of emissions from offshore commercial marine shipping. Other marine shipping emissions include near port emissions, and in-shore emissions from cruise, reduced speed zone, and maneuvering and hotelling. Depending upon the type of emissions and where they occur, the federal government, international treaties, or the state may have or share jurisdiction for controlling emissions. The in-shore emissions in this WRAP inventory do not include Canadian vessel traffic within and just outside the Strait of Juan de Fuca, which is located along the north shore of the Olympic Peninsula though the WRAP acknowledges that these emissions affect Washington[1].

The PSAT information indicates that Canadian emissions contribute similar amounts of $NO_x$ and $SO_x$ as Washington state sources, as indicated in Chapter 8. These Canadian emissions primarily affect the northern four Class I Areas (three of which border Canada). As with the outside the domain emissions, these emissions are part of the background entering Washington and cannot be controlled by Washington State.

WEP is a screening tool that does not address chemistry or deposition. WEP does provide a broad overview of potential contributions from within and near Washington for a much larger number of visibility-impairing pollutants than PSAT. WEP does not look at emissions from outside the domain or Pacific offshore.

Overall, while results from both tools provide relative information on sources of visibility-impairing pollutants, the PSAT results are more reliable and the WEP results more qualitative because of the way the results are developed. The PSAT results come from one-atmosphere, photochemical modeling simulations for sulfate and nitrate and thus are a modeling prediction of how emissions impact a mandatory Class I Area. WEP on the other hand estimates impacts from the residence time of the area mass over an area, the total emissions in that area without any consideration of seasonality or time of day, and wind patterns. Both tools are useful so long as the limitations of each are taken into account.

[1] http://vista.cira.colostate.edu/docs/wrap/emissions/OffshoreEmissions.doc

# Chapter 8 Source Apportionment of Washington's Mandatory Class I Areas and Washington's Impacts on Out-of-State Mandatory Class I Areas

This chapter discusses the following:

- Significant in-state and regional sources of haze affecting Washington's mandatory Class I Areas and projected to affect visibility in 2018 and
- Mandatory Class I Areas in states significantly impacted by Washington emissions.

The contributions from each of the Western Regional Air Partnership (WRAP) designated regions and source categories were determined using Particulate Matter Source Apportionment Technology (PSAT) or Weighted Emissions Potential (WEP) which were described in Chapter 7.

This chapter looks at the most important visibility impairing pollutants as defined by Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data. Data are organized by each mandatory Class I Area. Where two mandatory Class I Areas share an IMPROVE monitor the areas are discussed together. Data are presented in the following order:

- Olympic National Park
- North Cascades National Park and Glacier Peak Wilderness
- Alpine Lakes Wilderness
- Mount Rainer National Park
- Goat Rocks Wilderness and Mount Adams Wilderness
- Pasayten Wilderness

Within each mandatory Class I Area, or group of areas, sulfate data for the Most Impaired and Least Impaired Days are presented using PSAT analysis. Next, nitrate data are presented for the Most Impaired Days and Least Impaired Days using PSAT analysis. Organic Mass Carbon (OMC) data are presented using WEP analysis. Data are also presented for the Pasayten Wilderness for Elemental Carbon (EC) which is important at this site.

## 8.1 Olympic National Park

Visibility at Olympic National Park is represented by the OLYM1 IMPROVE monitoring site. The baseline conditions in Chapter 5 show that sulfates (39%), Organic Carbon (OC) (28%), and nitrates (19%) together contribute to 86% of the light extinction on the Most Impaired Days. On the Least Impaired Days sulfates (36%), OC (26%), and nitrates (17%) contributed to 79% of the light extinction at OLYM1.

### 8.1.1 Sulfates

Monitoring data show that sulfates were the highest contributor to haze on both the Most Impaired and Least Impaired Days in 2002.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days in 2002 sulfate emissions come primarily from outside the modeling domain (37%), Canada (21%) and Pacific offshore (15%). All of these source areas are beyond Washington's control. Washington sources emitted 25% of the sulfates responsible for haze at this monitoring site.

In comparison, the projected sulfate concentration in 2018 is the same and the relative contribution from the various source regions is almost identical. Additional detail is shown in Figure 8-1.

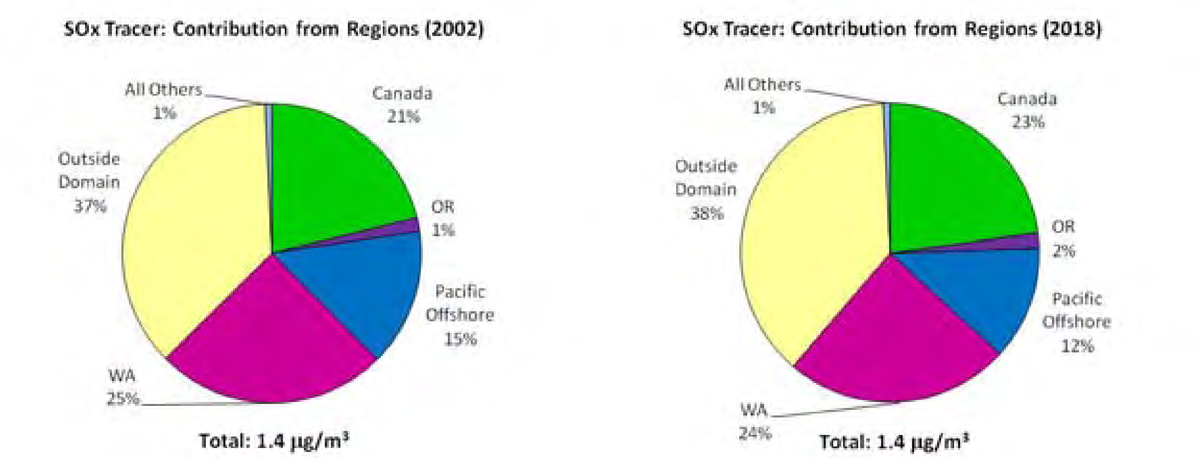



**Figure 8-1 Sulfate Contributions by Source Regions for Most Impaired Days at OLYM1**

Figure 8-2 shows the source regions and source categories that contribute sulfate at the OLYM1 monitoring site on the Most Impaired Days. In 2002, Washington point sources contributed to 15% of the total contribution to light extinction by sulfates, followed by mobile sources (7%) and area sources (3%). In 2018, Washington point sources are expected to contribute to 19% of the total light extinction by sulfates, followed by area sources (4%) and mobile sources (1%).

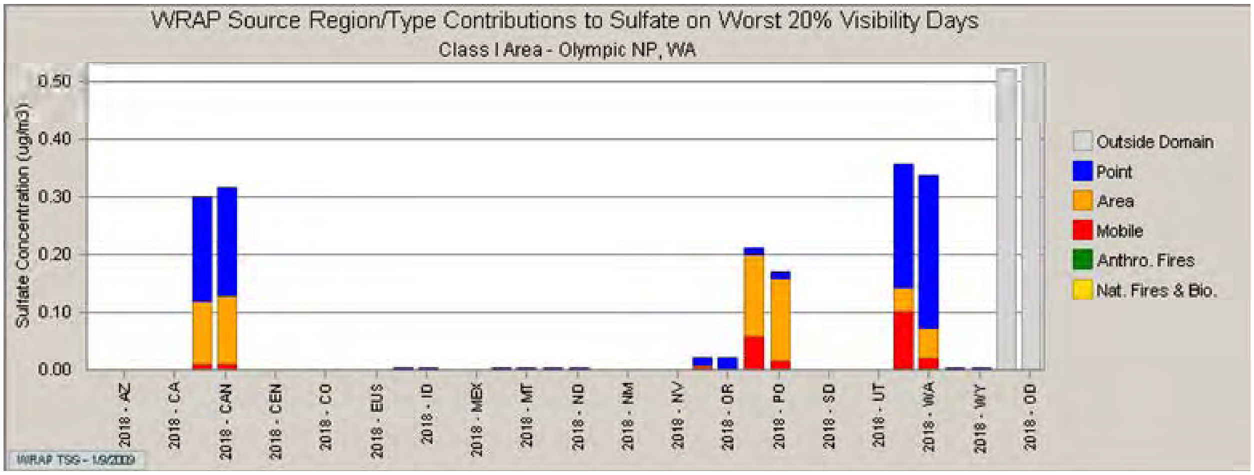



**Figure 8-2 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at OLYM1**

### Least Impaired Days

The PSAT tracer analysis sulfate emissions on the Least Impaired Days in 2002 came primarily from sources outside modeling domain (39%) and within Washington (34%). Compared with the most impaired days in 2002, contributions from Canada diminished while contributions from Oregon increased. Point, area and mobile sources are still the three major source categories which contribute to light extinction by sulfates.

In comparison to the Least Impaired Days in 2002, the projected sulfate concentration in 2018 decreases by 0.1 µg/m$^3$ and the relative contributions from the source regions change. The most significant change is a 5% reduction in relative contribution from Washington sources while the relative contributions from sources outside the modeling domain increase by 4%. Additional details are shown in Figure 8-3.

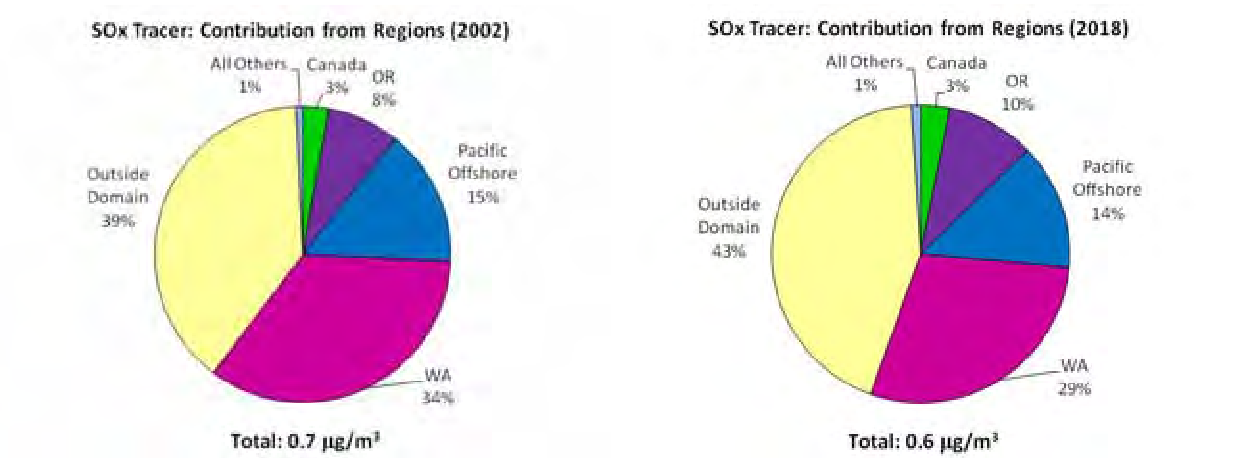



**Figure 8-3 Sulfate Contributions by Source Regions for Least Impaired Days at OLYM1**

Figure 8-4 shows the source regions and source categories that contribute sulfate at the OLYM1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to

18% of the total contribution to light extinction by sulfates, followed by mobile sources (10%) and area sources (6%). In 2018, Washington point sources are expected to contribute to 18% of the total light extinction by sulfates, followed by area sources (8%) and mobile sources (2%).

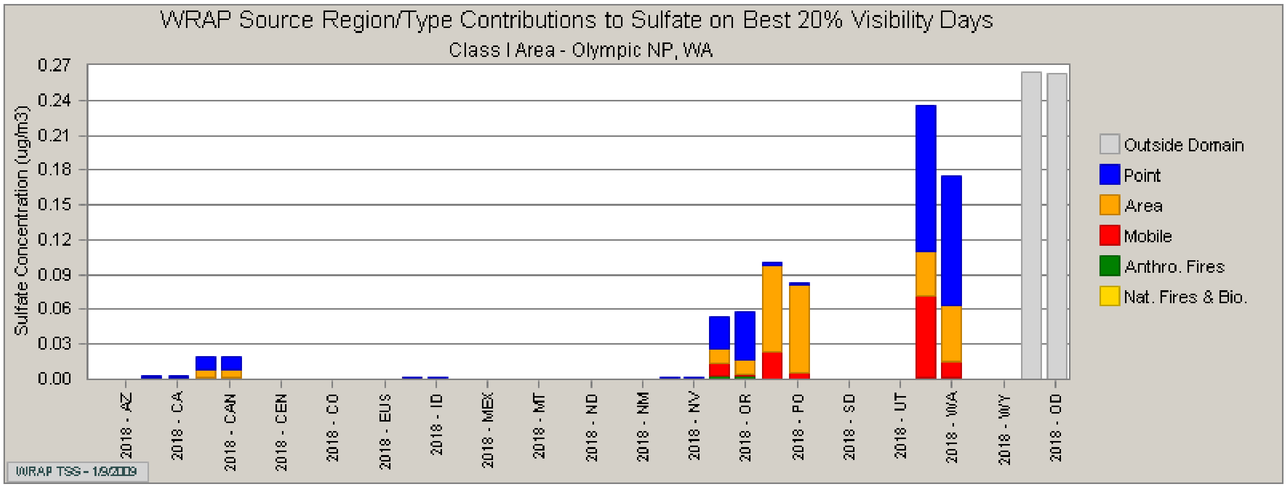



**Figure 8-4 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at OLYM1**

## 8.1.2 Nitrates

Monitoring data indicate that nitrates were the third highest contributor to haze in 2002 on both the Most Impaired and Least Impaired Days at the OLYM1 site.

### Most Impaired Days

Washington sources are responsible for 53% of the nitrates on the Most Impaired Days in 2002, followed by Canada (21%) and Pacific offshore (15%).

In comparison to the Least Impaired Days in 2002, on the Most Impaired Days the projected nitrate concentration in 2018 decreases 0.3 µg/m$^3$. The most significant change is an 11% reduction in contributions from Washington sources while the contributions from Canada, outside the modeling domain, and Pacific offshore sources increase. Additional detail is shown in Figure 8-5.

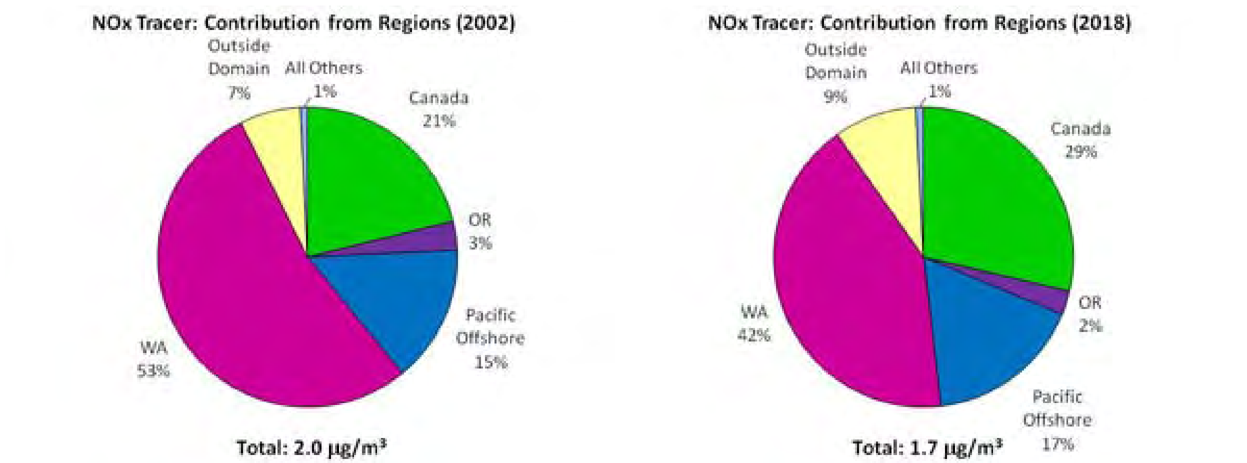



**Figure 8-5 Nitrate Contributions by Source Regions for Most Impaired Days at OLYM1**

Figure 8-6 shows the source regions and source categories that contribute nitrate at the OLYM1 monitoring site on the Most Impaired Days. Washington mobile sources contributed to 40% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by point sources (9%), area sources (3%), and natural fires and biogenic sources (1%). In 2018, Washington mobile sources are expected to contribute to 19% of the total light extinction by nitrates, followed by point sources (15%), area sources (6%), and natural fires and biogenic sources (1%).

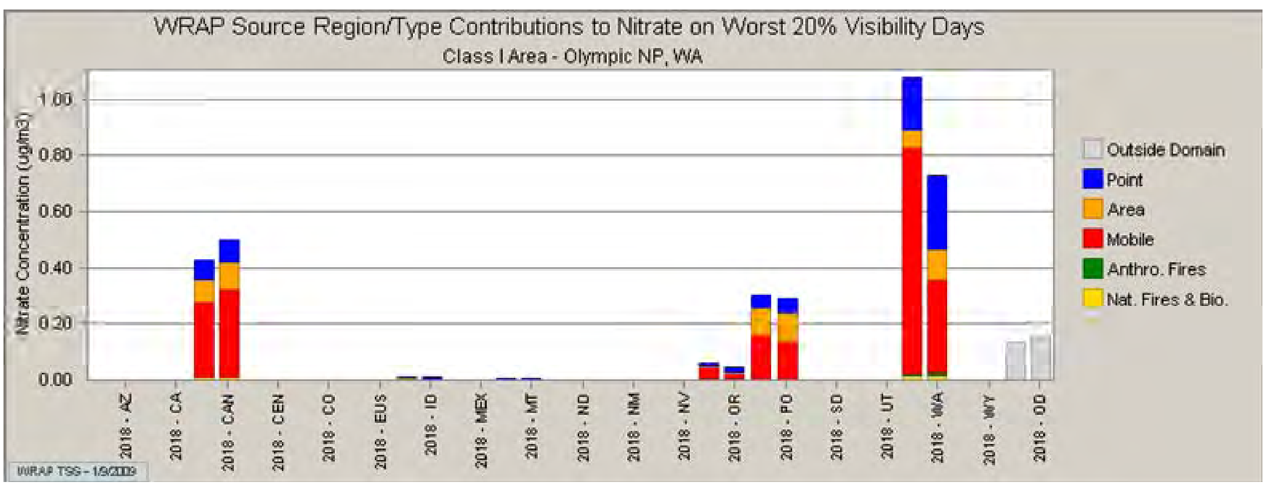



**Figure 8-6 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at OLYM1**

**Least Impaired Days**

Compared to the worst days in 2002, on the Least Impaired Days the percentage contribution to visibility impairment from Canada decreased while Oregon's contribution increased. No other major changes from Most Impaired Days have been observed on the Least Impaired Days for 2002.

In comparison to the Least Impaired Days in 2002, the projected nitrate concentration in 2018 decreases 0.4 µg/m$^3$. The relative contributions from Washington sources decrease by 7% while contributions from outside the modeling domain, Canada, and Pacific offshore increase by 8%. Additional detail is shown in Figure 8-7.

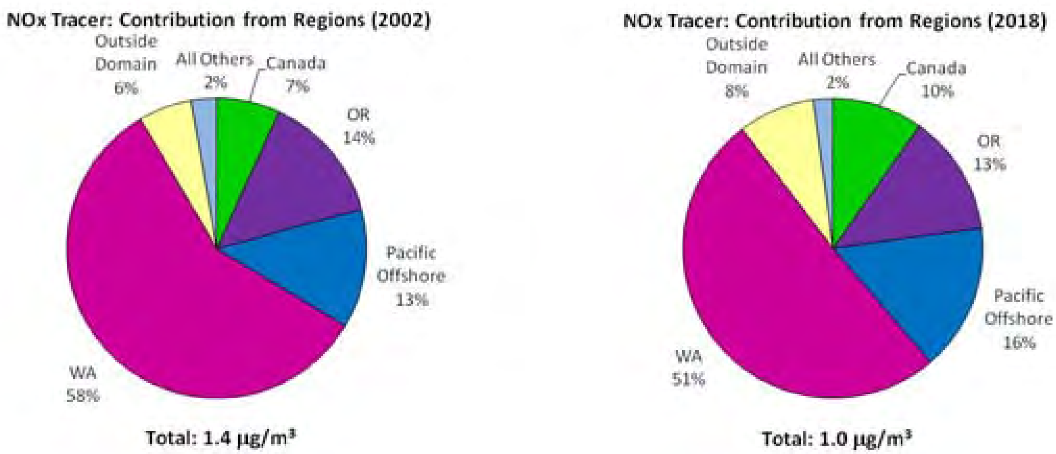



**Figure 8-7 Nitrate Contributions by Source Regions for Least Impaired Days at OLYM1**

Figure 8-8 shows the source regions and source categories that contribute nitrate at the OLYM1 monitoring site on the Least Impaired Days. In 2002, Washington mobile sources contributed to 45% of the total contribution to light extinction by nitrates, followed by point sources (8%), area sources (4%), and natural fire and biogenic sources (1%). The source categories contribute differently in 2018. In 2018, Washington mobile sources are expected to contribute to 26% of the total light extinction by nitrates on the Least Impaired Days, followed by point sources (15%), area sources (9%), and natural fire and biogenic sources (1%).

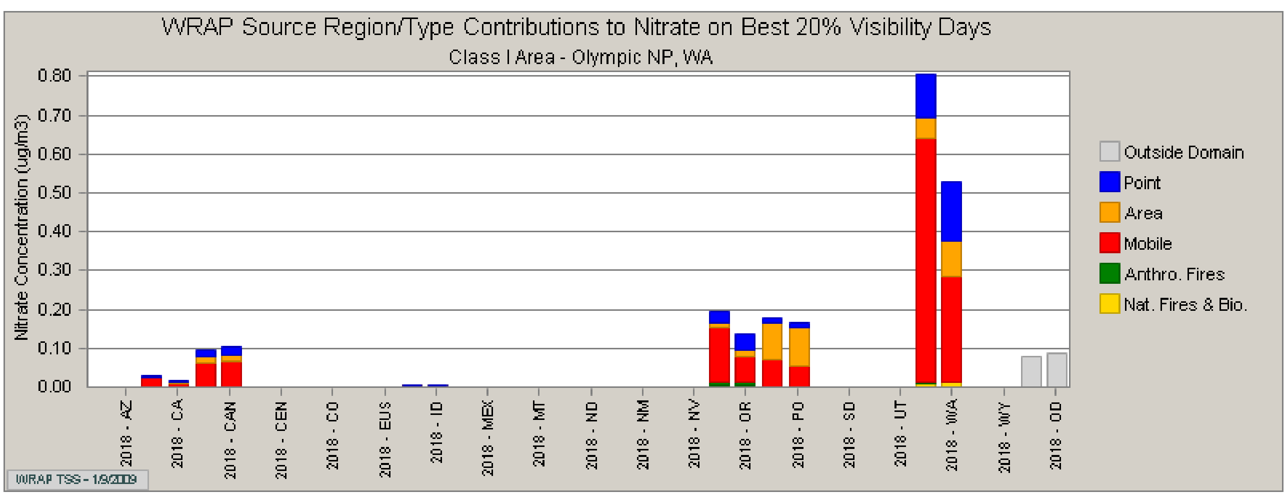



**Figure 8-8 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at OLYM1**

### 8.1.3 Organic Mass Carbon

Monitoring indicates that after sulfates, OMC is the second highest cause of light extinction on both the Most Impaired and Least Impaired Days at the OLYM1 site in 2002.

As described in Chapter 7, the WEP tool helps identify source regions of OMC.  WEP combines emission inventories, wind patterns, and the residence time of the air mass over each area where emissions occur to estimate the percent contribution from each source area.

While OMC is calculated from the amount of OC measured by the IMPROVE filter, neither OMC nor OC are directly represented in emission inventories. OMC consists of Primary Organic Aerosol (POA) emissions and secondary OMC compounds.  The primary compounds are emitted directly as particulates; the secondary compounds condense from emitted Volatile Organic Compounds (VOCs).

WEP uses POA emissions to estimate the contribution from source areas within WRAP states and from Canada and Pacific offshore.  WEP does not provide an estimate of the background contribution from outside the domain.

As WEP indicates, most of the OMC emissions come from the Puget Sound areas.  Additional detail is shown in Figure 8-9.

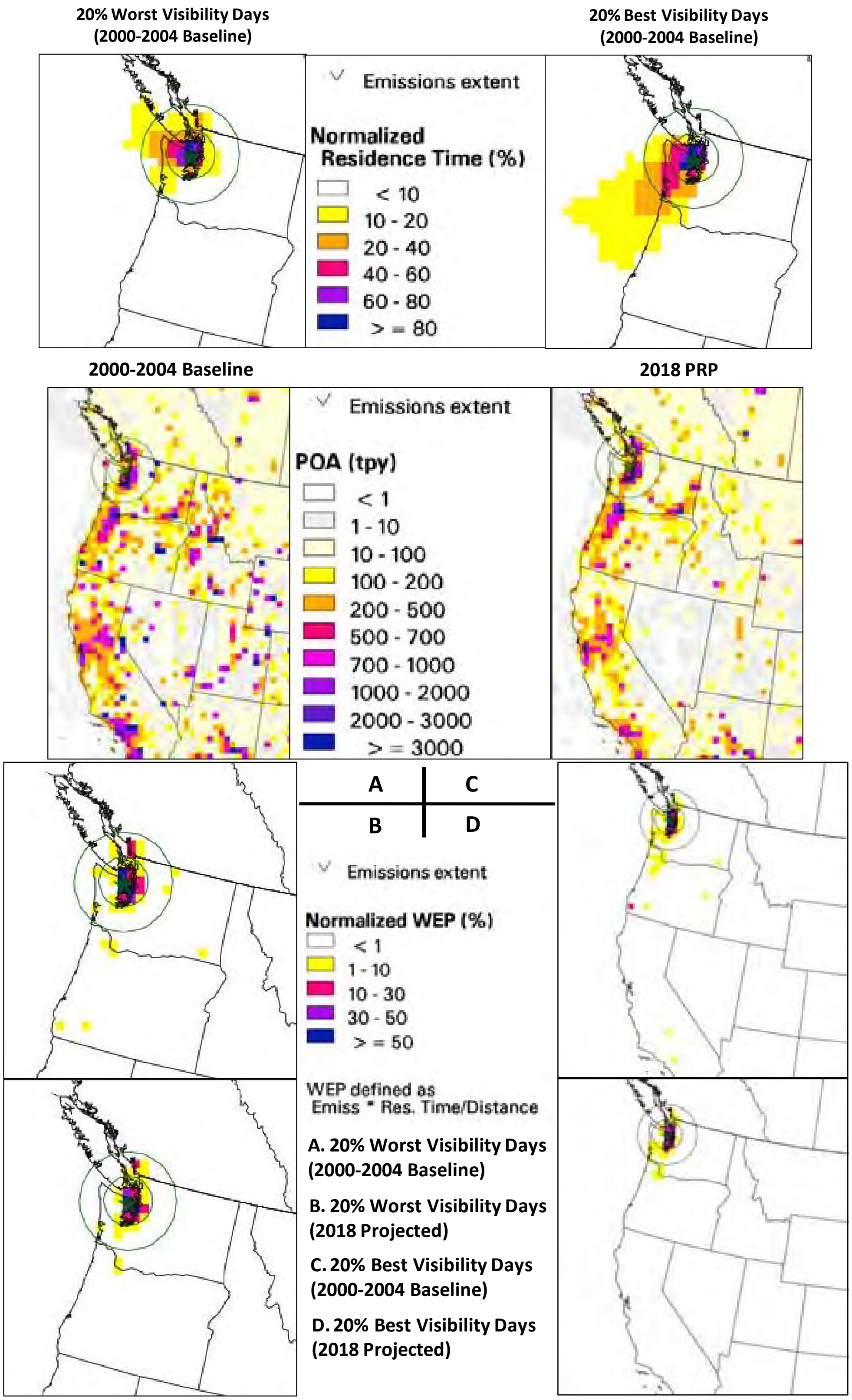



**Figure 8-9 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at OLYM1**

For both the Most Impaired and Least Impaired Days in 2002 and 2018, area sources are the predominant sources. The emissions from this source are projected to increase 19% on the Most Impaired Days and 21% on the Least Impaired Days during the first planning period. The relative contributions from other sources are also shown in Figures 8-10 and 8-11.

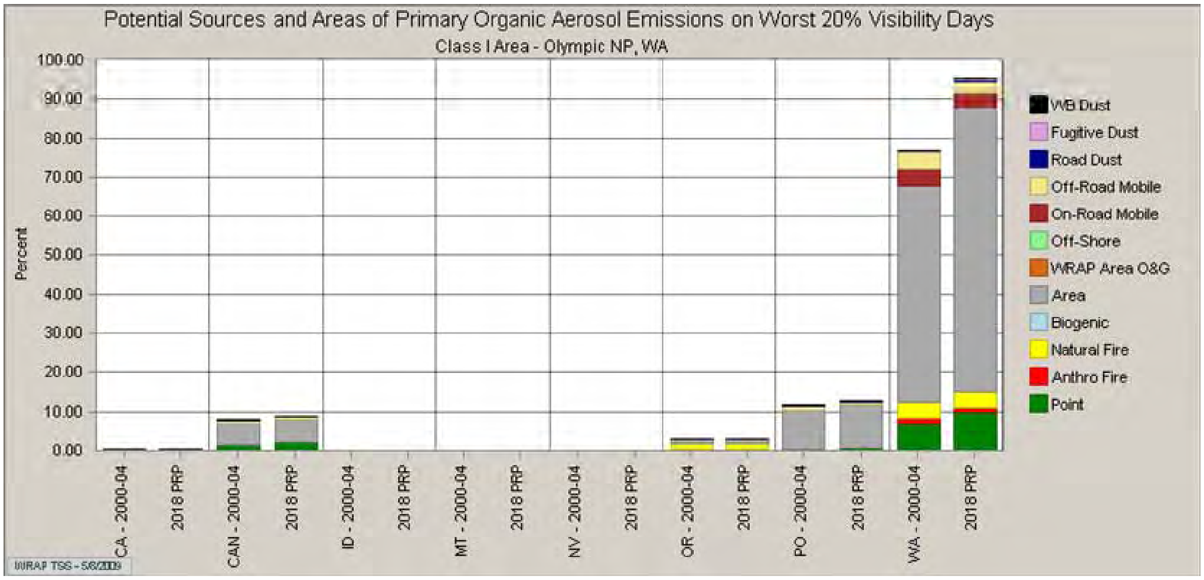



**Figure 8-10 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Most Impaired Days at OLYM1**

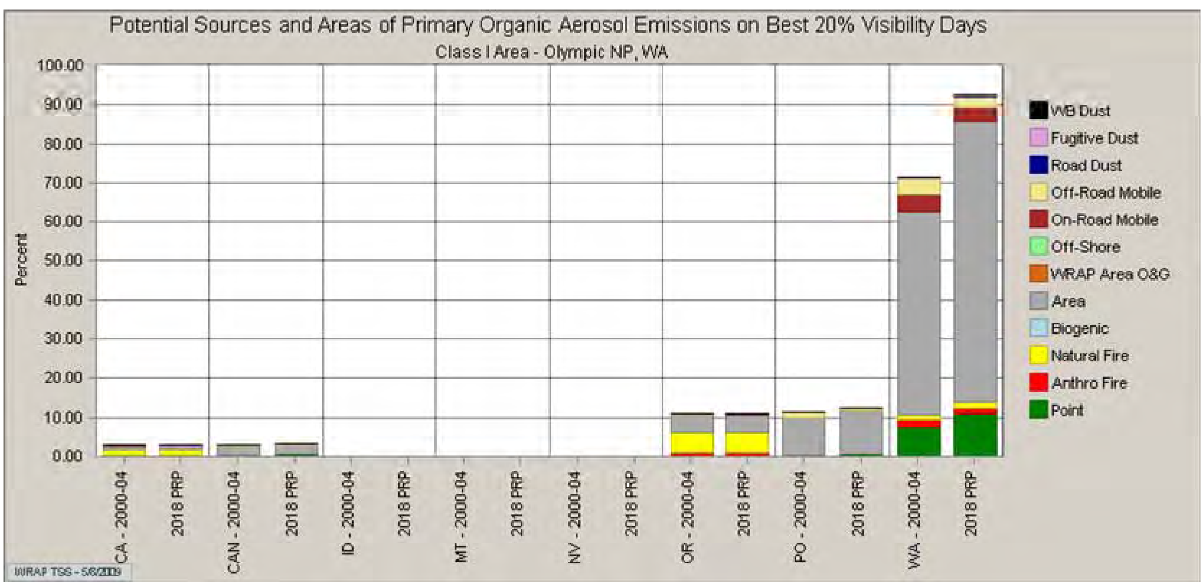



**Figure 8-11 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Least Impaired Days at OLYM1**

## 8.2 North Cascades National Park and Glacier Peak Wilderness

The North Cascades National Park and Glacier Peak Wilderness areas are represented by the NOCA1 IMPROVE monitoring site. The baseline conditions in Chapter 5 show that together

OC (58%), sulfates (26%), and nitrates (5%) contributed to 89% of the light extinction on the Most Impaired Days at this monitoring site. On the Least Impaired Days sulfates (45%), OC (21%), and nitrates (14%) contributed to 80% of the light extinction at this monitoring site.

In 2003 there were many wildfires in or near North Cascades National Park and Glacier Peak Wilderness. The 2003 data from this high wildfire year was included in the source apportionment analysis below. The baseline conditions in Chapter 5 were presented with and without the 2003 monitoring data. The time and resources were not available to re-run the source apportionment analysis without the 2003 data to show wildfire impacts on visibility impairment.

## 8.2.1 Sulfates

Monitoring data show that sulfates were the second highest contributor to haze on the Most Impaired Days and the highest contributor to haze on the Least Impaired Days at this site.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days for 2002 sulfate emissions came primarily from outside the modeling domain (32%), Washington (29%), and Canada (28%). Sulfate sources outside of the modeling domain and Canada are beyond state or local control.

In comparison, the projected sulfate concentration in 2018 decreases 0.1 μg/m$^3$ and the relative contribution from the various source categories is almost identical. For Washington sulfate emissions, the relative contribution is the same in 2002 and 2018. Additional detail is shown in Figure 8-12.

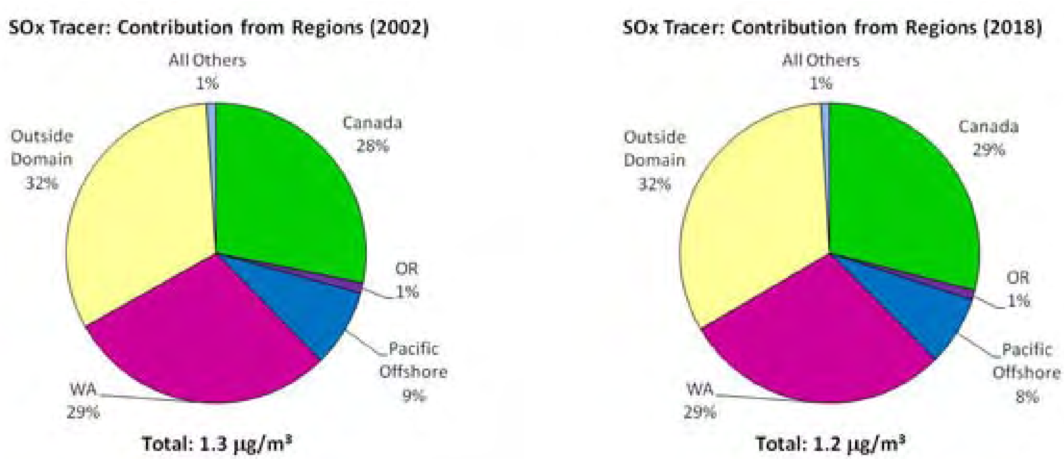



**Figure 8-12 Sulfate Contributions by Source Regions for Most Impaired Days at NOCA1**

Figure 8-13 shows the source regions and source categories that contribute sulfate at the NOCA1 monitoring site on the Most Impaired Days. In 2002, Washington point sources contributed to 20% of total contribution to light extinction by sulfates, followed by mobile sources (5%), area sources (3%), and natural fire and biogenic sources (1%). In 2018, Washington point sources are expected to contribute to 24% of the total light extinction by sulfates, followed by area sources (3%), mobile sources (1%), and natural fire and biogenic sources (1%).

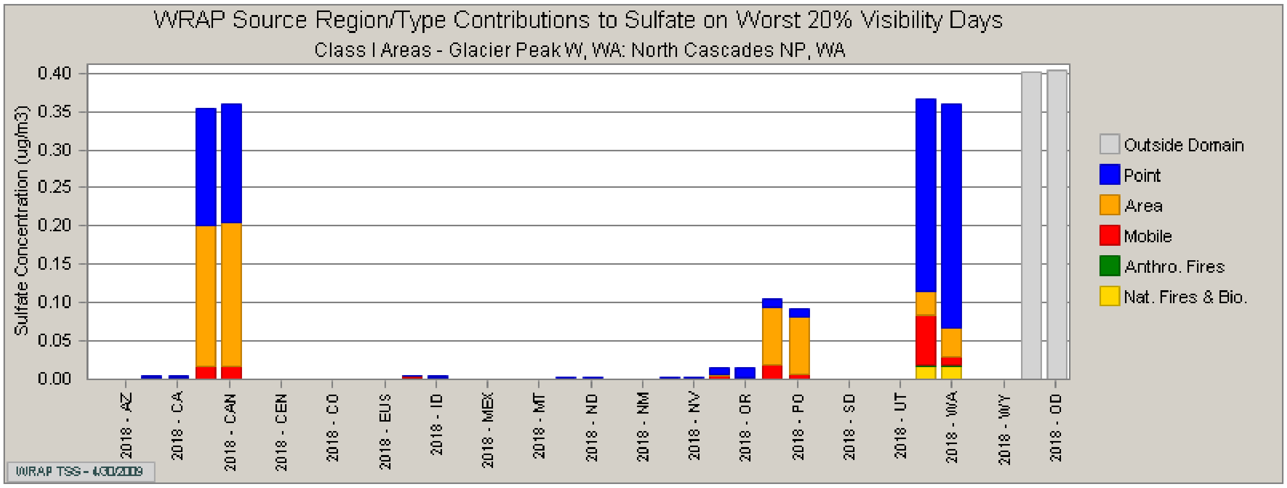



**Figure 8-13 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at NOCA1**

**Least Impaired Days**

The PSAT tracer analysis shows that on the Least Impaired Days in 2002 sulfate emissions come primarily from outside the modeling domain (40%) and Washington (39%). Compared to the Most Impaired Days, on the Least Impaired Days Canada contributes far less while Oregon's contribution slightly increases.

In comparison to the Least Impaired Days in 2002, the projected sulfate concentration in 2018 is the same. The most significant change is a 6% reduction in contribution from Washington sources while the contributions from sources outside the modeling domain, Oregon, and Canada increase by the same amount. Additional detail is shown in Figure 8-14.

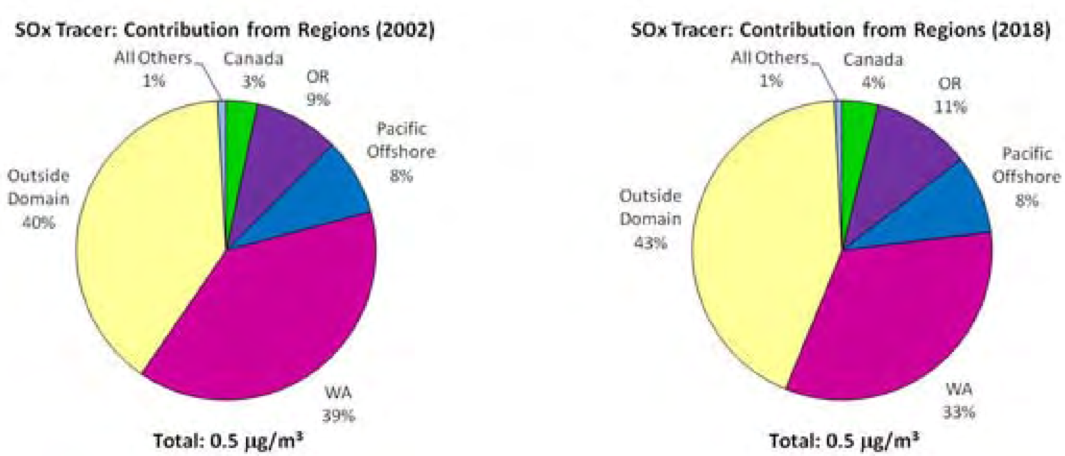



**Figure 8-14 Sulfate Contributions by Source Regions for Least Impaired Days at NOCA1**

Figure 8-15 shows the source regions and source categories that contribute sulfate at the NOCA1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to

23% of the total contribution to light extinction by sulfates, followed by mobile sources (10%), area sources (5%), and natural fire and biogenic sources (2%). In 2018, Washington point sources are expected to contribute to 24% of the total light extinction by sulfates, followed by area sources (8%), natural fire and biogenic sources (4%), and mobile sources (1%).

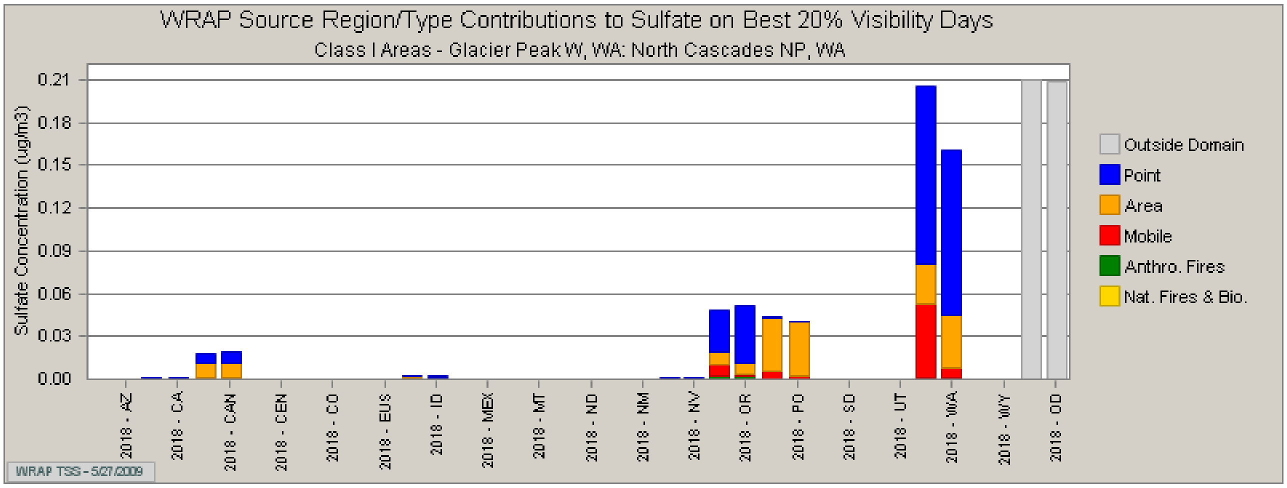



**Figure 8-15 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at NOCA1**

## 8.2.2 Nitrates

Monitoring data indicate that nitrates are the third highest contributor to haze in 2002 on both the Most Impaired and Least Impaired Days.

**Most Impaired Days**

Washington sources are responsible for 46% of the nitrates, followed by Canada (27%), outside the modeling domain (16%) and Pacific offshore (7%) sources.

In comparison to the Most Impaired Days in 2002, the projected sulfate concentration in 2018 decreases 0.1 µg/m$^3$. The most significant change is a 15% reduction in relative contribution from Washington sources. The relative contributions from sources in Canada and outside the modeling domain increase by 14%. Additional detail is shown in Figure 8-16.

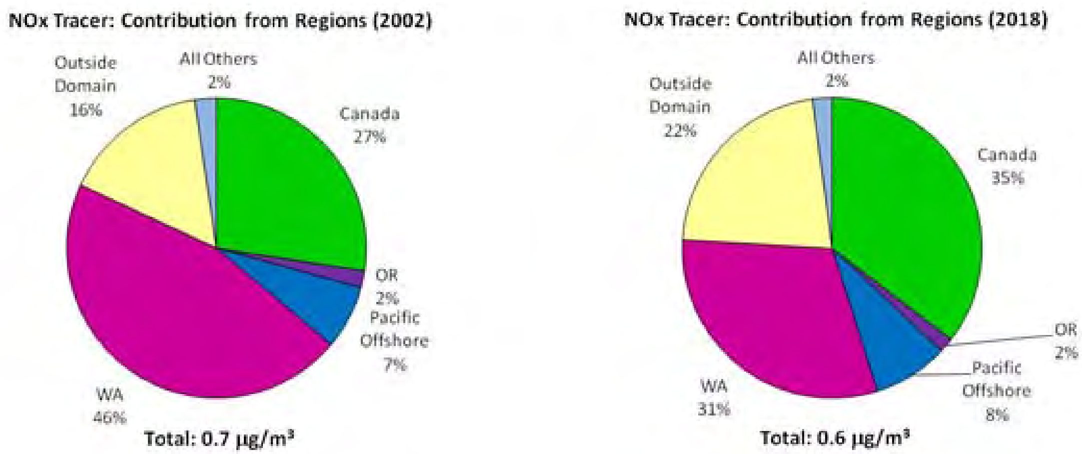



**Figure 8-16 Nitrate Contributions by Source Regions for Most Impaired Days at NOCA1**

Figure 8-17 shows the source regions and source categories that contribute nitrate at the NOCA1 monitoring site on the Most Impaired Days. Washington mobile sources contributed to 34% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by point sources (6%), natural fire and biogenic sources (3%), and area sources (2%). In 2018, Washington mobile sources are expected to contribute to 14% of the total light extinction by nitrates, followed by point sources (9%), natural and biogenic sources (4%) and area sources (4%).

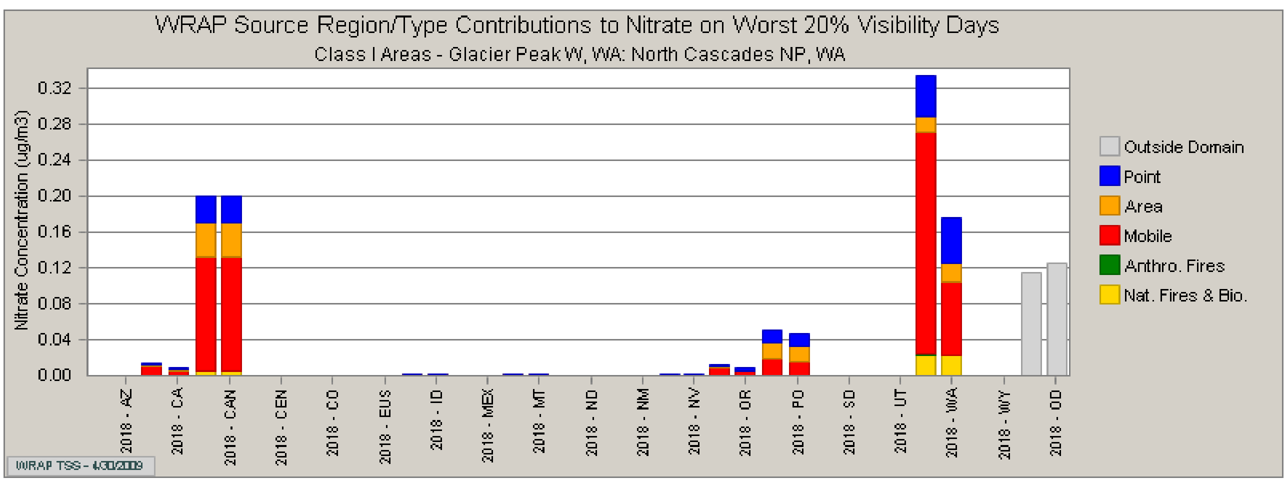



**Figure 8-17 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at NOCA1**

**Least Impaired Days**

On the Least Impaired Days in 2002 Washington nitrate sources become even more dominant, contributing to 63% of the light extinction, followed by Oregon (13%) and outside the modeling domain (10%).

In comparison to the Least Impaired Days in 2002, the projected nitrate concentration in 2018 decreases 0.4 µg/m$^3$. The relative contributions from Washington sources decrease by 12%

while contributions from outside the modeling domain, Canada, and Pacific offshore increase by 12%. Additional detail is shown in Figure 8-18.

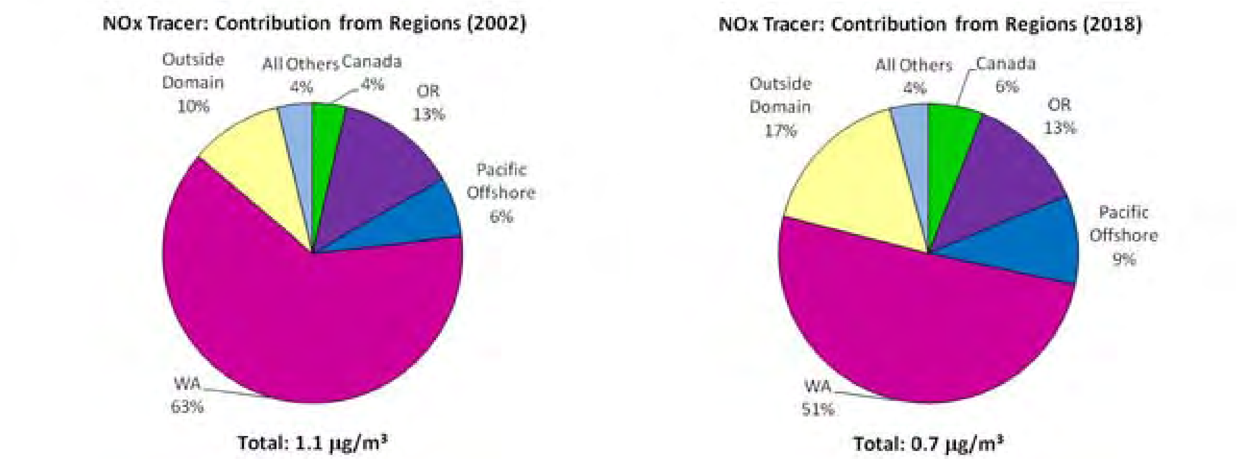



**Figure 8-18 Nitrate Contributions by Source Regions for Least Impaired Days at NOCA1**

Figure 8-19 shows the source regions and source categories that contribute nitrate at the NOCA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 51% of the total contribution to light extinction by nitrates on the Least Impaired Days in 2002, followed by point sources (6%), areas sources (3%), and natural fire and biogenic sources (2%). In 2018, Washington mobile sources are expected to contribute to 29% of the total light extinction by nitrates, followed by point sources (11%), area sources (7%), and natural and biogenic sources (4%).

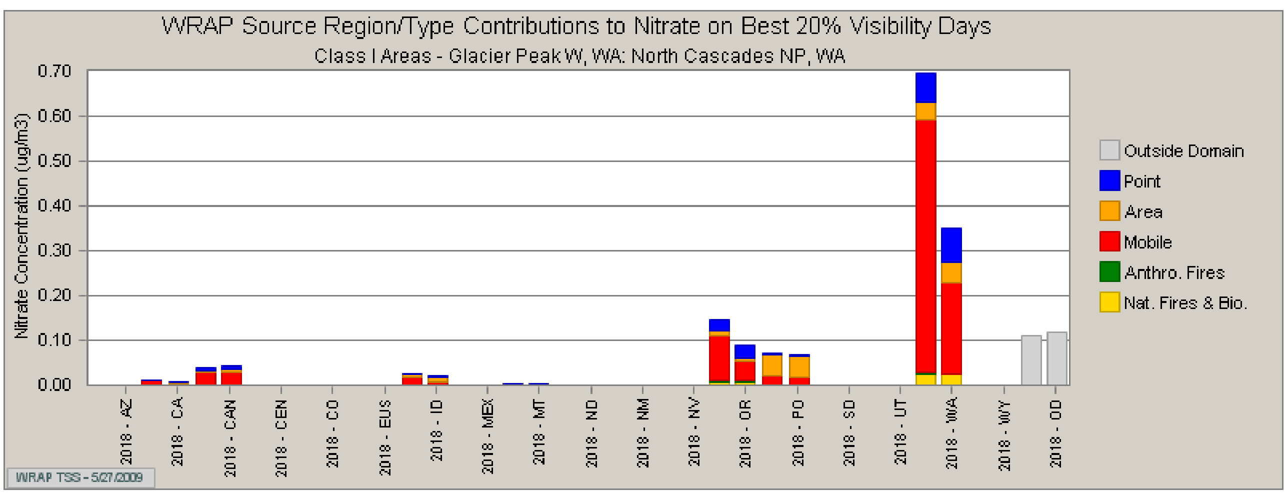



**Figure 8-19 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at NOCA1**

### 8.2.3 Organic Mass Carbon

Monitoring data indicate that OMC is the highest cause of light extinction on the Most Impaired Days and second highest cause of light extinction on the Least Impaired Days at the NOCA1 site.

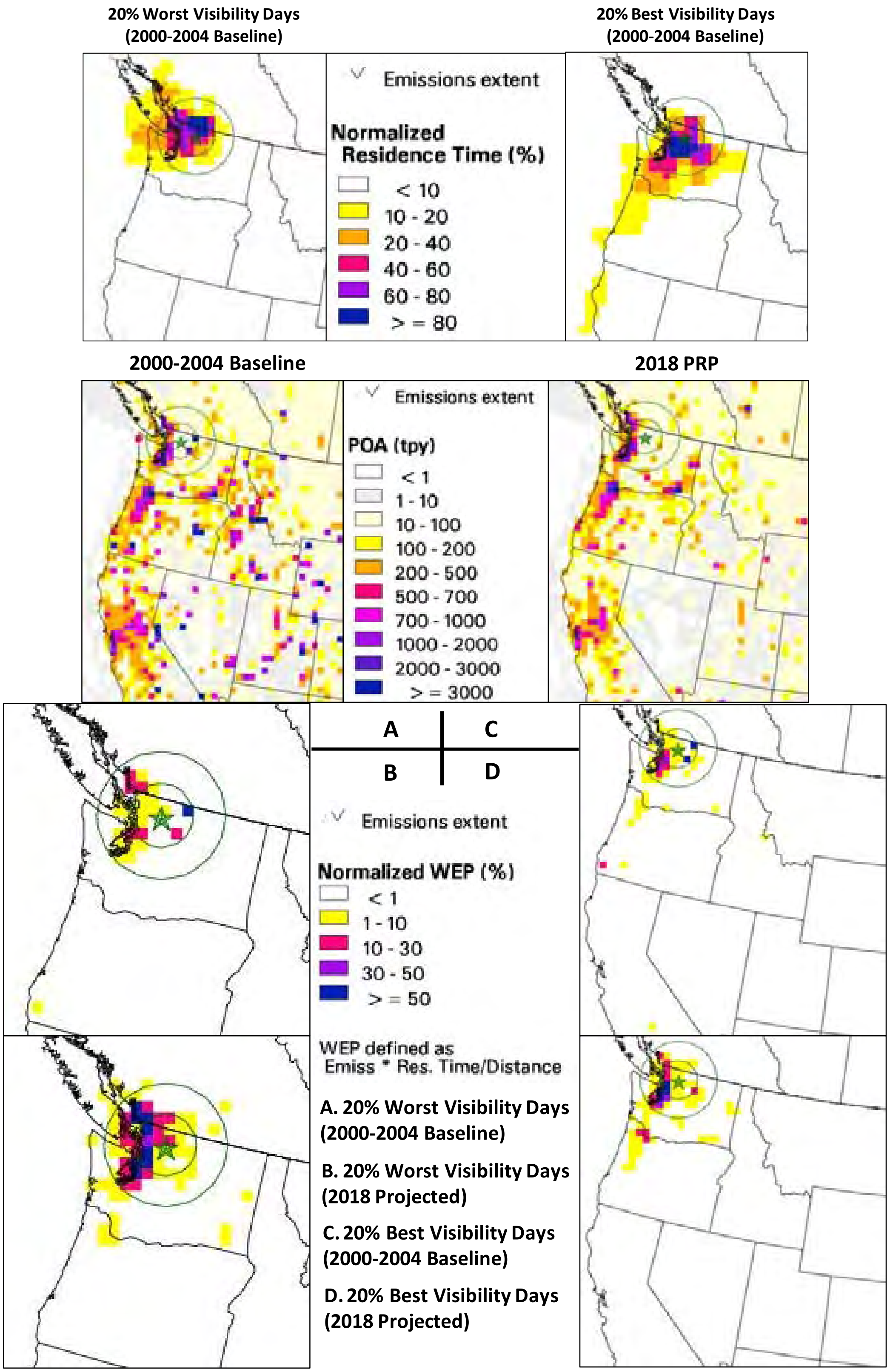



**Figure 8-20 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at NOCA1**

WEP indicates that most of the OMC emissions come from within Washington. Additional detail is shown in Figure 8-20.

For both Most Impaired and Least Impaired Days in 2002 and 2018 natural fire and area sources are the predominant sources of OMC. The emissions from natural fire were held constant in the modeling. Area sources are projected to increase slightly during the first planning period. The relative contributions from other sources are also shown in Figures 8-21 and 8-22.

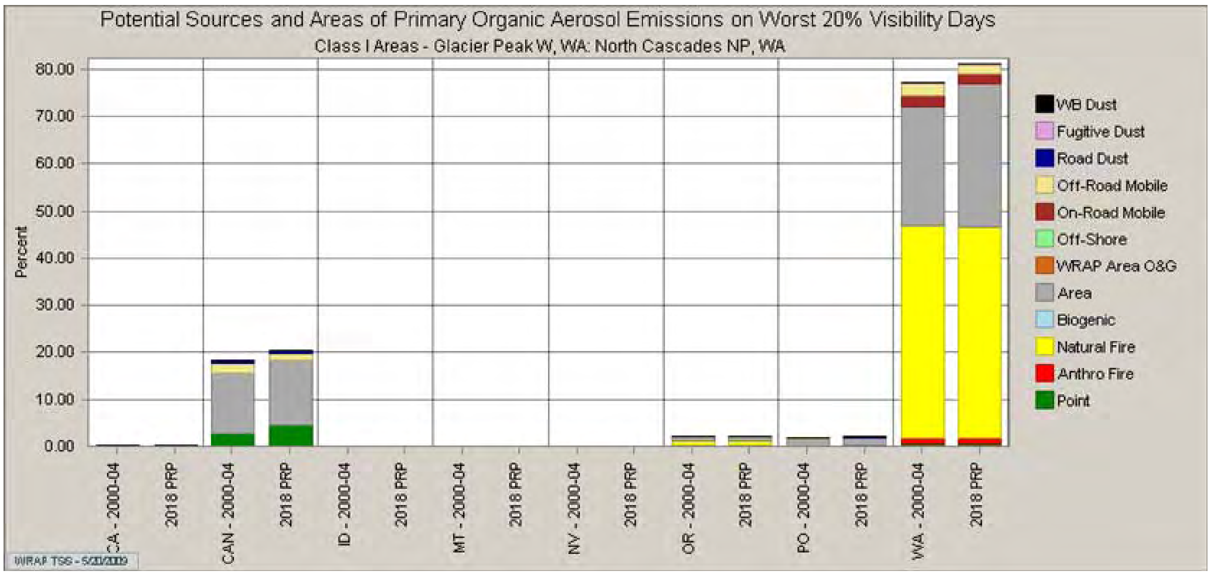



**Figure 8-21 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Most Impaired Days at NOCA1**

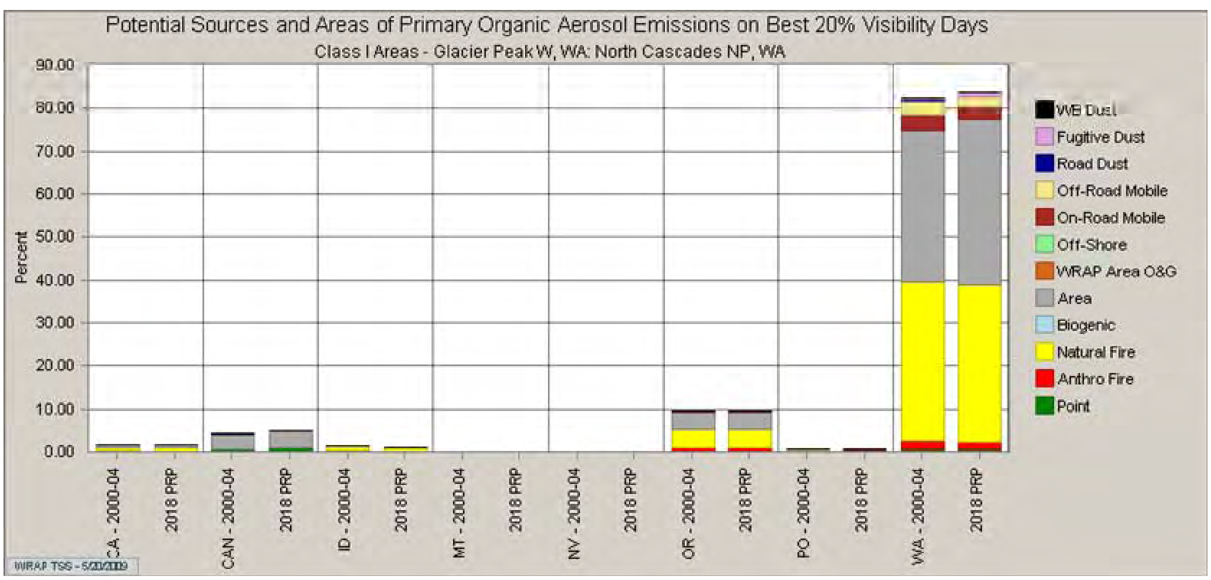



**Figure 8-22 Organic Aerosol Contributions by Source Regions for 2002 and 2018 Least Impaired Days at NOCA1**

## 8.3 Alpine Lakes Wilderness

Alpine Lakes Wilderness is represented by the SNPA1 IMPROVE monitoring site. The baseline conditions in presented in Chapter 5 show that sulfates (34%), OC (30%), and nitrates (23%) together contribute to 87% of the light extinction on the Most Impaired Days at this site. On the Least Impaired Days sulfates (40%), nitrates (18%), and OC (16%) contribute to 74% of the light extinction at this monitoring site.

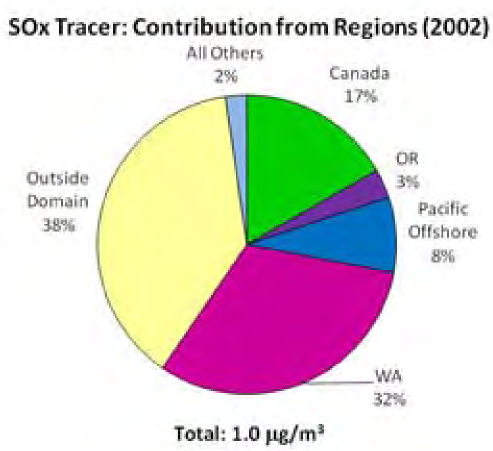
### 8.3.1 Sulfates

Monitoring data show that sulfates were the highest contributor to haze on both the Most Impaired and Least Impaired Days in 2002 at the SNPA1 site.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days for 2002 sulfate emissions come primarily from outside the modeling domain (38%), closely followed by from Washington's own sources (32%). In addition, a small portion is from Canada (17%) and Pacific offshore (8%) sources. Sulfate sources outside of the modeling domain, in Canada and from Pacific offshore are beyond state or local control.

In comparison, the projected sulfate concentration in 2018 is the same. There is some change in the contributions between source regions. Washington sources decrease their contributions by 4% while sources outside the modeling domain and Canada increase by 4%.



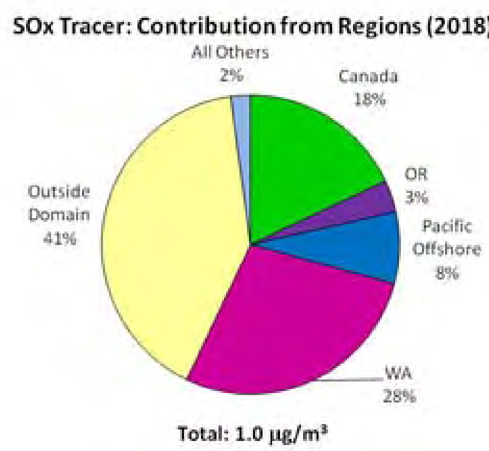




**Figure 8-23 Sulfate Contributions by Source Regions for Most Impaired Days at SNPA1**

Figure 8-24 shows the source regions and source categories that contribute sulfate at the SNPA1 monitoring site on the Most Impaired Days. In 2002, Washington point sources contributed to 16% of the total contribution to light extinction by sulfates, followed by mobile sources (10%) and area sources (5%). In 2018, Washington point sources are expected to contribute to 19% of the total light extinction by sulfates, followed by area sources (6%), and mobile sources (3%).

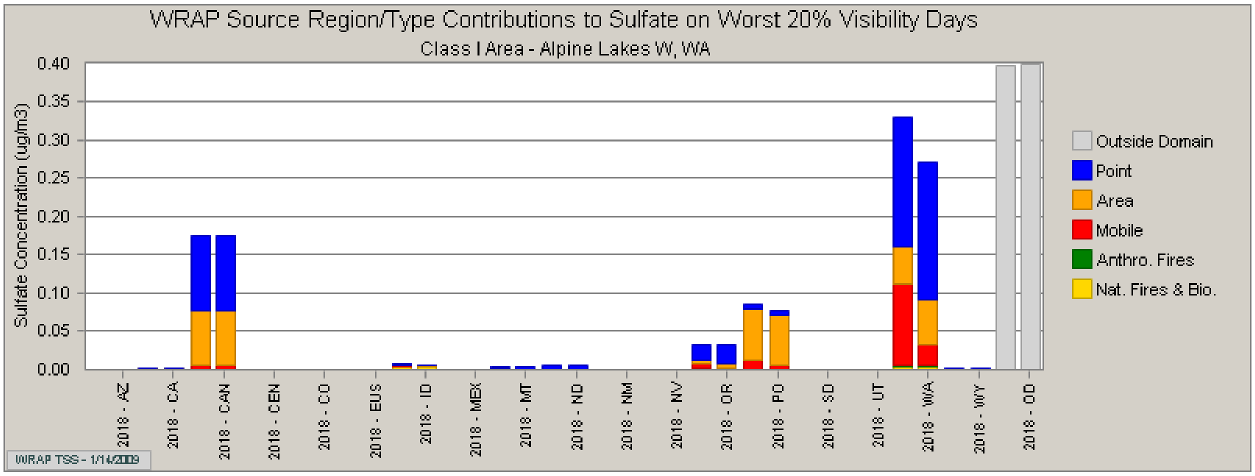



**Figure 8-24 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at SNPA1**

**Least Impaired Days**

The PSAT tracer analysis for the Least Impaired Days in 2002 shows that while Washington and Oregon contributed a greater percentage of sulfates than on the Most Impaired Days. Sulfate emissions from outside the modeling domain are the dominant contributor on the Least Impaired Days.

In comparison to the Least Impaired Days in 2002, the projected sulfate concentration in 2018 is the same. There is some change in the contributions between source regions. Washington sources decrease their contributions by 7% while sources from outside the modeling domain, Pacific offshore and Oregon increase by 7%.

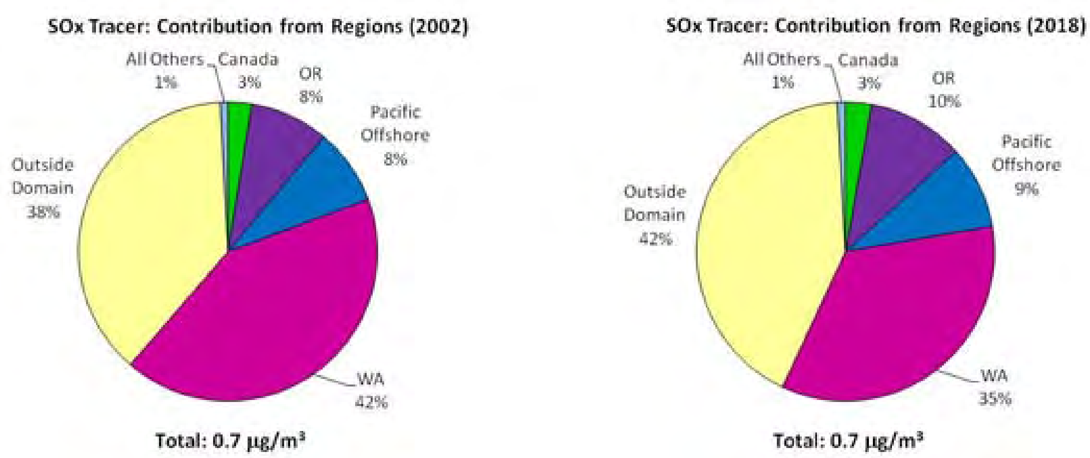



**Figure 8-25 Sulfate Contributions by Source Regions for Least Impaired Days at SNPA1**

Figure 8-26 shows the source regions and source categories that contribute sulfate at the SNPA1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to 26% of the total contribution to light extinction by sulfates, followed by mobile sources (11%), and area sources (5%). In 2018, Washington point sources are expected to contribute to 25% of the total light extinction by sulfates, followed by area sources (7%), and mobile sources (2%).

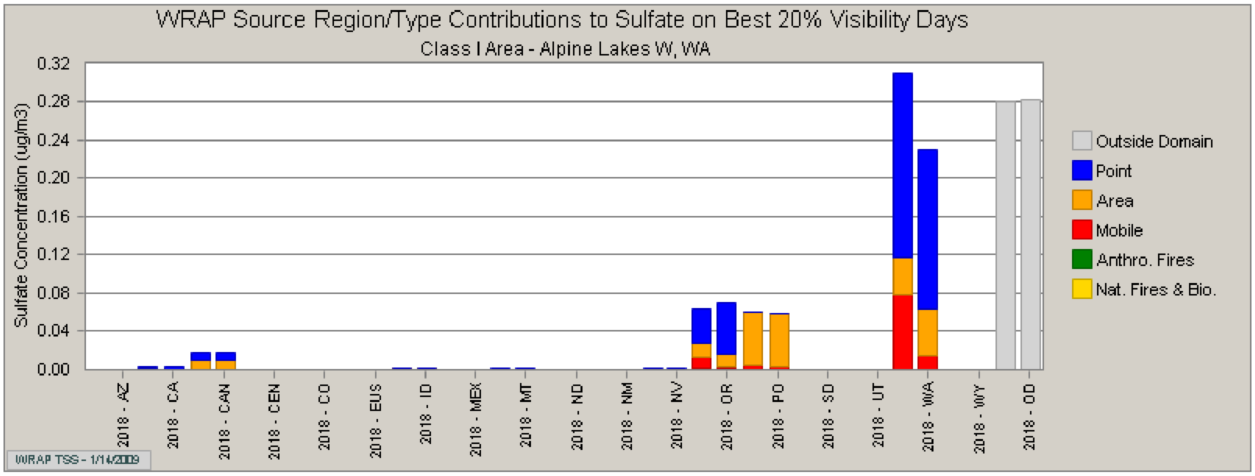



**Figure 8-26 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at SNPA1**

## 8.3.2 Nitrates

Monitoring data indicate that nitrates are the third highest contributor to haze on the Most Impaired Days and the second highest contributor on the Least Impaired Days in 2002 at the SNPA1 site.

**Most Impaired Days**

On the Most Impaired Days in 2002, Washington sources were responsible for about two thirds (68%) of the nitrates, followed by small contributors from outside of the modeling domain (9%), Oregon (9%), and Canada (5%) sources.

In comparison, on the Most Impaired Days the projected nitrate concentration in 2018 decreases 0.3 µg/m$^3$. The most significant change is a 12% reduction in relative contribution from Washington sources. Additional detail is shown in Figure 8-27.

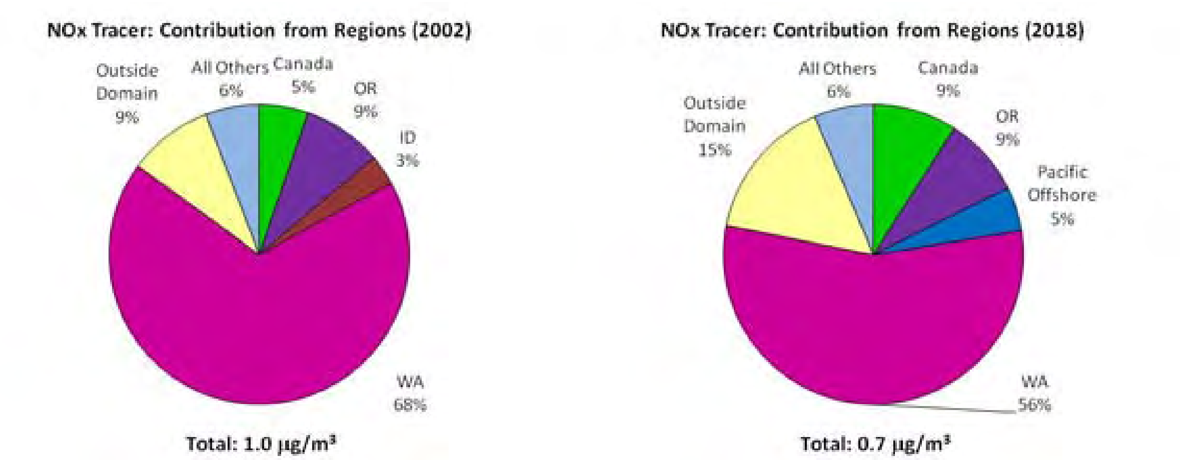



**Figure 8-27 Nitrate Contributions by Source Regions for Most Impaired Days at SNPA1**

Figure 8-28 shows the source regions and source categories that contribute nitrate at the SNPA1 monitoring site on the Most Impaired Days. Washington mobile sources contributed to 56% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by point sources (5%), natural fire and biogenic sources (3%), and area sources (3%). In 2018, Washington mobile sources are expected to contribute to 34% of the total light extinction by nitrates, followed by point sources (10%), areas sources (7%), and natural fire and biogenic sources (4%).

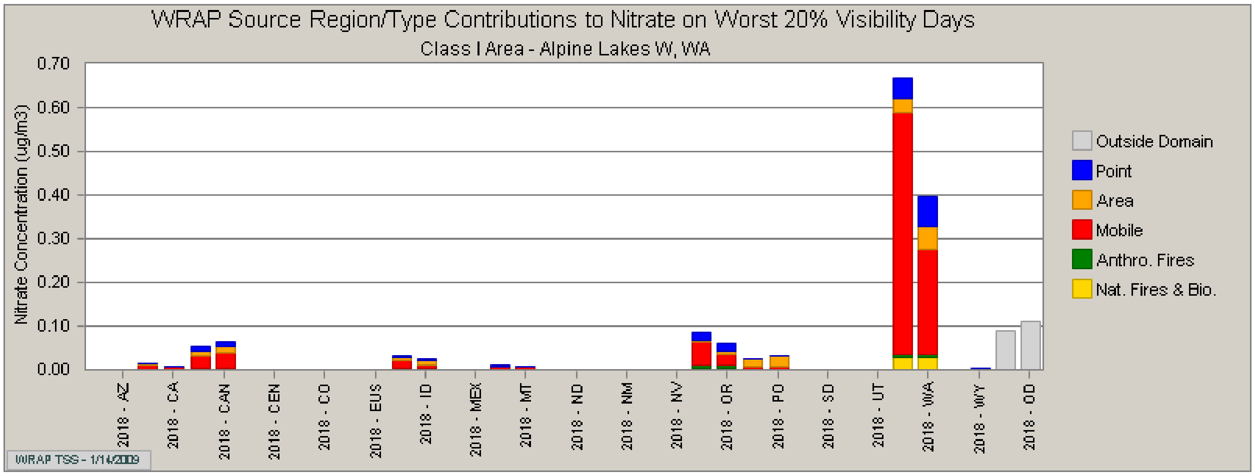



**Figure 8-28 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at SNPA1**

**Least Impaired Days**

On the Least Impaired Days in 2002, Canada's percent contribution decreases when compared to their share on the Most Impaired Days. When compared to the Most Impaired Days, the relative contributions from Oregon and Pacific offshore sources increased.

In comparison to the Least Impaired Days in 2002, on the Least Impaired Days in 2018 the projected nitrate concentration decreases 0.4 $\mu g/m^3$. The relative contributions from Washington sources decrease by 10%. Additional detail is shown in Figure 8-29.

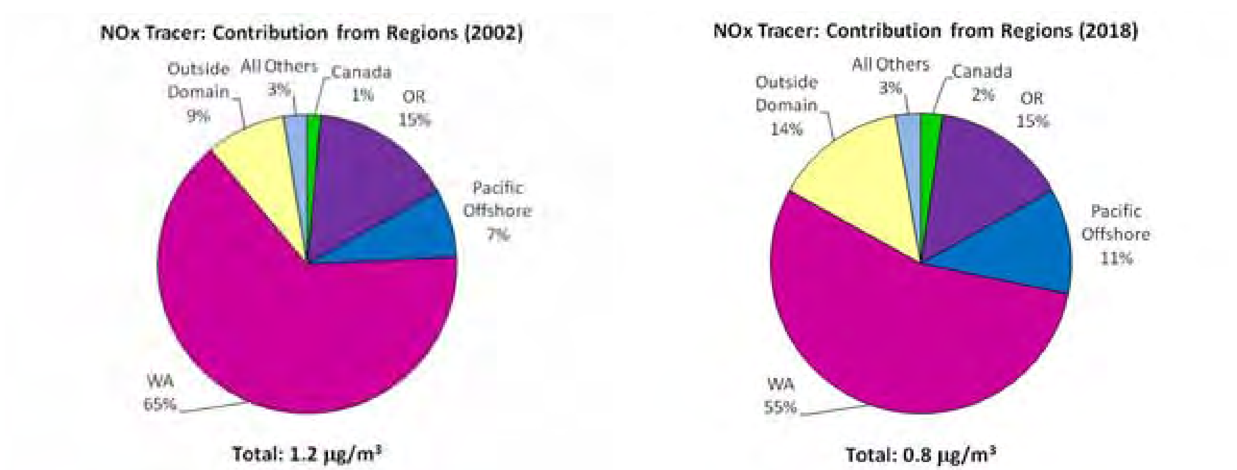



**Figure 8-29 Nitrate Contributions by Source Regions for Least Impaired Days at SNPA1**

Figure 8-30 shows the source regions and source categories that contribute nitrate at the SNPA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 52% of the total contribution to light extinction by nitrates on the Least Impaired Days in 2002, followed by point sources (7%), area sources (3%), and natural fire and biogenic sources (1%). In 2018, Washington mobile sources are expected to contribute to 31% of the total light extinction by nitrates, followed by point sources (14%), area sources (8%), and natural fire and biogenic sources (2%).

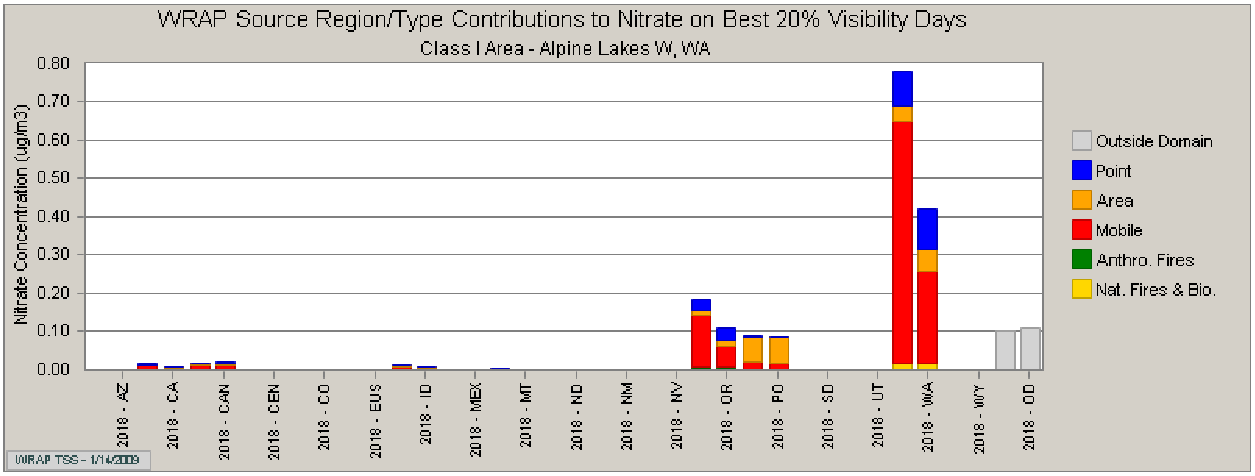



**Figure 8-30 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at SNPA1**

### 8.2.3 Organic Mass Carbon

Monitoring data indicate that OMC is the second highest cause of light extinction on the most impaired days at the SNPA1 site. On the least impaired days, OC is the third highest cause of light extinction.

As WEP indicates, most of the OMC emissions come from Washington. Additional detail is shown in Figure 8-31.

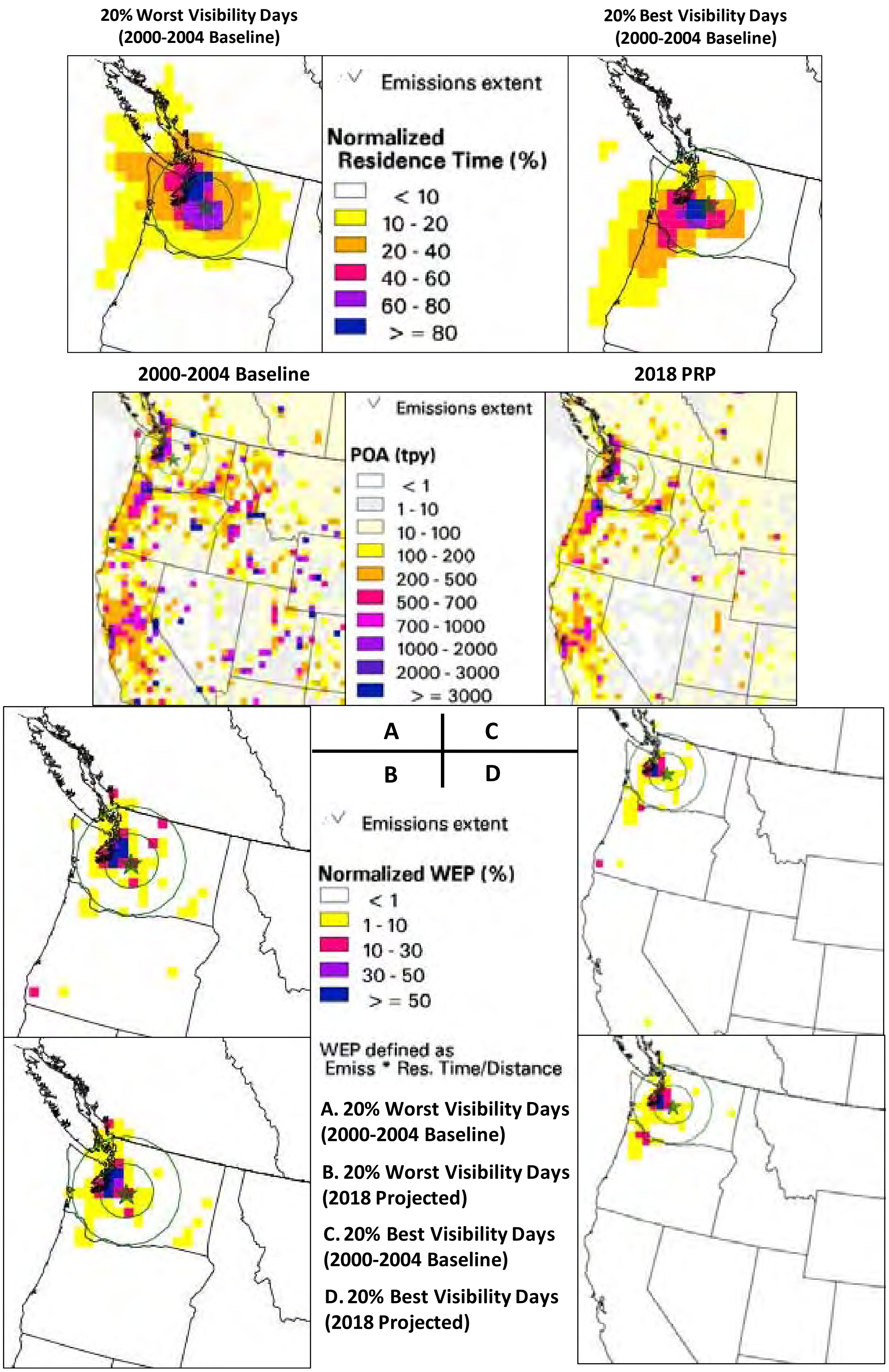



**Figure 8-31 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at SNPA1**

For both the Most Impaired and Least Impaired in 2002 and 2018 area sources are the predominant sources of OMC. Area sources are projected to hold constant during the first planning period for both the Most Impaired and Least Impaired Days. The emissions from natural fire were also held constant in the modeling. Overall, there was 3% decrease in projected year 2018. The relative contributions from other sources are also shown in Figures 8-32 and 8-33.

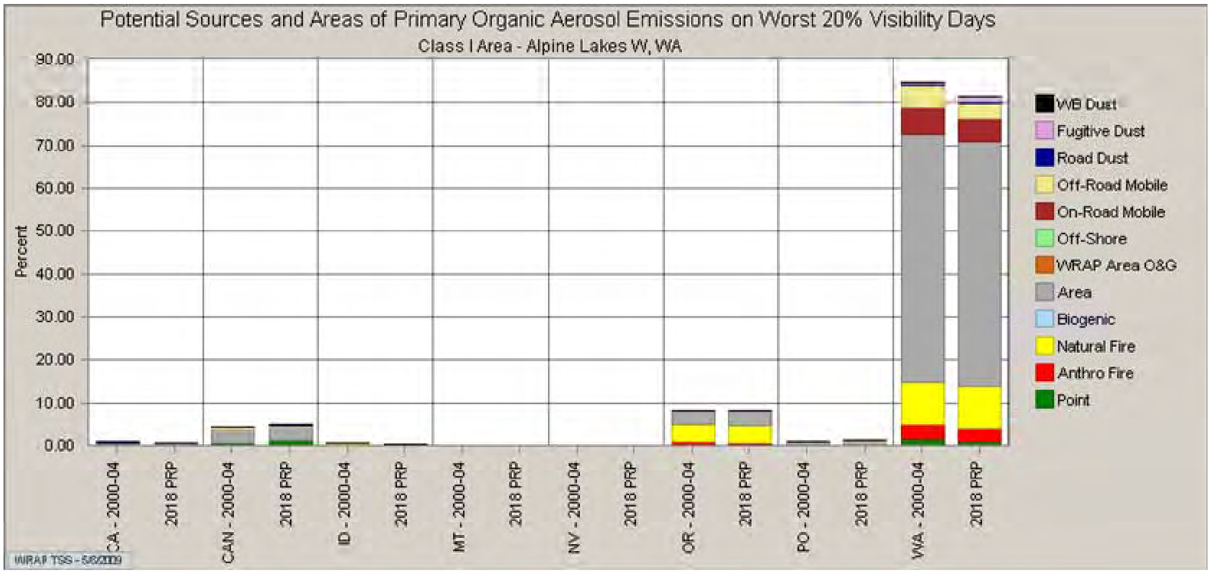



**Figure 8-32 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 most impaired days at SNPA1**

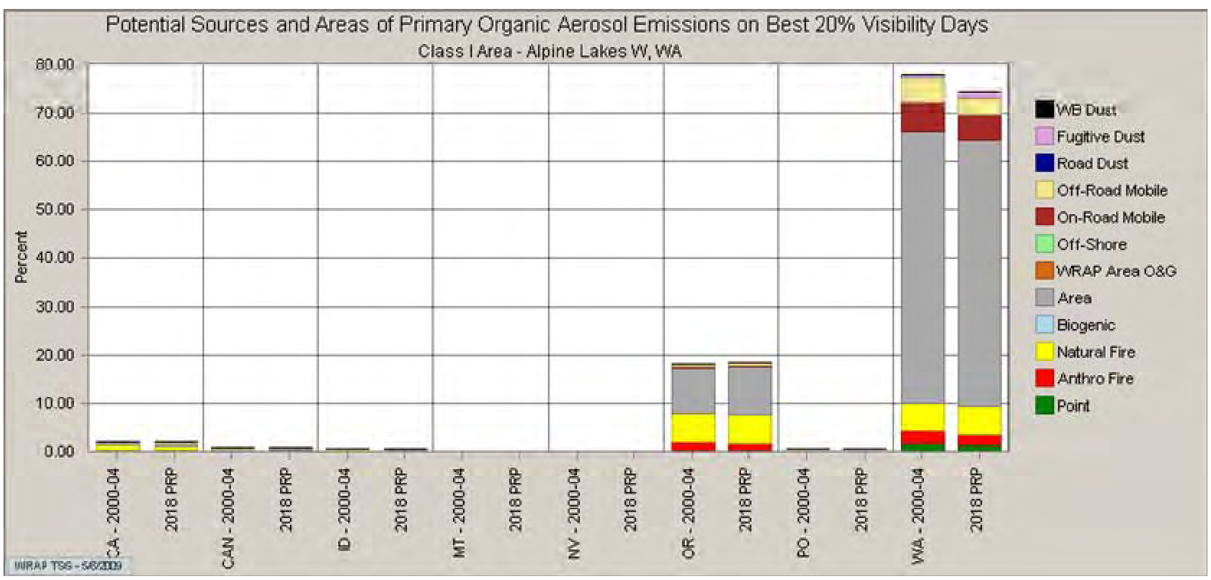



**Figure 8-33 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 least impaired days at SNPA1**

## 8.4 Mount Rainier National Park

Mount Rainier National Park is represented by the MORA1 IMPROVE monitoring site. The baseline conditions in Chapter 5 show that sulfates (46%) and OC (29%) make up 75% of the light extinction on the Most Impaired Days at this monitoring site. Nitrates (10%) and EC (10%) contribute to another 20% of the light extinction on the Most Impaired Days at this monitoring site. On the Least Impaired Days sulfates (40%) and OC (23%) make up 63% of the light extinction at this monitoring site. Nitrates (10%) and EC (10%) contribute to another 20% of the light extinction on the Least Impaired Days at this monitoring site.

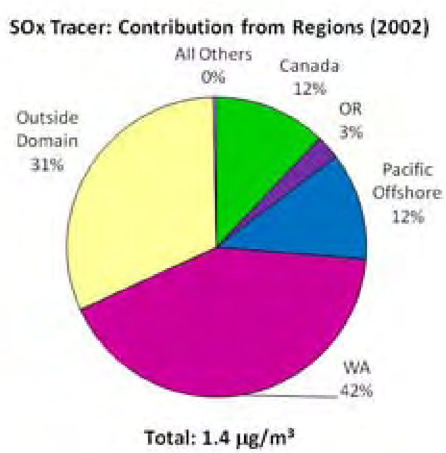
### 8.4.1 Sulfates

Monitoring data show that sulfates were the highest contributor to haze on both the Most Impaired and Least Impaired Days in 2002.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days for 2002 sulfate emissions come primarily from primary from Washington sources (42%). Other significant regional contributors include emissions from outside the modeling domain (31%), Canada (12%) and Pacific offshore (12%). Sulfate sources from outside of the modeling domain, Canada and Pacific offshore are beyond state or local control.

In comparison to the Most Impaired Days in 2002, the projected sulfate concentration in 2018 decreases by 0.1 $\mu g/m^3$. There is some change in the relative contributions between source regions. Washington sources decrease their contributions by 8% while sources from outside the modeling domain, Canada, and Pacific offshore increase their contributions by 8%. Additional detail is shown in Figure 8-34.



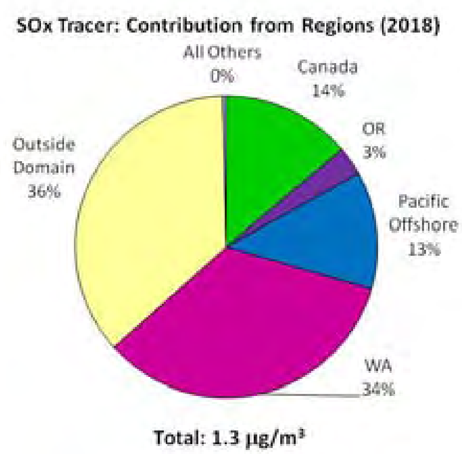




**Figure 8-34 Sulfate Contributions by Source Regions for Most Impaired Days at MORA1**

Figure 8-35 shows the source regions and source categories that contribute sulfate at the MORA1 monitoring site on the Most Impaired Days. In 2002, Washington point sources contributed to

25% of the total contribution to light extinction by sulfates, followed by mobile (11%) and area (6%) sources. In 2018, Washington point sources are expected to contribute to 22% of the total light extinction by sulfates, followed by area sources (8%), and mobile sources (3%).

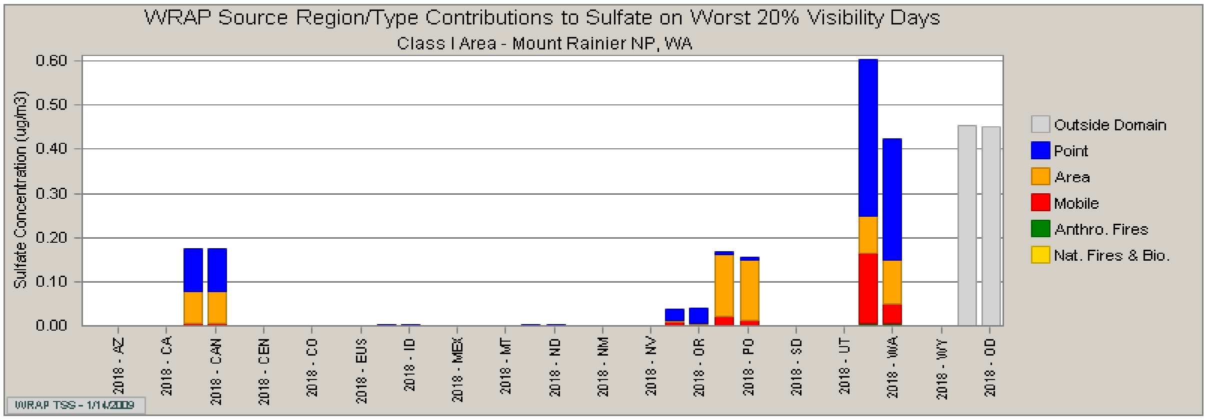



**Figure 8-35 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at MORA1**

**Least Impaired Days**

The PSAT tracer analysis shows that for the Least Impaired Days in 2002, sulfate emissions come primarily from outside modeling domain and Washington's own sources. Contributions from Canada decreased on the Least Impaired Days when compared to the Most Impaired Days. Contributions from Oregon sources increased on the Least Impaired Days when compared to the Most Impaired Days.

In comparison to the Least Impaired Days in 2002, the projected sulfate concentration in 2018 decreases 0.1 µg/m$^3$ and the relative contributions from the source regions change. The relative contributions from Washington sources decrease by 11% while contributions from outside the modeling domain and Oregon increase by 9%. Additional detail is shown in Figure 8-36.

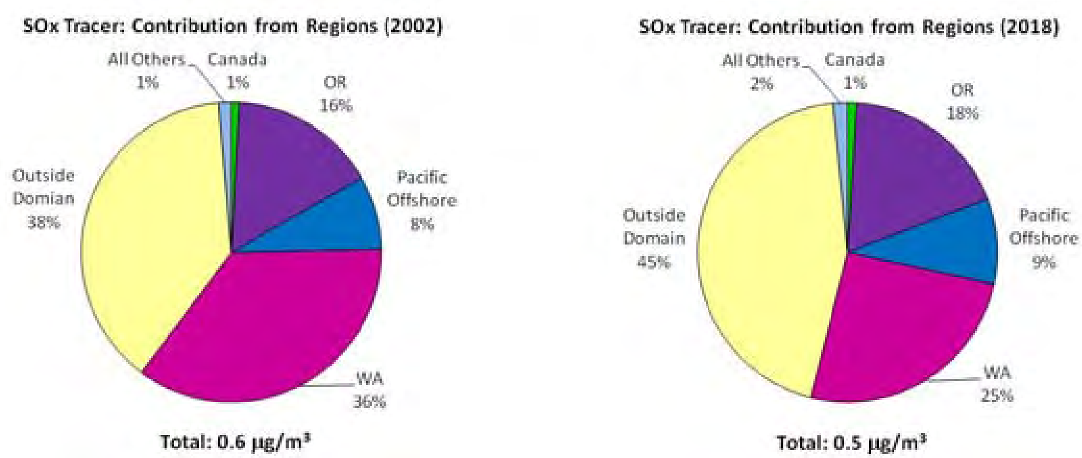



**Figure 8-36 Sulfate Contributions by Source Regions for Least Impaired Days at MORA1**

Figure 8-37 shows the source regions and source categories that contribute sulfate at the MORA1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to 25% of the total contribution to light extinction by sulfates, followed by mobile sources (7%), and area sources (3%). In 2018, Washington point sources are expected to contribute to 19% of the total light extinction by sulfates, followed by area sources (4%), and mobile sources (2%).

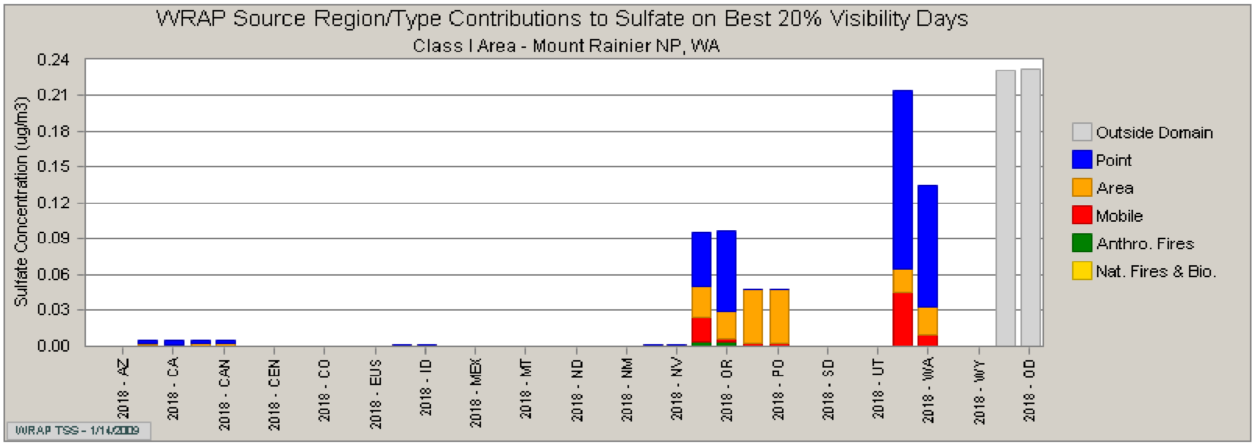



**Figure 8-37 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at MORA1**

## 8.4.2 Nitrates

Monitoring data show that nitrates contributed to 10% of the haze on both the Most Impaired and Least Impaired Days in 2002 at the MORA1site.

**Most Impaired Days**

Washington sources are responsible for the majority (78%) of the nitrates on the Most Impaired Days in 2002, followed by other small sources (< 10% each).

In comparison to 2002, on the Most Impaired Days the projected nitrate concentration in 2018 decreases 0.3 $\mu g/m^3$. The relative contributions from Washington sources decrease by 9% while contributions from sources outside the modeling domain, Pacific offshore, and Canada increase by 7%. The relative contributions from Oregon and all other sources also increase slightly. Additional detail is shown in Figure 8-38.

Figure 8-39 shows the source regions and source categories that contribute nitrate at the MORA1 monitoring site on the Most Impaired Days. Washington mobile sources contributed to 62% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by point sources (9%), area sources (5%), and natural fire and biogenic sources (1%). In 2018, Washington mobile sources are expected to contribute to 37% of the total light extinction by nitrates, followed by point sources (18%), area sources (11%), natural and biogenic sources (2%).

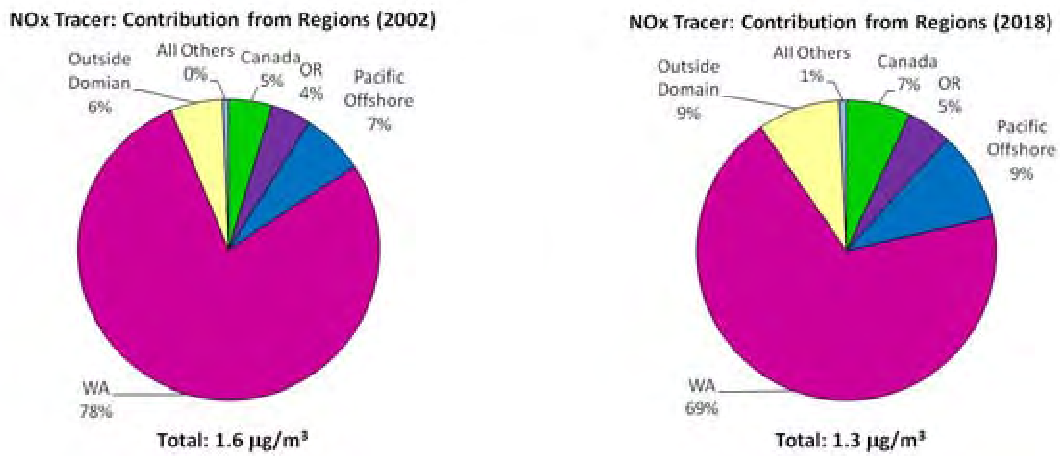



**Figure 8-38 Nitrate Contributions by Source Regions for Most Impaired Days at MORA1**

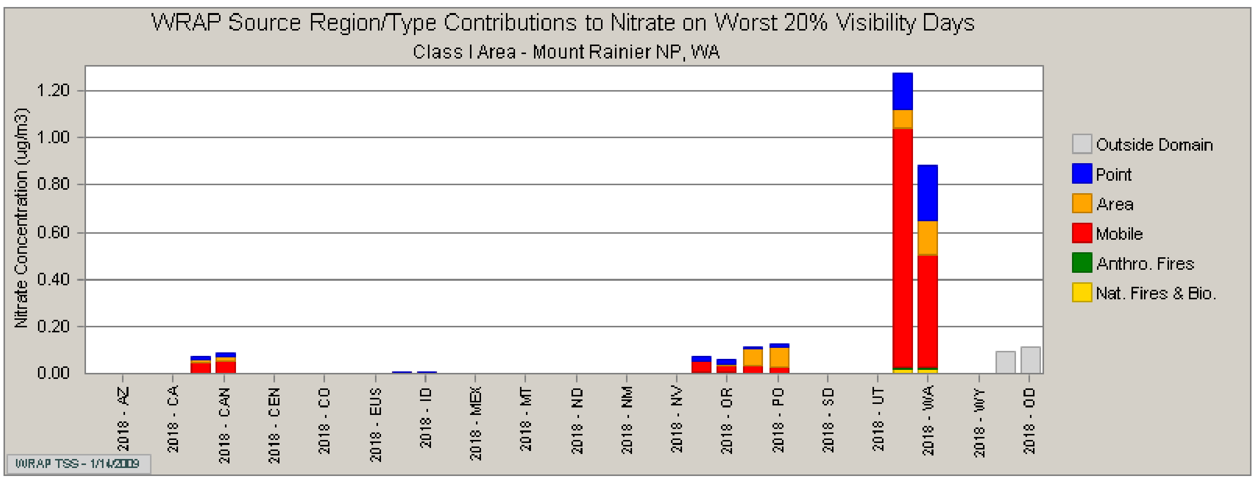



**Figure 8-39 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at MORA1**

**Least Impaired Days**

On the least impaired days in 2002 Washington (42%) and Oregon (35%) account for 77% of the nitrate impacts at MORA1.

In comparison to 2002, on the Least Impaired Days the projected nitrate concentration in 2018 decreases 0.4 µg/m$^3$. The relative contributions from Washington sources decrease by 6%. Relative contributions from California (1%) and Oregon (3%) sources decrease by 4%. The relative contributions of nitrates from outside the modeling domain and Pacific offshore increase by 10%. Additional detail is shown in Figure 8-40.

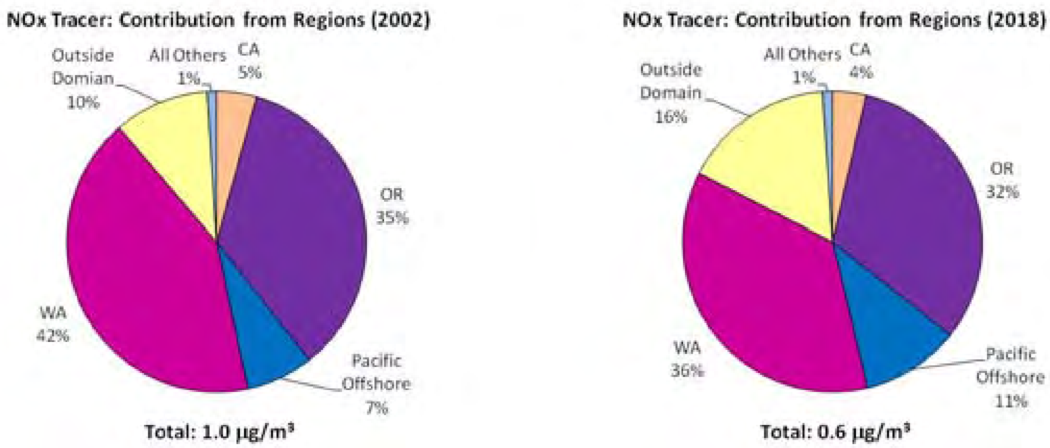



**Figure 8-40 Nitrate Contributions by Source Regions for Least Impaired Days at MORA1**

Figure 8-41 shows the source regions and source categories that contribute nitrate at the MORA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 32% of the total contribution to light extinction by nitrates on the Least Impaired Days in 2002, followed by point sources (7%), areas sources (2%), and natural fire and biogenic sources (1%). In 2018, Washington mobile sources are expected to contribute to 19% of the total light extinction by nitrates, followed by point sources (11%), area sources (4%), and natural and biogenic sources (2%).

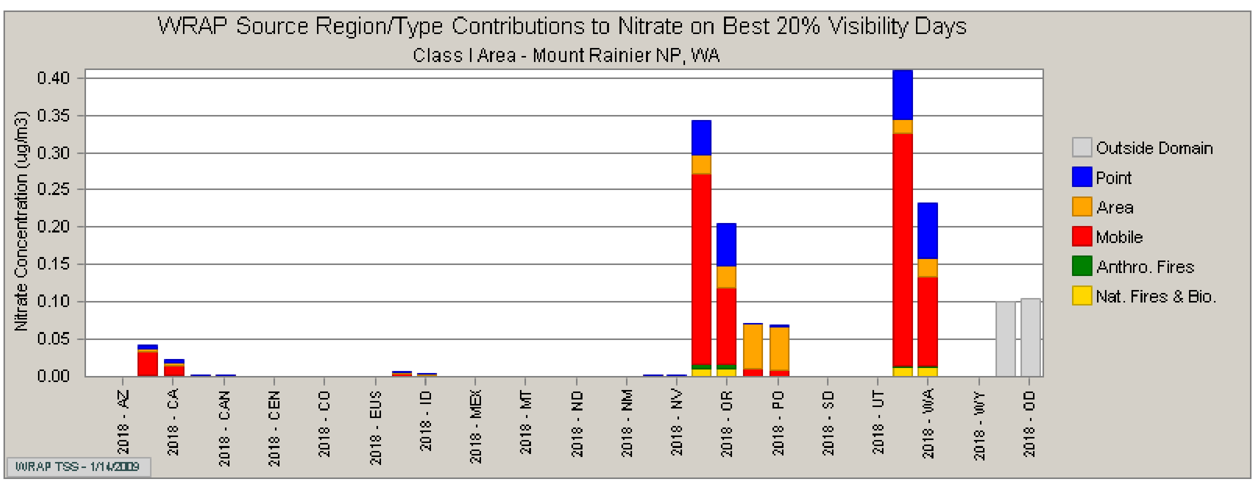



**Figure 8-41 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at MORA1**

## 8.4.3 Organic Mass Carbon

Monitoring data indicate that after sulfates, OMC is the second highest cause of light extinction on both the Most Impaired and Least Impaired Days at the MORA1 site.

WEP source apportionment shows that Washington's own sources contribute most of the OMC on the Most Impaired Days at the MORA1 site. Additional detail is shown in Figure 8-42.

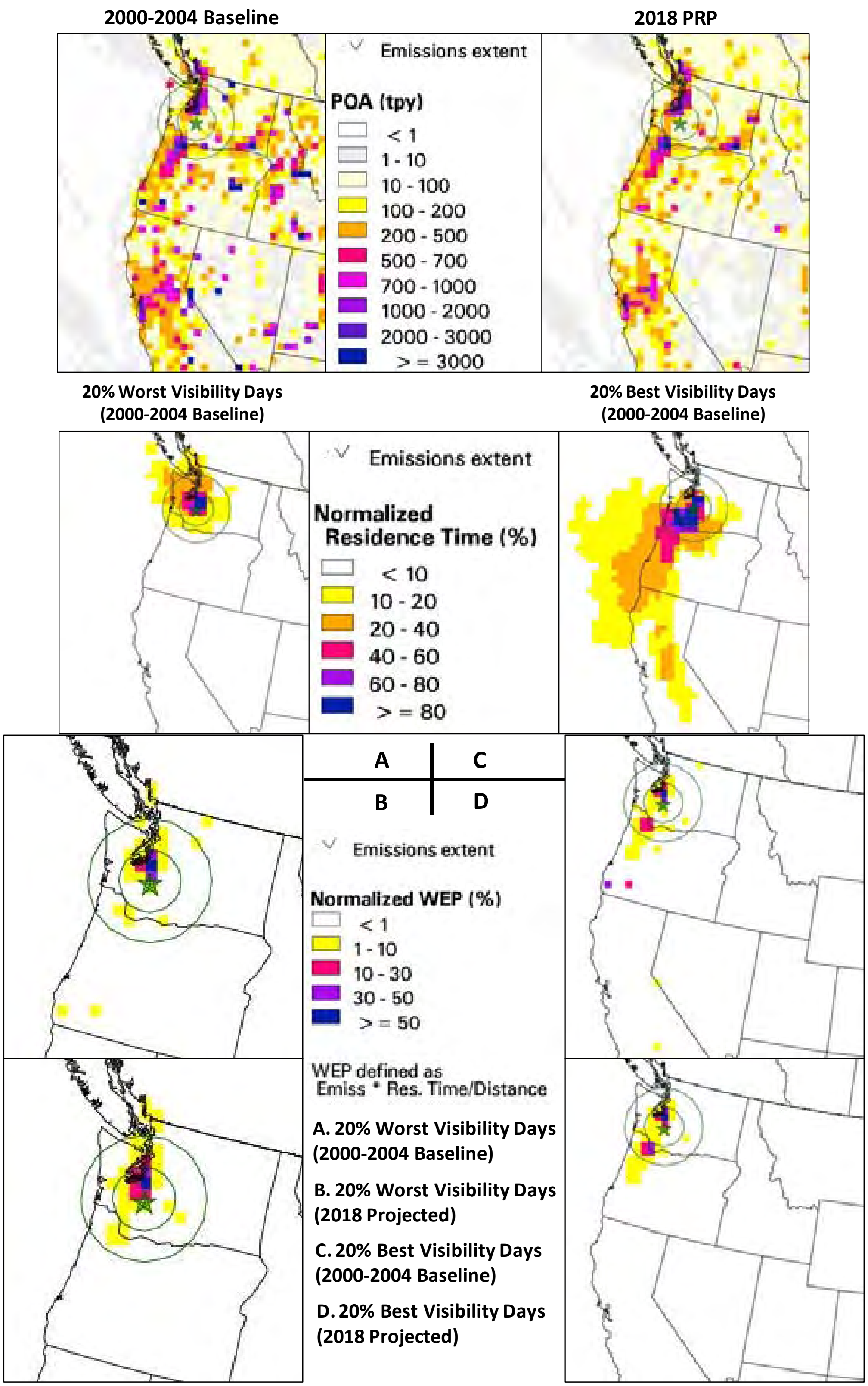



**Figure 8-42 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at MORA1**

For both Most Impaired and Least Impaired Days in 2002 and 2018 area sources are the predominant sources. The emissions from this source are projected to decrease slightly during the first planning period. The relative contributions from other sources are also shown in Figures 8-43 and 8-44.

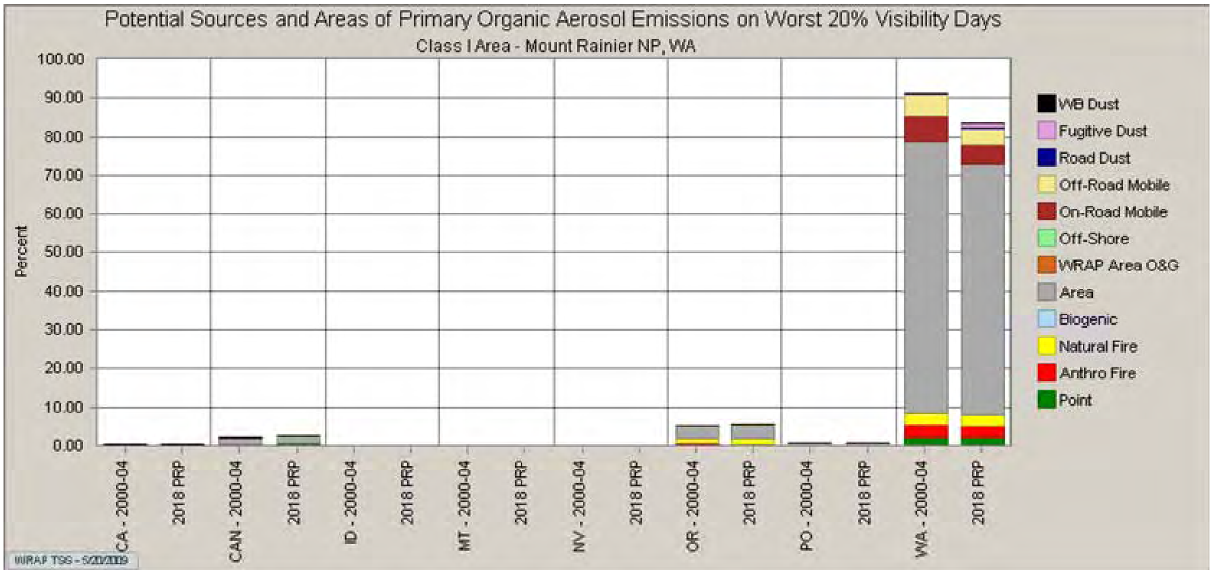



**Figure 8-43 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Most Impaired Days at MORA1**

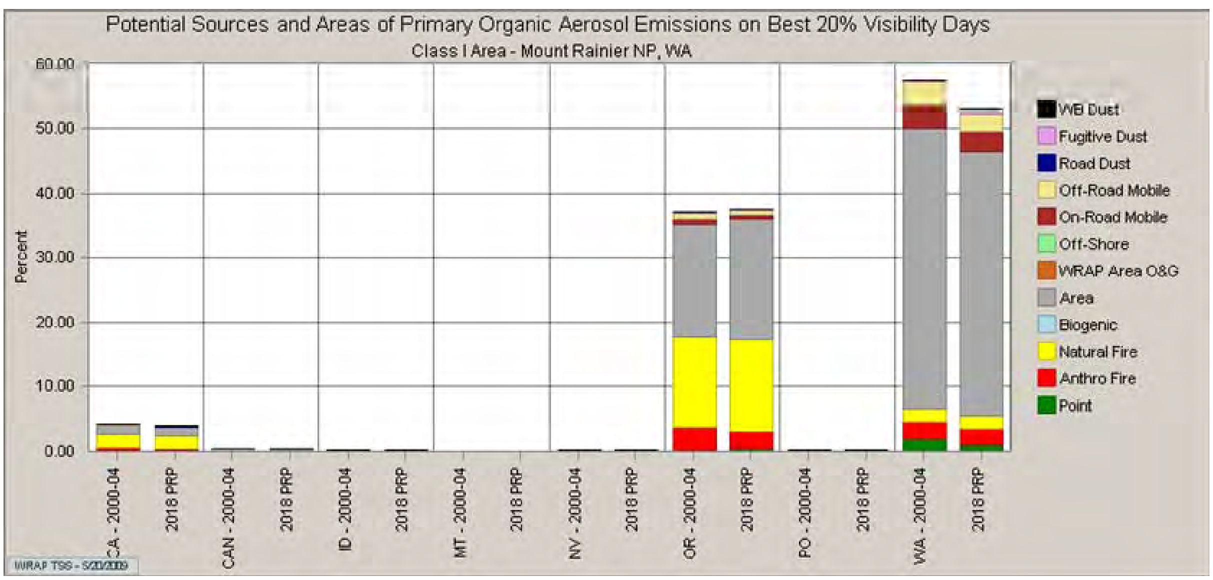



**Figure 8-44 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Least Impaired Days at MORA1**

## 8.5 Goat Rocks Wilderness and Mount Adams Wilderness

Goat Rocks Wilderness and Mount Adams Wilderness are represented by the WHPA1 IMPROVE monitoring site. The baseline conditions in Chapter 5 show that sulfates (37%), OC

(36%), and nitrates (11%) together contribute to 84% of the light extinction on the Most Impaired Days at this monitoring site. On the Least Impaired Days sulfates (49%), OC (14%), and nitrates (13%) contribute to 76% of the light extinction at this monitoring site.

### 8.5.1 Sulfates

Monitoring data show that sulfates were the highest contributor to haze on both the Most Impaired and Least Impaired Days in 2002.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days in 2002 sulfate emissions come primarily from sources outside the modeling domain (39%), Washington (29%) and Canada (18%). Sulfate sources outside of the modeling domain and Canada are beyond state or local control.

In comparison to 2002, the projected sulfate concentration in 2018 decreases 0.1 µg/m$^3$. There is some change in the relative contributions among source regions. Washington sources decrease their contributions by 6% while sources from outside the modeling domain, Canada, and Oregon increase by 6%. Additional details are shown in Figure 8-45.

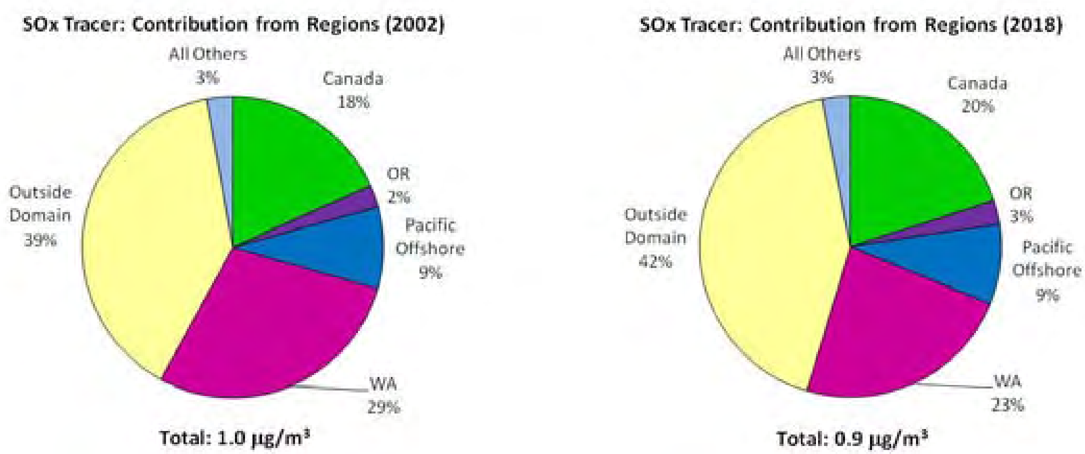



**Figure 8-45 Sulfate Contributions by Source Regions for Most Impaired Days at WHPA1**

Figure 8-46 shows the source regions and source categories that contribute sulfate at the WHPA1 monitoring site on the Most Impaired Days. In 2002 Washington point sources contribute to 16% of the total contributions to light extinction by sulfates, followed by mobile (8%) and area (4%) sources. In 2018, Washington point sources are expected to contribute to 16% of the total light extinction by sulfates, followed by area sources (5%), and mobile sources (2%).

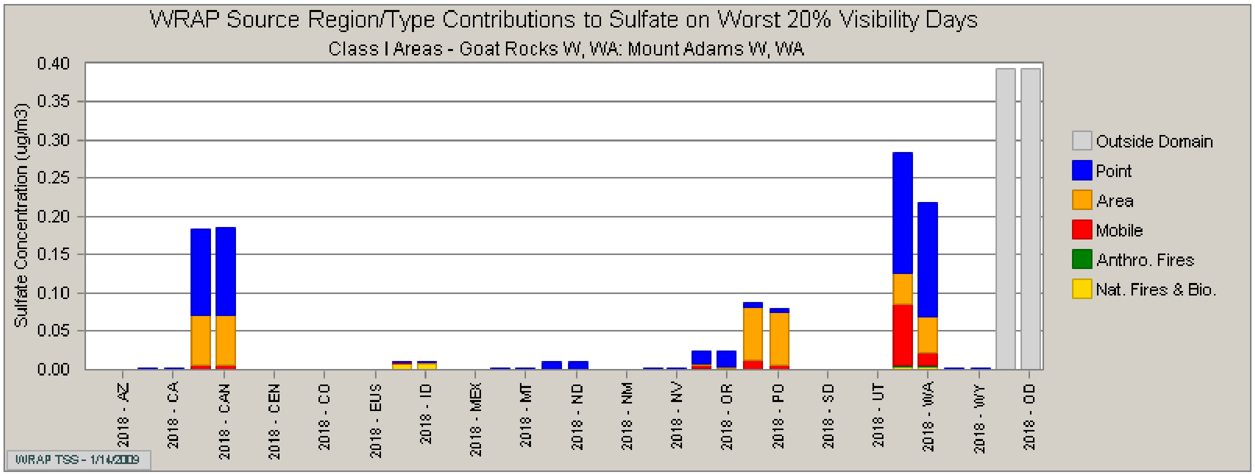



**Figure 8-46 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at WHPA1**

**Least Impaired Days**

The PSAT tracer analysis shows that for the Least Impaired Days in 2002, sulfate emissions come mostly from Washington sources. Compared to the Most Impaired Days in 2002, on the Least Impaired Days in 2002 the sources from Canada and outside the modeling domain contribute far less while Oregon's contribution increases.

In comparison to the Least Impaired Days in 2018, the projected sulfate concentration decreases by 0.2 µg/m$^3$ and the relative contributions from the source regions change. The most significant change is a reduction in contribution from Washington sources by 13%. Other changes in relative contributions are shown in Figure 8-47.

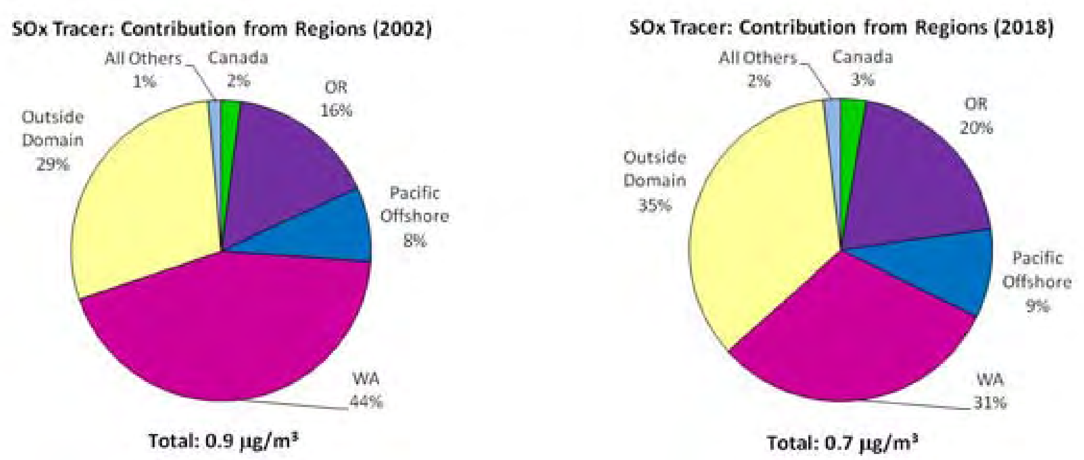



**Figure 8-47 Sulfate Contributions by Source Regions for Least Impaired Days at WHPA1**

Figure 8-48 shows the source regions and source categories that contribute sulfate at the WHPA1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to 30% of the total contribution to light extinction by sulfates, followed by mobile sources (9%), and area sources (4%). In 2018, Washington point sources are expected to contribute to 23% of the total light extinction by sulfates, followed by area sources (6%), and mobile sources (2%).

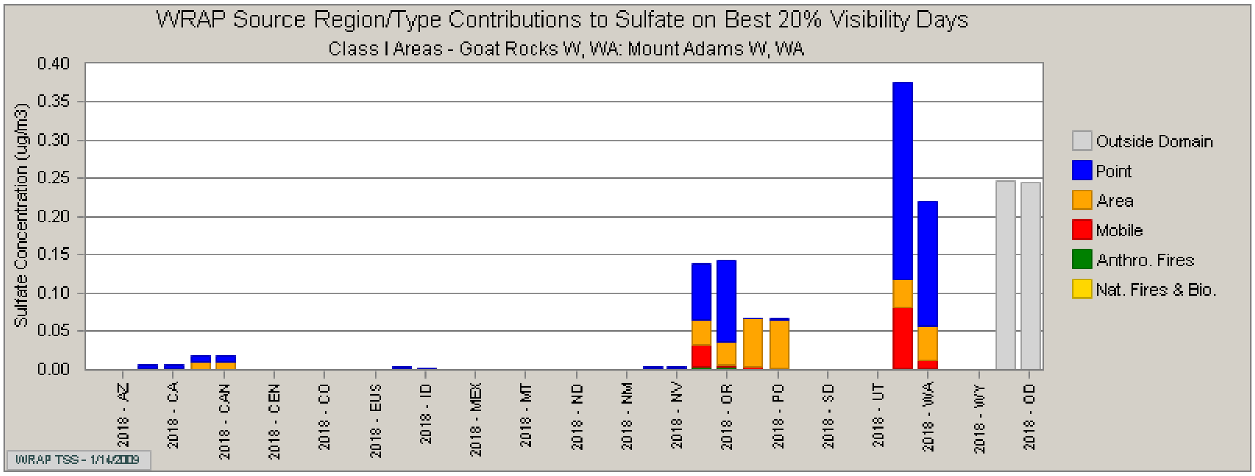



**Figure 8-48 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at WHPA1**

## 8.5.2 Nitrates

Monitoring data indicate that nitrates are the third highest contributor to haze in 2002 on both the Most Impaired and Least Impaired at the WHPA1 site.

### Most Impaired Days

Washington sources are responsible for 64% of the nitrates on the Most Impaired Days. Sources from outside of the modeling domain (13%), Canada (9%), Pacific offshore (5%) and Oregon (4%) contribute to another 31% of the haze impairment from nitrates.

In comparison, on the Most Impaired Days the projected nitrate concentration in 2018 decreases by 0.3 µg/m$^3$. The most significant change is a 14% reduction in relative contribution from Washington sources. Additional details are shown in Figure 8-49.

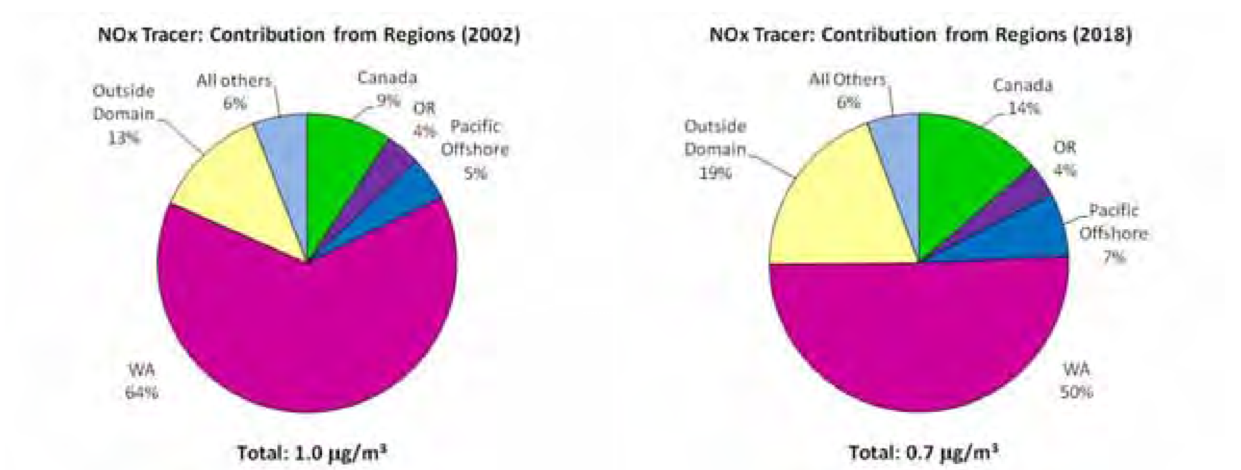



**Figure 8-49 Nitrate Contributions by Source Regions for Most Impaired Days at WHPA1**

Figure 8-50 shows the source regions and source categories that contribute nitrate at the WHPA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 52% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by point sources (6%), and area sources (4%) and natural fire and biogenic sources (2%). In 2018, Washington mobile sources are expected to contribute 29% of the total light extinction by nitrates, followed by point sources (12%), areas sources (8%), and natural and biogenic sources (1%).

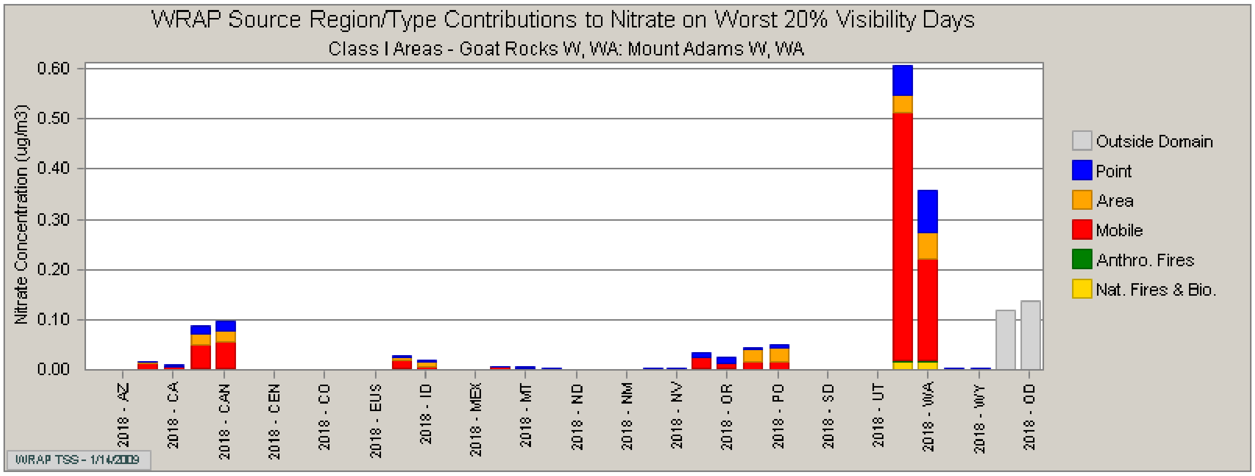



**Figure 8-50 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at WHPA1**

**Least Impaired Days**

On the Least Impaired Days in 2002 Washington (48%) and Oregon (29%) sources account for 77% of the nitrate impacts at WHPA1.

In comparison to 2002, the projected nitrate concentration in 2018 decreases 0.3 µg/m$^3$. The relative contributions from Washington sources decrease by 5%. Contributions from Oregon decrease by 4% and California by 1%. Additional detail on the relative contributions of other regions is shown in Figure 8-51.

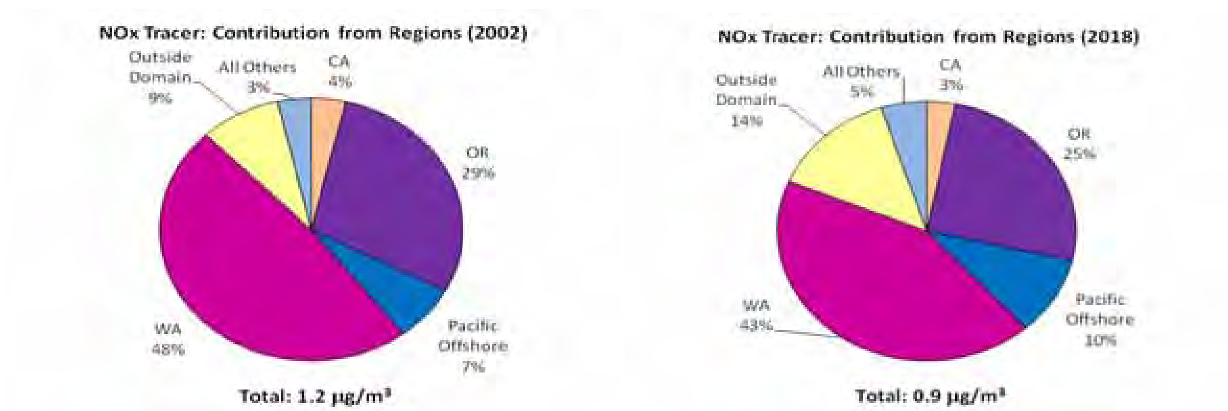



**Figure 8-51 Nitrate Contributions by Source Regions for Least Impaired Days at WHPA1**

Figure 8-52 shows the source regions and source categories that contribute nitrate at the WHPA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 38% of the total contribution to light extinction by nitrates on the Least Impaired Days in 2002, followed by point sources (7%), area sources (2%), and natural fire and biogenic sources (1%). In 2018, Washington mobile sources are expected to contribute to 23% of the total light extinction by nitrates, followed by point sources (12%), area sources (5%), and natural and biogenic sources (2%).

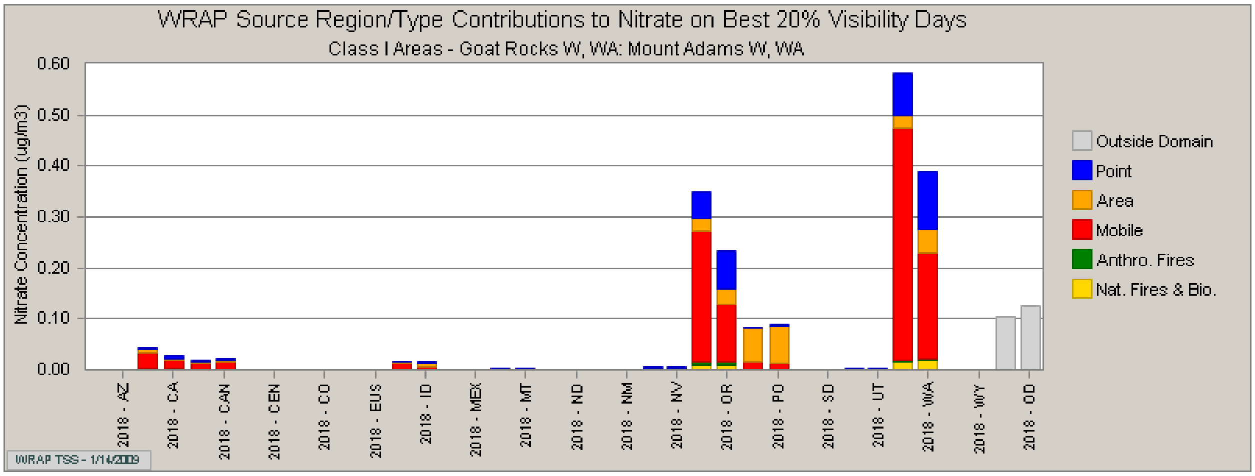



**Figure 8-52 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at WHPA1**

## 8.5.3 Organic Mass Carbon

Monitoring data indicate that after sulfates, OMC is the second highest cause of light extinction on both the Most Impaired and Least Impaired Days at the WHPA1 site. As WEP indicates, most of the OMC emissions come from Washington. Additional detail is shown in Figure 8-53.

For both Most Impaired and Least Impaired Days in 2002 and 2018 area sources are the predominant sources of OMC. Area sources are projected to increase slightly during the first planning period. The relative contributions from other sources are also shown in Figures 8-54 and 8-55.

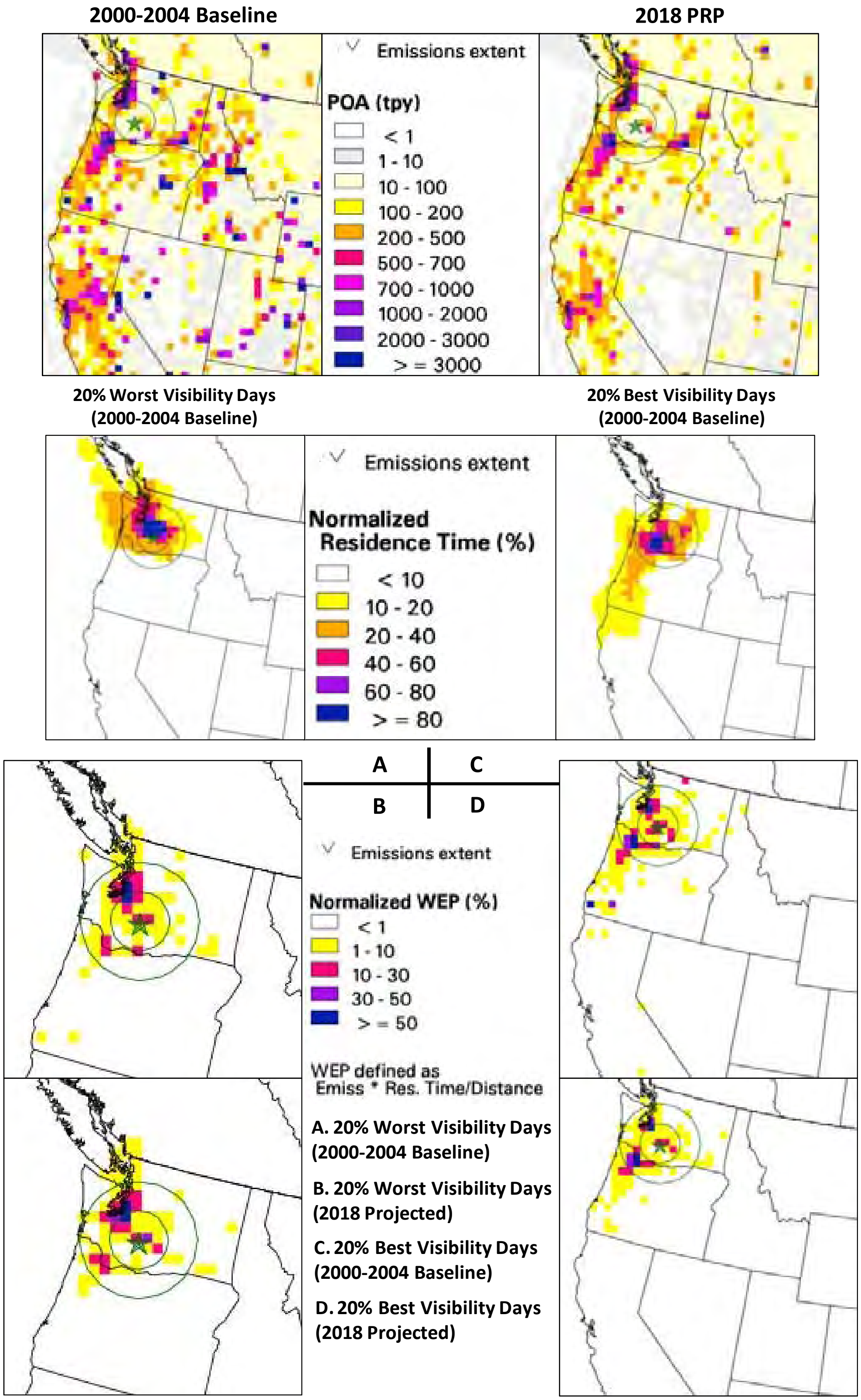



**Figure 8-53 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at WHPA1**

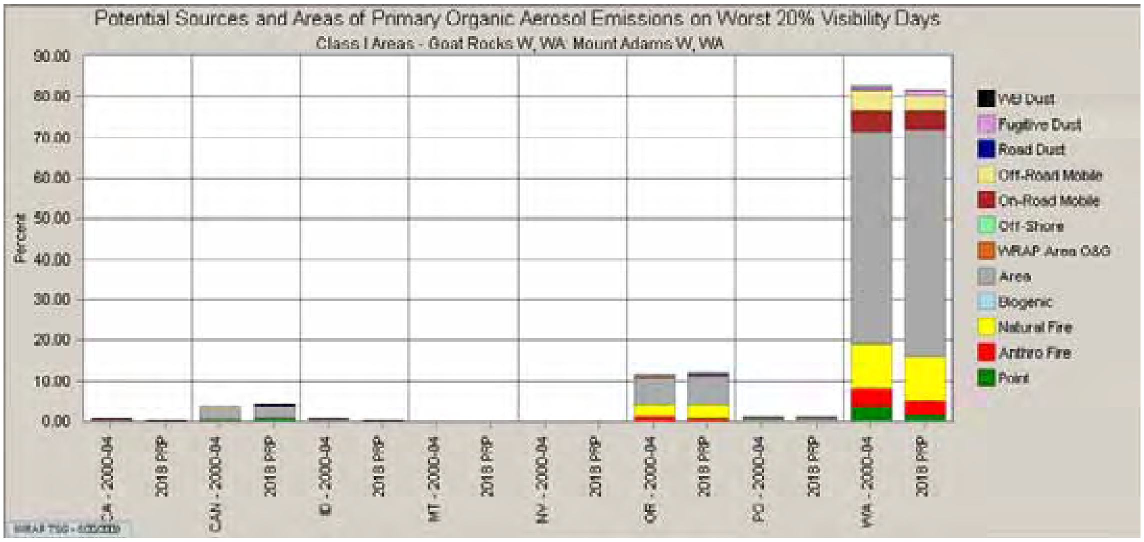



**Figure 8-54 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Most Impaired Days at WHPA1**

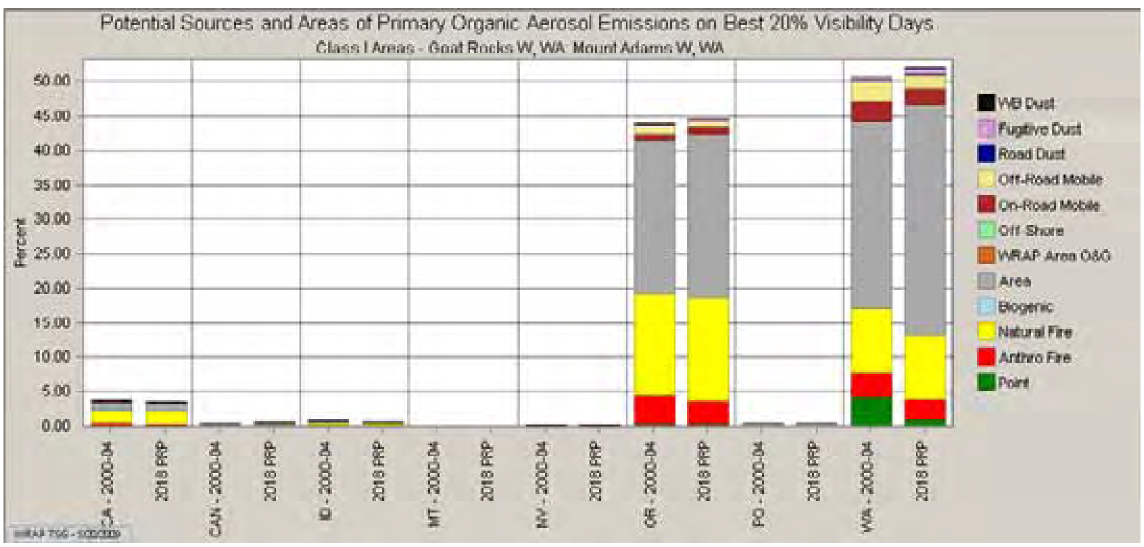



**Figure 8-55 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Least Impaired Days at WHPA1**

## 8.6 Pasayten Wilderness

Pasayten Wilderness is represented by the PASA1 IMPROVE monitoring site. The baseline conditions in Chapter 5 show that OC (56%) and sulfates (20%) make up 76% of the light extinction on the Most Impaired Days at this monitoring site. EC (9%) and nitrates (8%) contribute to another 17% of the light extinction on the Most Impaired Days at this monitoring site. On the Least Impaired Days, sulfates make up 48% of the light extinction at this monitoring site. OC (17%), nitrates (17%) and EC (7%) and make up another 41% of the light extinction on the Least Impaired Days at this monitoring site.

## 8.6.1 Sulfate

Monitoring data show sulfates are the second highest cause of light extinction on the Most Impaired Days and highest cause of light extinction on the Least Impaired Days at this site.

**Most Impaired Days**

The PSAT tracer analysis shows that on the Most Impaired Days for 2002 most sulfate emissions came from sources outside the modeling domain (50%) and in Canada (22%) which are beyond state or local control.

In comparison to 2002, the projected sulfate concentration in 2018 is about the same. There is some change in the contributions between sources. Washington sources decrease their contributions by 2% while sources outside the modeling domain and Canada increase by 2%. Additional detail is shown in Figure 8-56.

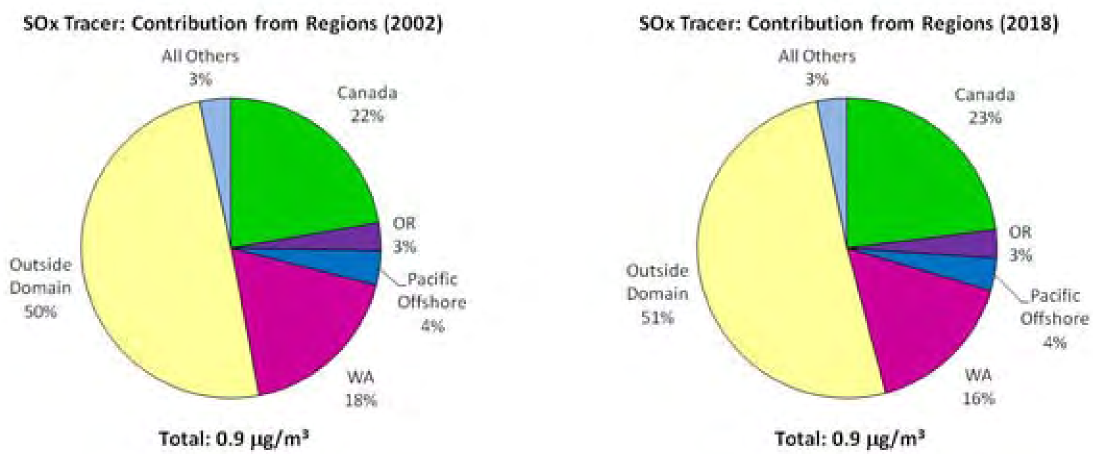



**Figure 8-56 Sulfate Contributions by Source Regions for Most Impaired Days at PASA1**

Figure 8-57 shows the source regions and source categories that contribute sulfate at the PASA1 monitoring site on the Most Impaired Days. In 2002, Washington point sources contributed to 8% of the total contribution to light extinction by sulfates, followed by mobile sources (4%), natural fire and biogenic sources (4%), and area sources (2%). In 2018, Washington point sources are expected to contribute to 9% of the total light extinction by sulfates, followed by natural fire and biogenic sources (4%), area sources (2%), and mobile sources (1%).

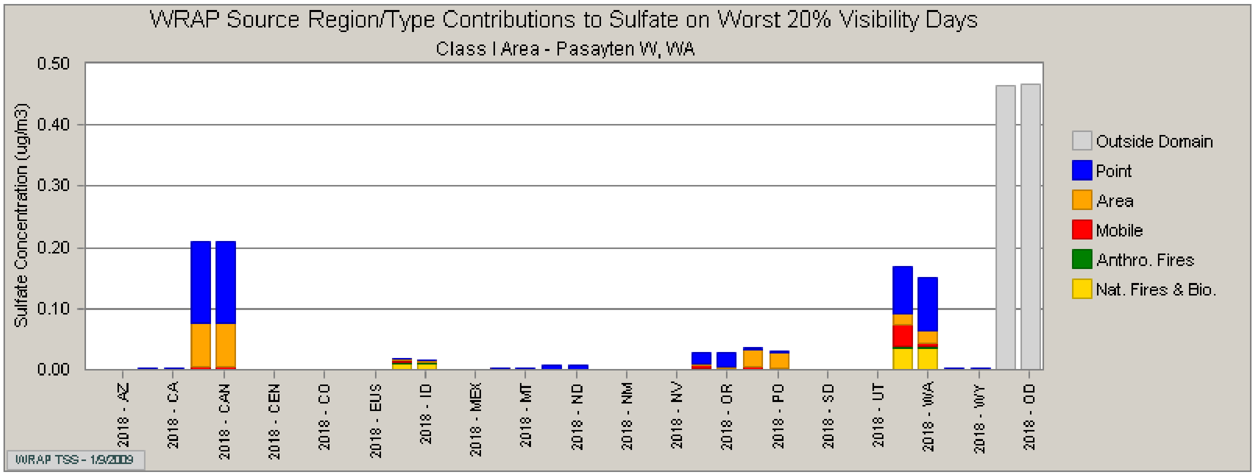



**Figure 8-57 Sulfate Source Regions for 2002 and 2018 Most Impaired Days at PASA1**

### Least Impaired Days

On the Least Impaired Days in 2002 sulfate emissions come primarily from outside the modeling domain (40%) and Washington (36%).

In comparison to the Least Impaired Days in 2002, the projected sulfate concentration in 2018 decreases 0.1 µg/m$^3$. The most significant change is a 7% reduction in relative contribution from Washington sources. Changes in the relative contributions from other source regions are shown in Figure 8-58.

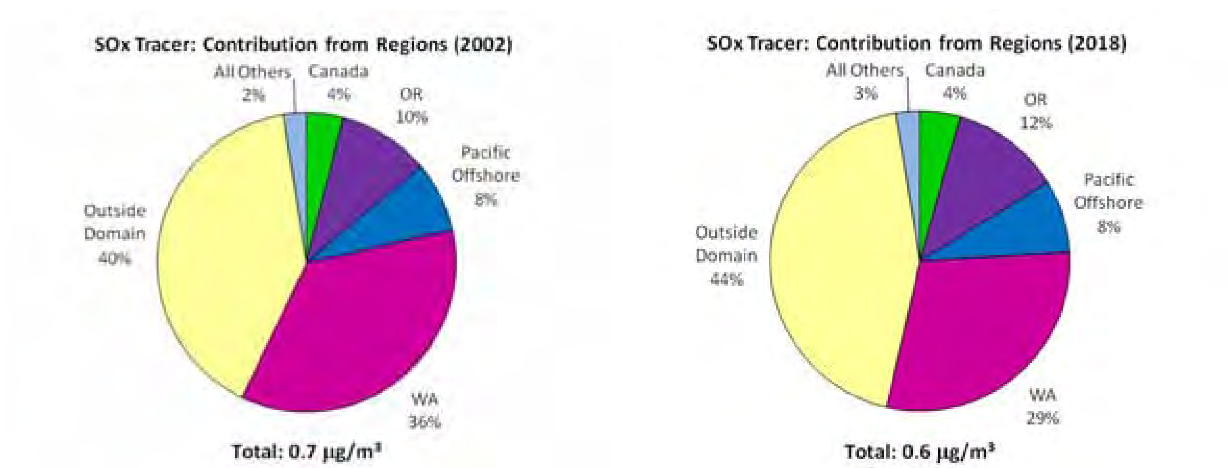



**Figure 8-58 Sulfate Contributions by Source Regions for Least Impaired Days at PASA1**

Figure 8-59 shows the source regions and source categories that contribute sulfate at the PASA1 monitoring site on the Least Impaired Days. In 2002, Washington point sources contributed to 21% of the total contribution to light extinction by sulfates, followed by mobile sources (10%), and area sources (5%). In 2018, Washington point sources are expected to contribute to 21% of the total light extinction by sulfates, followed by area sources (7%), and mobile sources (2%).

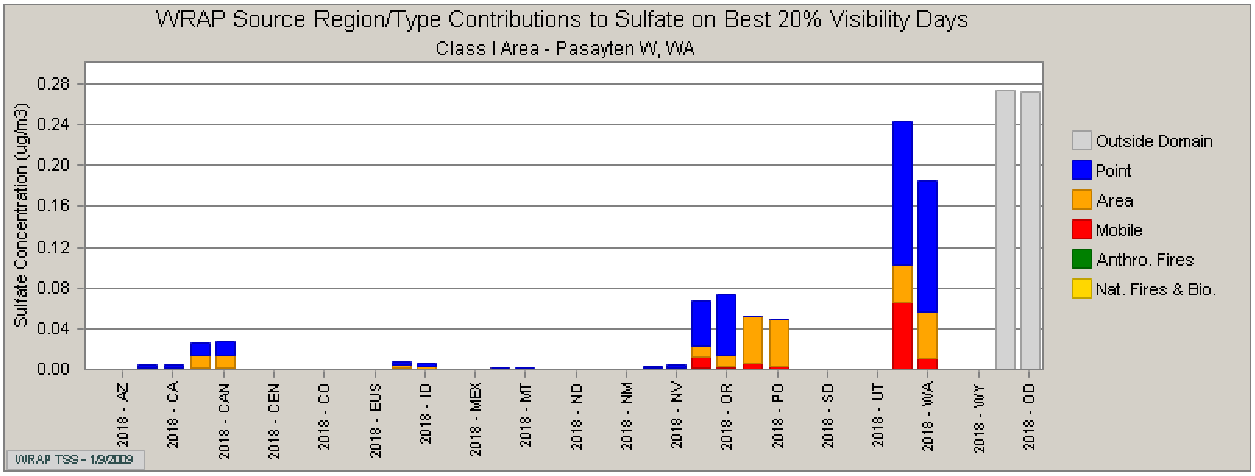



**Figure 8-59 Sulfate Source Regions for 2002 and 2018 Least Impaired Days at PASA1**

## 8.6.2 Nitrates

Monitoring data indicate that nitrates are the fourth highest contributor to haze in 2002 on the Most Impaired Days and tied with OMC as second highest on the Least Impaired Days.

**Most Impaired Days**

Washington sources are responsible for 48% of the nitrates, followed by sources from outside of the modeling domain (17%) and in Canada (13%).

In comparison to 2002, the projected nitrate concentration in 2018 decreases 0.2 µg/m$^3$. The most significant change is an 11% reduction in relative contribution from Washington sources. The changes in relative contributions from other source regions are shown in Figure 8-60.

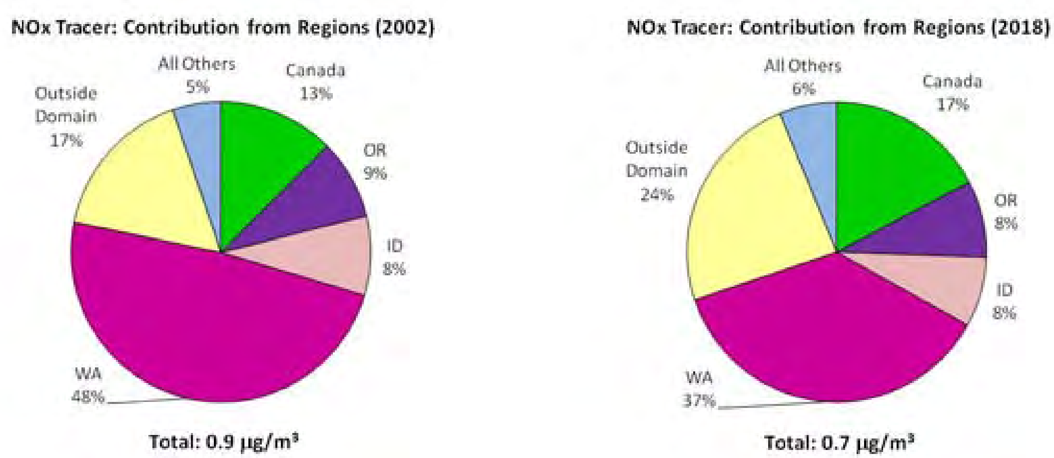



**Figure 8-60 Nitrate Contributions by Source Regions for Most Impaired Days at PASA1**

Figure 8-61 shows the source regions and source categories that contribute nitrate at the PASA1 monitoring site on the Most Impaired Days. Washington mobile sources contributed to 36% of the total contribution to light extinction by nitrates on the Most Impaired Days in 2002, followed by natural fire and biogenic sources (6%), point sources (3%), and area sources (2%). In 2018, Washington mobile sources are expected to contribute to 19% of the total light extinction by nitrates, followed by natural fire and biogenic sources (8%), point sources (5%), and areas sources (3%).

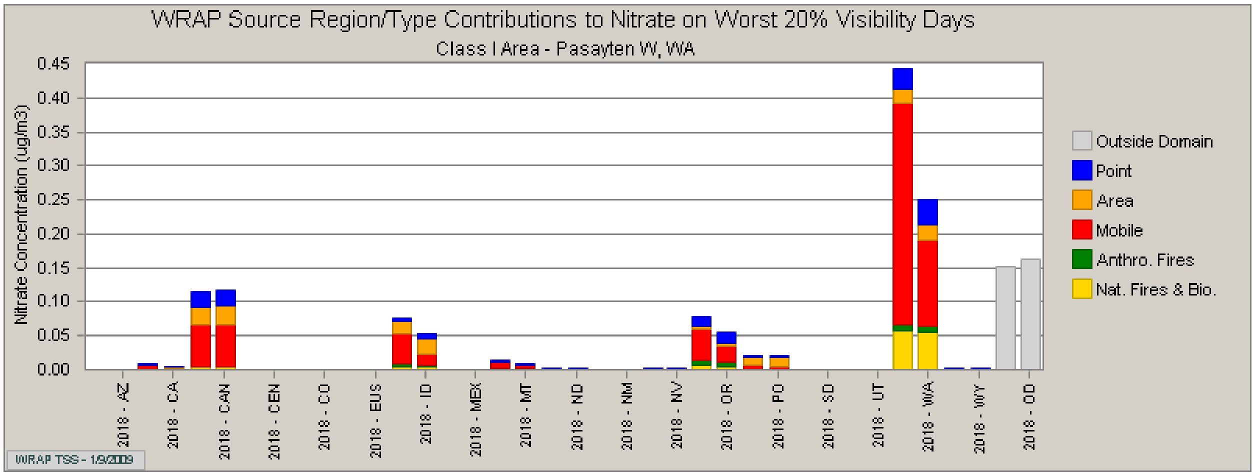



**Figure 8-61 Nitrate Source Regions for 2002 and 2018 Most Impaired Days at PASA1**

## Least Impaired Days

On the Least Impaired Days in 2002, sources from Washington (62%), Oregon (15%) and outside of the modeling domain (8%) make up 85% of the light extinction caused by nitrates.

In comparison to the Least Impaired Days in 2002, the projected nitrate concentration in 2018 decreases 0.6 µg/m$^3$. The relative contributions from Washington sources decrease by 12% while contributions from outside the modeling domain, Canada, and Pacific offshore increase by 12%. Additional details are shown in Figure 8-62.

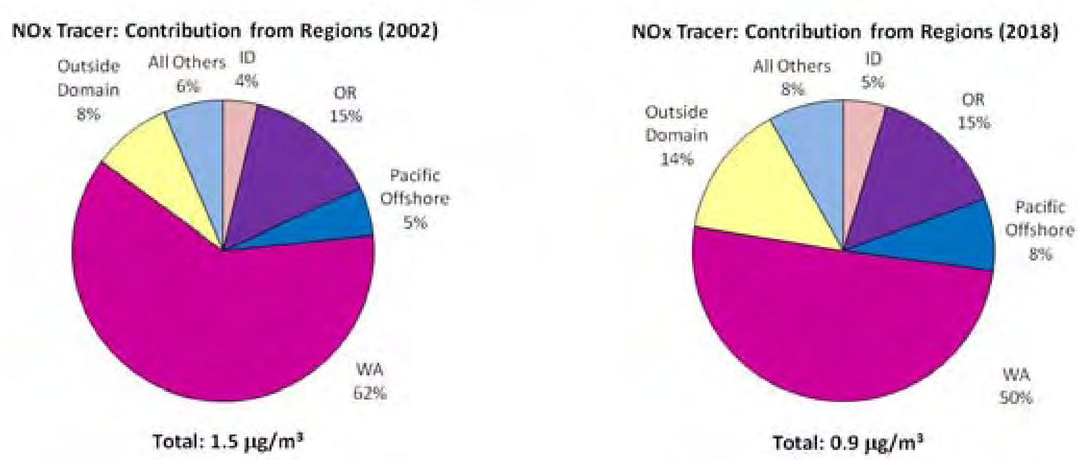



**Figure 8-62 Nitrate Contributions by Source Regions for Least Impaired Days at PASA1**

Figure 8-63 shows the source regions and source categories that contribute nitrate at the PASA1 monitoring site on the Least Impaired Days. Washington mobile sources contributed to 49% of the total contribution to light extinction by nitrates on the Least Impaired Days in 2002, followed by point sources (6%), natural fire and biogenic sources (4%), and area sources (3%). In 2018, Washington mobile sources are expected to contribute to 28% of the total light extinction by nitrates, followed by point sources (10%), area sources (6%), and natural fire and biogenic sources (5%).

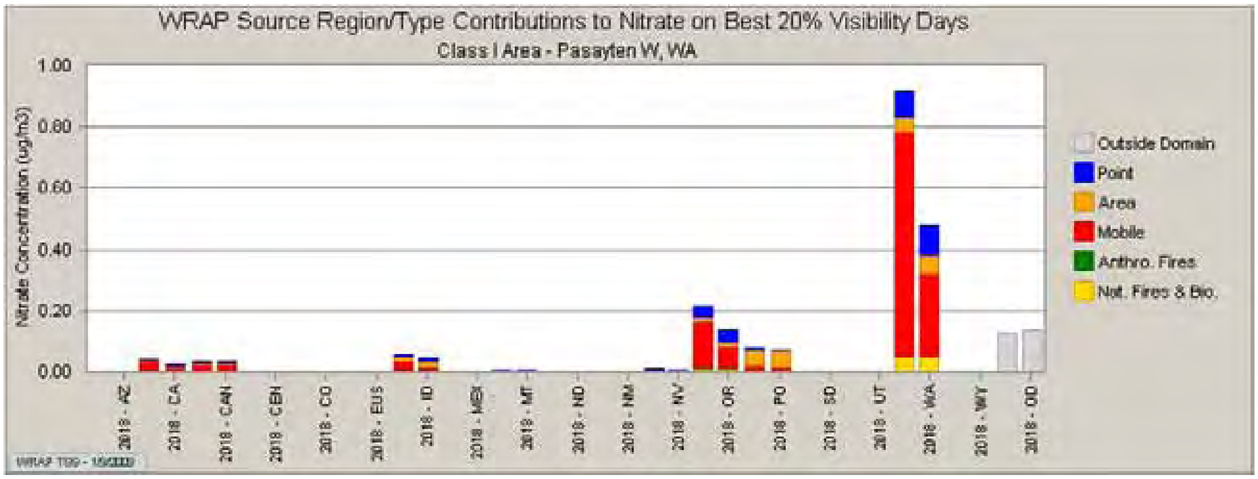


**Figure 8-63 Nitrate Source Regions for 2002 and 2018 Least Impaired Days at PASA1**

### 8.6.3 Organic Mass Carbon

Monitoring data indicate that OMC is the highest cause of light extinction on the Most Impaired Days and tied with nitrates as the second highest cause on the Least Impaired Days at the PASA1 site.

As WEP indicates, most of the OMC emissions come from Washington. Additional detail is shown in Figure 8-64.

For both Most Impaired and Least Impaired Days in 2002 and 2018 natural fire is the predominant source of OMC. The emissions from natural fire were held constant from 2002 and 2018. The relative contributions from other sources are also shown in Figures 8-65 and 8-66.

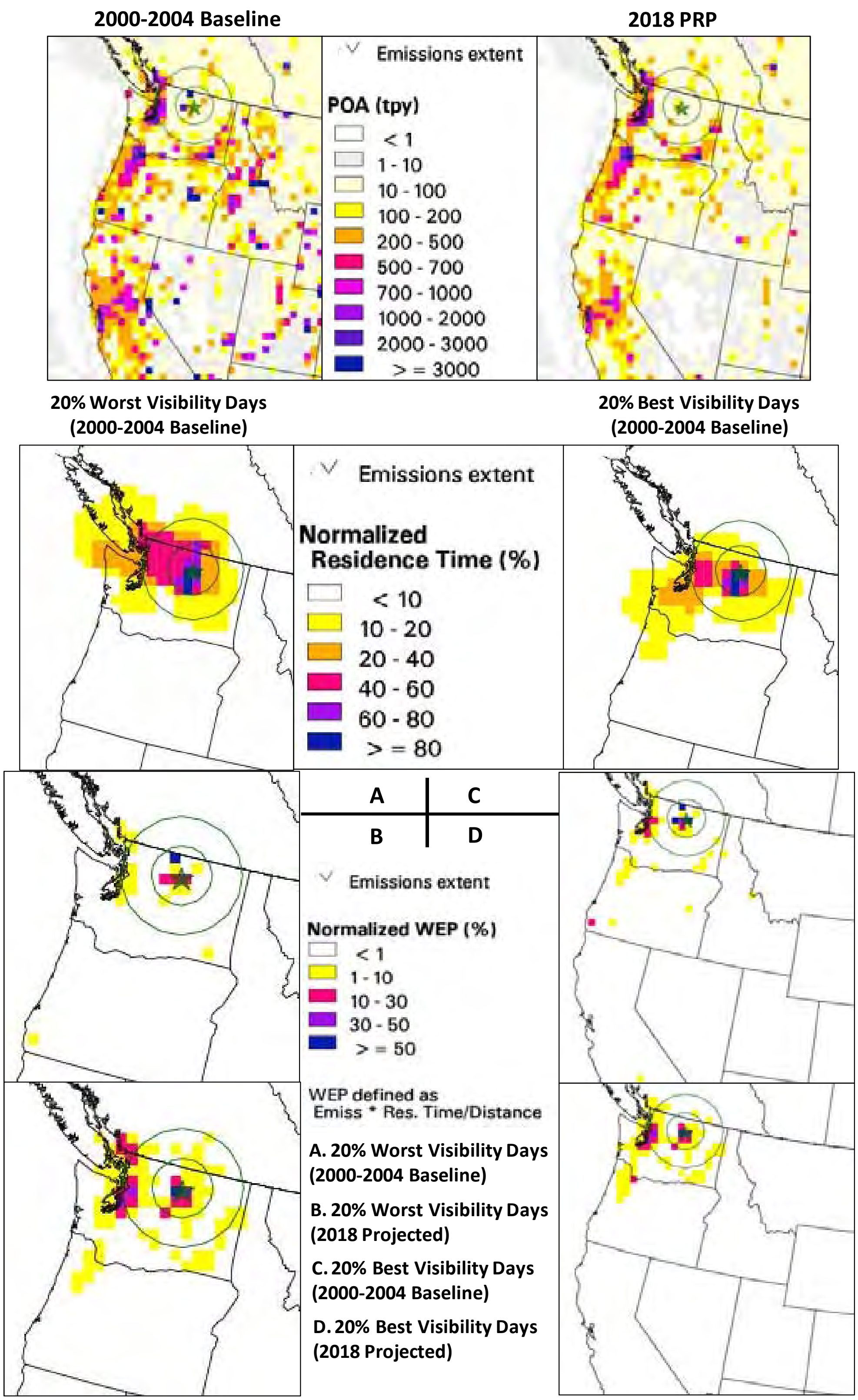



**Figure 8-64 Primary Organic Aerosols Residence Time, Mapped Emissions, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at PASA1**

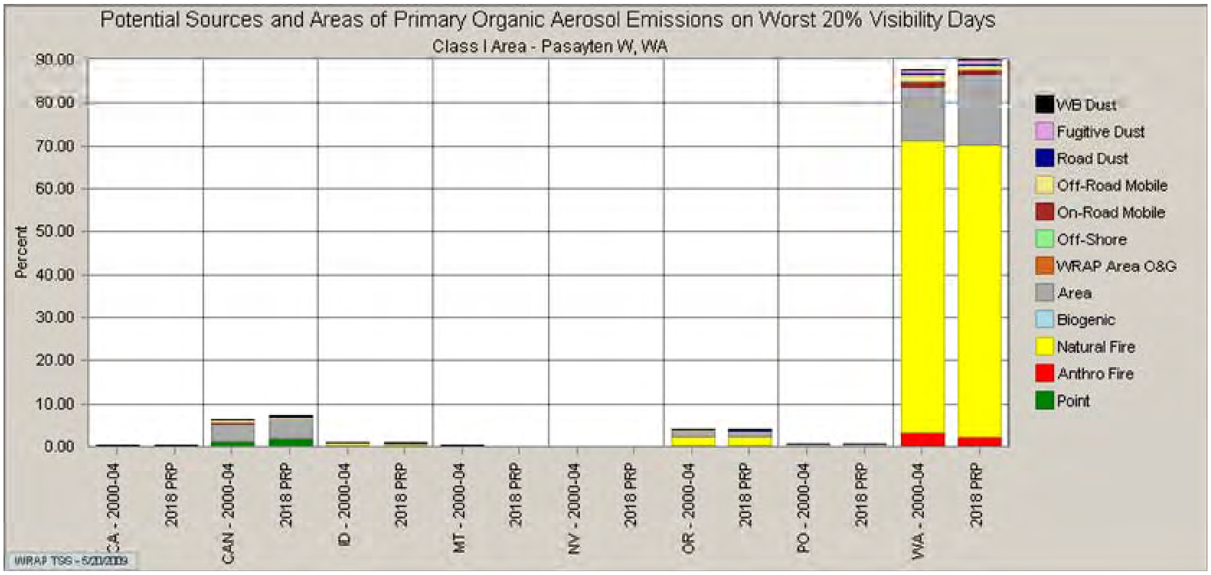



**Figure 8-65 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Most Impaired Days at PASA1**

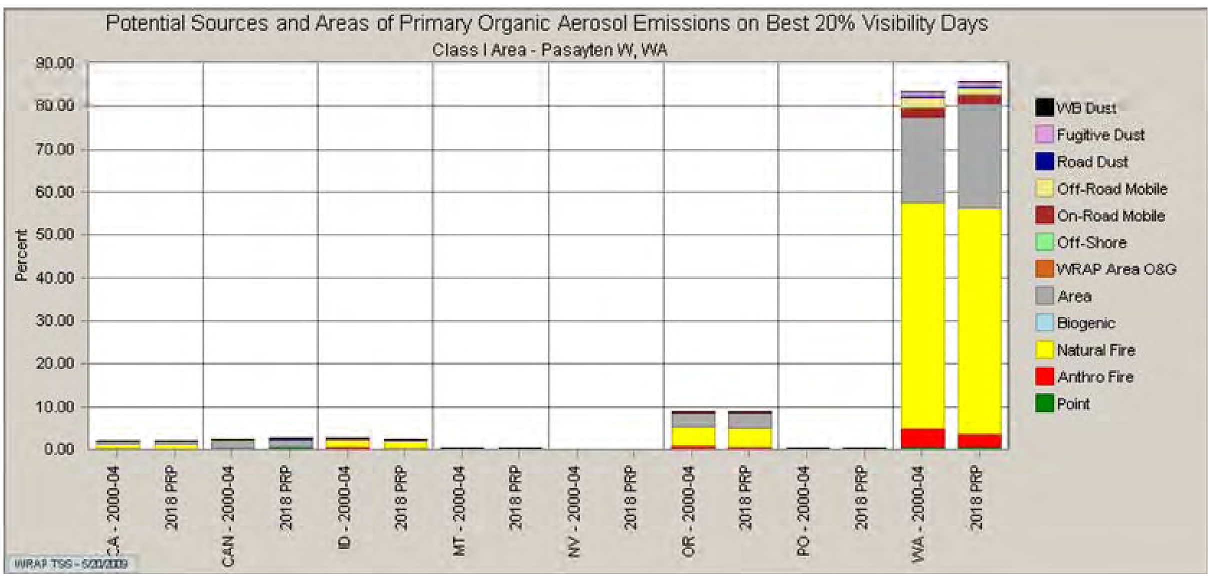



**Figure 8-66 Primary Organic Aerosol Contributions by Source Regions for 2002 and 2018 Least Impaired Days at PASA1**

## 8.6.4 Elemental Carbon

Monitoring data indicate that EC is the third highest cause of light extinction on the Most Impaired Days and fourth highest cause on the Least Impaired Days at the PASA1 site in 2002.

WEP is the screening tool used to help identify source regions for EC. As WEP indicates, most of the EC emissions come from Washington sources. Additional detail is shown in Figure 8-67.

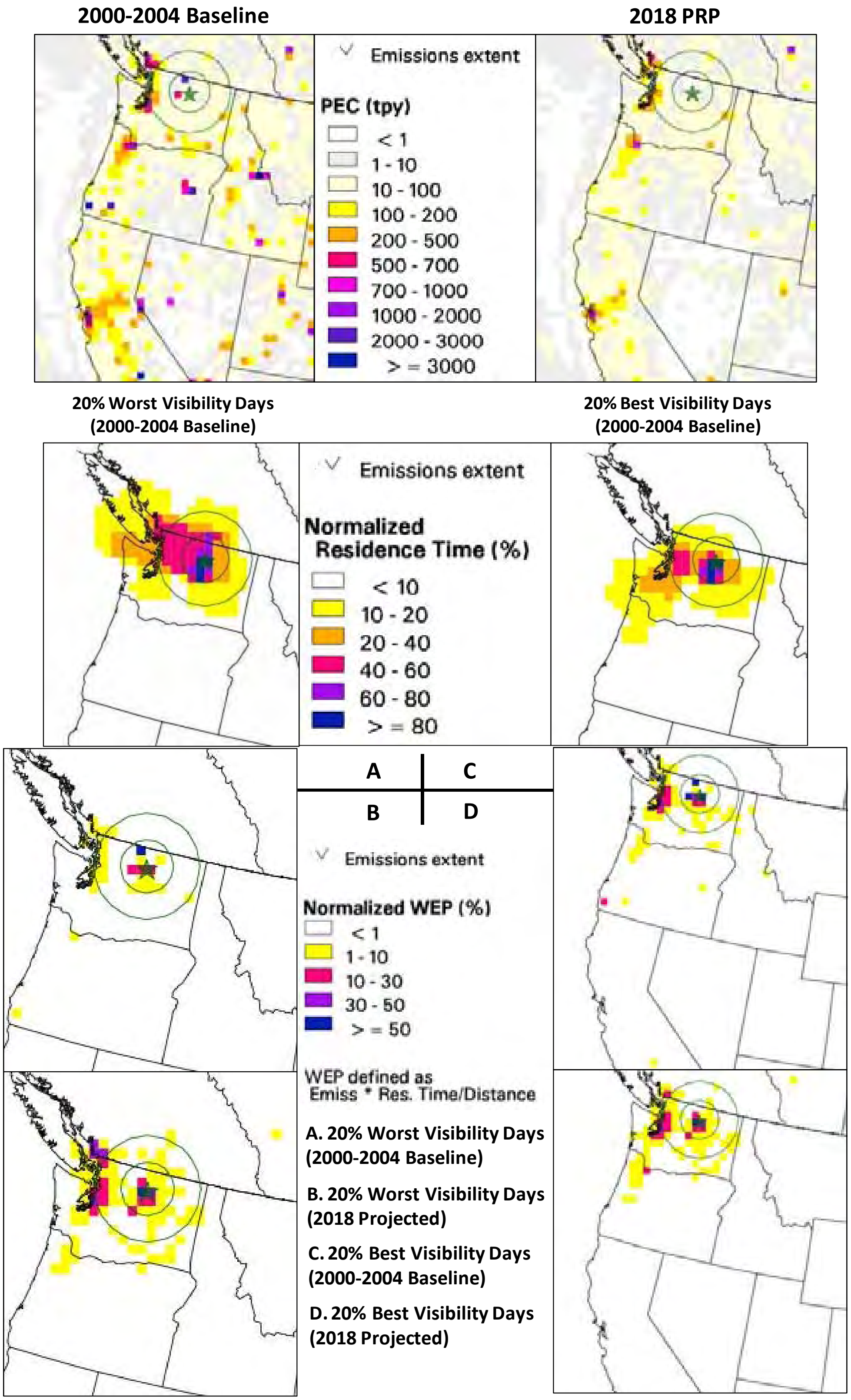



**Figure 8-67 Elemental Carbon Mapped Emissions, Residence Time, and Weighted Emission Potentials for Most Impaired and Least Impaired Days in 2002 and 2018 at PASA1**

For both Most Impaired and Least Impaired Days in 2002 and 2018 natural fire is the predominant source of EC. The emissions from natural fire were held constant from 2002 and 2018. The relative contributions from other sources are also shown in Figures 8-68 and 8-69.

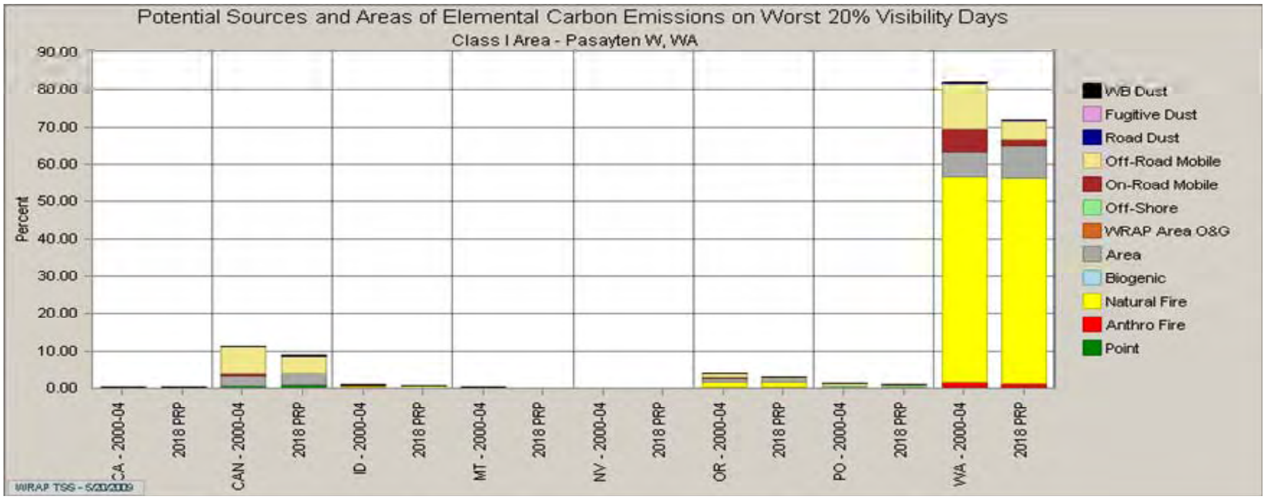



**Figure 8-68 Elemental Carbon Contributions by Source Regions for 2002 and 2018 Most Impaired Days at PASA1**

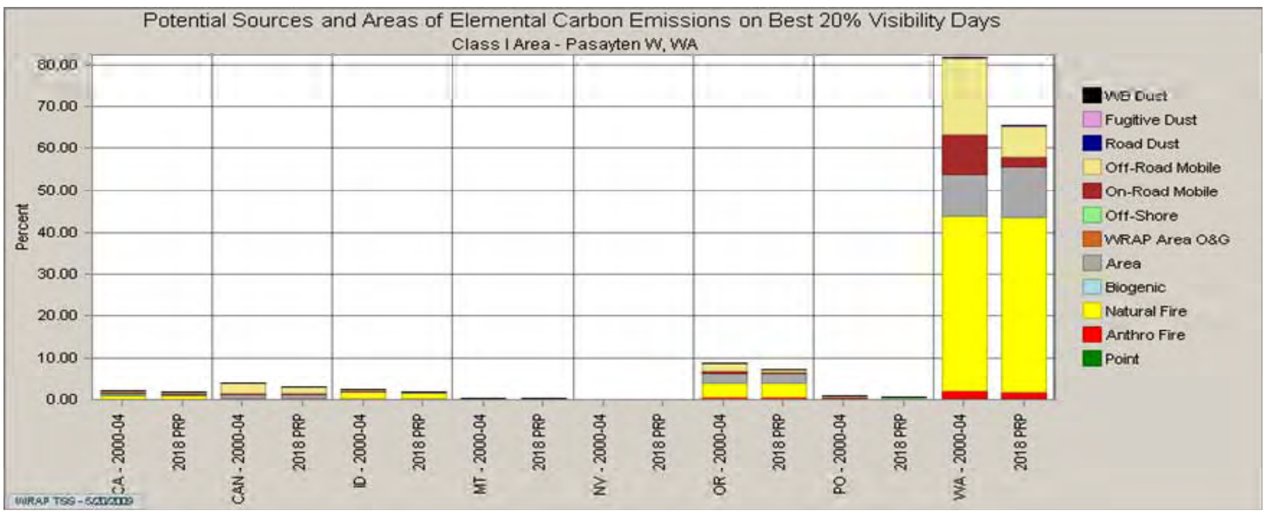



**Figure 8-69 Elemental Carbon Contributions by Source Regions for 2002 and 2018 Least Impaired Days at PASA1**

## 8.7 Summary of In State Source Contributions of Nitrates and Sulfates

Table 8-1 summarizes the in-state sources of sulfates for the four major source categories at each of the mandatory Class I Areas in Washington for both the Most Impaired and Least Impaired Days.

Table 8-2 summarizes the in-state sources of nitrates for the four major source categories at each of the mandatory Class I Areas in Washington for both the Most Impaired and Least Impaired Days.

**Table 8-1 Sulfate Contributions by Major Source Category for Washington's Mandatory Class I Areas**

| IMPROVE Site | Most Impaired Days | | | | | | | | | | Least Impaired Days | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | | | | | 2018 | | | | | 2002 | | | | | 2018 | | | | |
| | WA | Major Source Categories | | | | WA | Major Source Categories | | | | WA | Major Source Categories | | | | WA | Major Source Categories | | | |
| | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. |
| OLYM1 | **25%** | 15% | 3% | 7% | 0% | **24%** | 19% | 4% | 1% | 0% | **34%** | 18% | 6% | 10% | 0% | **29%** | 18% | 8% | 2% | 0% |
| NOCA1 | **29%** | 20% | 3% | 5% | 1% | **29%** | 24% | 3% | 1% | 1% | **39%** | 23% | 5% | 10% | 2% | **33%** | 24% | 8% | 1% | 4% |
| SNPA1 | **32%** | 16% | 5% | 10% | 0% | **28%** | 19% | 6% | 3% | 0% | **42%** | 26% | 5% | 11% | 0% | **35%** | 25% | 7% | 2% | 0% |
| MORA1 | **42%** | 25% | 6% | 11% | 0% | **34%** | 22% | 8% | 3% | 0% | **36%** | 25% | 3% | 7% | 0% | **25%** | 19% | 4% | 2% | 0% |
| WHPA1 | **29%** | 16% | 4% | 8% | 0% | **23%** | 16% | 5% | 2% | 0% | **44%** | 30% | 4% | 9% | 0% | **31%** | 23% | 6% | 2% | 0% |
| PASA1 | **18%** | 8% | 2% | 4% | 4% | **16%** | 9% | 2% | 1% | 4% | **36%** | 21% | 5% | 10% | 0% | **29%*** | 21% | 7% | 2% | 0% |

**Table 8-2 Nitrate Contributions by Major Source Category for Washington's Mandatory Class I Areas**

| IMPROVE Site | Most Impaired Days | | | | | | | | | | Least Impaired Days | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | | | | | 2018 | | | | | 2002 | | | | | 2018 | | | | |
| | WA | Major Source Categories | | | | WA | Major Source Categories | | | | WA | Major Source Categories | | | | WA | Major Source Categories | | | |
| | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. | | Point | Area | Mobile | Nat. Fires & Bio. |
| OLYM1 | **53%** | 9% | 3% | 40% | 1% | **42%** | 15% | 6% | 19% | 1% | **58%** | 8% | 4% | 45% | 1% | **51%** | 15% | 9% | 26% | 1% |
| NOCA1 | **46%** | 6% | 2% | 34% | 3% | **31%** | 9% | 4% | 14% | 4% | **63%** | 6% | 3% | 51% | 2% | **51%** | 11% | 7% | 29% | 4% |
| SNPA1 | **68%** | 5% | 3% | 56% | 3% | **56%** | 10% | 7% | 34% | 4% | **65%** | 7% | 3% | 52% | 1% | **55%** | 14% | 8% | 31% | 2% |
| MORA1 | **78%** | 9% | 5% | 62% | 1% | **69%** | 18% | 11% | 37% | 2% | **42%** | 7% | 2% | 32% | 1% | **36%** | 11% | 4% | 19% | 2% |
| WHPA1 | **64%** | 6% | 4% | 52% | 2% | **50%*** | 12% | 8% | 29% | 2% | **48%** | 7% | 2% | 38% | 1% | **43%** | 12% | 5% | 23% | 2% |
| PASA1 | **48%** | 3% | 2% | 36% | 6% | **37%** | 5% | 3% | 19% | 8% | **62%** | 6% | 3% | 49% | 4% | **50%** | 10% | 6% | 28% | 5% |

*Difference due to rounding.

## 8.8 Summary of In-State Dominant Source Contributions of Organic Mass Carbon

Table 8-3 summarizes the dominant in-state source categories that contribute to OMC on the Most Impaired and Least Impaired Days at each of the mandatory Class I Areas in Washington.

**Table 8-3 Summary of In-State Dominant Source Contributions of Organic Mass Carbon**

| IMPROVE SITE | Most Impaired Days | | Least Impaired Days | |
|---|---|---|---|---|
| | 2002 | 2018 | 2002 | 2018 |
| OLYM1 | Area | Area | Area | Area |
| NOCA1 | Natural Fire & Area | Natural Fire & Area | Natural Fire & Area | Natural Fire & Area |
| SNPA1 | Area | Area | Area | Area |
| MORA1 | Area | Area | Area | Area |
| WHPA1 | Area | Area | Area | Area |
| PASA1 | Natural Fire | Natural Fire | Natural Fire | Natural Fire |

## 8.9 Other Mandatory Class I Areas Impacted by Washington Emissions

The PSAT source apportionment modeling results were evaluated to determine which mandatory Class I Areas in adjacent states might be affected by emissions from Washington sources.

Table 8-4 presents the results of this evaluation for sulfates. The table identifies the rank and percentage of the total modeled concentration due to $SO_2$ emissions from sources within Washington to the IMPROVE monitors representing mandatory Class I Areas in California, Oregon, Idaho, Nevada, Montana, and Wyoming. The rank and percentage contribution is based on contributions from all modeled source areas. The red values indicate sulfate contributions from Washington sources equal to or greater than 10% at particular IMPROVE monitoring sites.

**Table 8-4 Washington's Sulfate Extinction Contribution to Mandatory Class I Areas in Areas Outside of Washington**

| IMPROVE Site Code | IMPROVE Site Name | Sulfate Extinction Contribution due to Washington Emissions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Most Impaired Days | | | | Least Impaired Days | | | |
| | | 2002 | | 2018 | | 2002 | | 2018 | |
| | | Impact | Rank | Impact | Rank | Impact | Rank | Impact | Rank |
| **California** | | | | | | | | | |
| AGTI1 | Agua Tibia W | 1.0% | 7 | 0.7% | 7 | 0.3% | 10 | 0.2% | 12 |
| BLIS1 | Desolation W, Mokelumne W | 3.3% | 6 | 2.0% | 7 | 0.3% | 6 | 0.3% | 6 |
| DOME1 | Dome Lands | 2.9% | 5 | 1.8% | 7 | 0.6% | 7 | 0.3% | 9 |
| HOOV1 | Hoover W | 3.6% | 5 | 2.5% | 6 | 0.4% | 5 | 0.4% | 5 |
| KAIS1 | Ansel Adams W, John Muir W, Kaiser W | 3.1% | 6 | 2.0% | 7 | 0.4% | 5 | 0.0% | 9 |
| LABE1 | Lava Beds NM, South Warner W | 7.1% | 4 | 5.1% | 5 | 2.8% | 6 | 2.0% | 6 |
| LAVO1 | Caribou W, Lassen Volcanic NP, Thousand Lakes W | 5.5% | 5 | 3.7% | 5 | 0.6% | 7 | 0.5% | 6 |
| PINN1 | Pinnacles NM, Ventana W | 3.6% | 5 | 2.3% | 5 | 0.8% | 4 | 0.5% | 4 |
| PORE1 | Point Reyes NS | 4.5% | 5 | 2.7% | 6 | 5.9% | 4 | 3.9% | 5 |
| RAFA1 | San Rafael W | 2.9% | 5 | 1.9% | 5 | 0.5% | 6 | 0.4% | 8 |
| REDW1 | Redwood NP | 2.6% | 4 | 1.7% | 5 | 4.2% | 5 | 2.7% | 5 |
| SAGA1 | Cucamonga W, San Gabriel W | 1.5% | 6 | 0.9% | 6 | 0.4% | 8 | 0.3% | 10 |
| SAGO1 | San Gorgonio W, San Jacinto W | 1.2% | 7 | 0.8% | 7 | 0.4% | 9 | 0.2% | 12 |
| SEQUI | Kings Canyon NP, Sequoia NP | 1.9% | 6 | 1.2% | 7 | 1.4% | 6 | 0.8% | 7 |
| TRIN1 | Marble Mountain W, Yolla Bolly-Middle Eel W, | 6.6% | 5 | 4.3% | 5 | 2.6% | 5 | 1.7% | 5 |
| YOSE1 | Emigrant W, Yosemite NP | 3.7% | 5 | 2.3% | 7 | 0.3% | 6 | 0.3% | 6 |
| **Oregon** | | | | | | | | | |
| CRLA1 | Crater Lake NP, Diamond Peak W, Gearhart Mountain W, Mountain Lakes W | 8.5% | 4 | 5.5% | 6 | 2.9% | 5 | 2.1% | 5 |
| KALM1 | Kalmiopsis W | 6.2% | 4 | 3.7% | 4 | 0.6% | 6 | 0.2% | 6 |
| MOHO1 | Mount Hood W | **21.6%** | 2 | **17.5%** | 2 | 7.1% | 4 | 5.7% | 4 |
| STAR1 | Eagle Cap W, Strawberry Mountain W | **14.4%** | 3 | **12.9%** | 3 | **10.6%** | 3 | 9.3% | 3 |
| THSI1 | Mount Jefferson W, Mount Washington W, Three Sisters W | **14.8%** | 3 | **11.0%** | 4 | 3.3% | 5 | 2.4% | 5 |
| **Idaho** | | | | | | | | | |
| CRMO1 | Craters of the Moon NM | 4.1% | 5 | 3.1% | 6 | 6.7% | 4 | 5.7% | 5 |
| HECA1 | Hells Canyon W | 5.8% | 5 | 4.5% | 5 | **10.4%** | 3 | 8.4% | 3 |
| SAWT1 | Sawtooth W | 8.9% | 4 | 6.9% | 4 | 5.1% | 6 | 3.6% | 7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nevada** | | | | | | | | | |
| JARB1 | Jarbidge W | 8.6% | 3 | 6.0% | 5 | 2.2% | 7 | 1.3% | 8 |
| **Montana** | | | | | | | | | |
| CABI1 | Cabinet Mountains W | **13.8%** | 3 | **10.7%** | 3 | **16.8%** | 2 | **14.7%** | 3 |
| GAMO1 | Gates of the Mountains W | 5.8% | 4 | 4.4% | 4 | 7.3% | 4 | 5.8% | 6 |
| GLAC1 | Glacier NP | 6.0% | 4 | 4.8% | 4 | **17.2%** | 3 | **13.7%** | 3 |
| MELA1 | Medicine Lake NWRW | 2.1% | 6 | 1.7% | 6 | 2.1% | 4 | 1.7% | 4 |
| MONT1 | Bob Marshall W, Mission Mountains W, Scapegoat W | 6.9% | 3 | 4.8% | 4 | **13.3%** | 3 | **10.8%** | 3 |
| SULA1 | Anaconda-Pintler W, Selway-Bitterroot W | 9.6% | 4 | 7.3% | 4 | 4.9% | 4 | 3.3% | 6 |
| ULBE1 | UL Bend NWRW | 2.3% | 7 | 1.7% | 7 | 7.7% | 3 | 6.6% | 4 |
| **Wyoming** | | | | | | | | | |
| BRID1 | Bridger W, Fitzpatrick W | 1.9% | 13 | 1.1% | 15 | 0.9% | 10 | 0.5% | 10 |
| NOAB1 | North Absaroka W, Washakie W | 3.3% | 6 | 2.1% | 8 | 2.4% | 8 | 1.7% | 9 |
| YELL2 | Grand Teton NP, Red Rock Lakes NWRW, Teton W, Yellowstone NP | 4.3% | 6 | 2.9% | 9 | 3.8% | 5 | 2.5% | 9 |

Table 8-5 presents the results of the PSAT source apportionment modeling for nitrate extinction at the mandatory Class I Areas in California, Oregon, Idaho, Nevada, Montana, and Wyoming. The rank and percentage contribution is based on contributions from all modeled source areas. The red values indicate sulfate contributions from Washington sources equal to or greater than 10% at particular IMPROVE monitoring sites.

**Table 8-5 Washington's Nitrate Extinction Contribution to Mandatory Class I Areas in Areas Outside of Washington**

| IMPROVE Site Code | IMPROVE Site Name | Nitrate Extinction Contribution due to Washington Emissions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Most Impaired Days | | | | Least Impaired Days | | | |
| | | 2002 | | 2018 | | 2002 | | 2018 | |
| | | Impact | Rank | Impact | Rank | Impact | Rank | Impact | Rank |
| **California** | | | | | | | | | |
| AGTI1 | Agua Tibia W | 0.2% | 7 | 0.2% | 8 | 0.2% | 8 | 0.2% | 9 |
| BLIS1 | Desolation W, Mokelumne W | 1.0% | 6 | 0.4% | 7 | 0.5% | 6 | 0.3% | 7 |
| DOME1 | Dome Lands | 0.9% | 6 | 0.8% | 6 | 0.6% | 7 | 0.4% | 9 |
| HOOV1 | Hoover W | 4.2% | 5 | 4.5% | 4 | 0.9% | 5 | 0.5% | 5 |
| KAIS1 | Ansel Adams W, John Muir W, Kaiser W | 2.7% | 4 | 1.9% | 6 | 0.4% | 6 | 0.2% | 6 |
| LABE1 | Lava Beds NM,South Warner W | 6.6% | 4 | 4.9% | 5 | 3.7% | 6 | 2.8% | 6 |
| LAVO1 | Caribou W, Lassen Volcanic NP, Thousand Lakes W | 2.9% | 5 | 3.0% | 5 | 0.7% | 6 | 0.5% | 7 |
| PINN1 | Pinnacles NM, Ventana W | 1.1% | 5 | 1.0% | 6 | 0.4% | 6 | 0.4% | 6 |
| PORE1 | Point Reyes NS | 2.1% | 5 | 1.5% | 6 | 4.3% | 5 | 3.7% | 5 |
| RAFA1 | San Rafael W | 1.4% | 5 | 1.2% | 5 | 0.4% | 5 | 0.3% | 5 |
| REDW1 | Redwood NP | 7.9% | 5 | 4.9% | 5 | 1.6% | 5 | 1.3% | 5 |
| SAGA1 | Cucamonga W, San Gabriel W | 0.5% | 5 | 0.3% | 6 | 0.3% | 6 | 0.2% | 8 |
| SAGO1 | San Gorgonio W, San Jacinto W | 0.3% | 7 | 0.2% | 7 | 0.5% | 8 | 0.3% | 9 |
| SEQUI | Kings Canyon NP, Sequoia NP | 0.5% | 6 | 0.4% | 6 | 1.1% | 6 | 0.8% | 8 |
| TRIN1 | Marble Mountain W, Yolla Bolly-Middle Eel W | 5.1% | 4 | 4.5% | 5 | 2.8% | 5 | 2.2% | 5 |
| YOSE1 | Emigrant W, Yosemite NP | 1.6% | 6 | 1.9% | 6 | 0.3% | 5 | 0.2% | 6 |
| **Oregon** | | | | | | | | | |
| CRLA1 | Crater Lake NP, Diamond Peak W, Gearhart Mountain W, Mountain Lakes W | **11.8%** | 4 | 7.9% | 4 | 3.2% | 5 | 2.9% | 5 |
| KALM1 | Kalmiopsis W | **13.2%** | 4 | 8.3% | 5 | 0.7% | 6 | 0.4% | 6 |
| MOHO1 | Mount Hood W | **33.5%** | 2 | **24.9%** | 2 | **10.0%** | 3 | 8.4% | 4 |
| STAR1 | Eagle Cap W, Strawberry Mountain W | **19.4%** | 3 | **13.7%** | 4 | **14.4%** | 4 | **10.7%** | 4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| THSI1 | Mount Jefferson W, Mount Washington W, Three Sisters W | **21.9%** | 2 | **15.9%** | 3 | 5.1% | 5 | 4.2% | 5 |
| **Idaho** | | | | | | | | | |
| CRMO1 | Craters of the Moon NM | 4.9% | 4 | 3.0% | 7 | 7.7% | 4 | 5.1% | 8 |
| HECA1 | Hells Canyon W | 7.6% | 5 | 4.7% | 6 | **17.1%** | 3 | **11.6%** | 3 |
| SAWT1 | Sawtooth W | **12.2%** | 3 | 8.1% | 4 | 6.7% | 5 | 4.0% | 7 |
| **Nevada** | | | | | | | | | |
| JARB1 | Jarbidge W | 6.6% | 6 | 4.6% | 6 | 2.9% | 7 | 1.8% | 8 |
| **Montana** | | | | | | | | | |
| CABI1 | Cabinet Mountains W | **33.4%** | 1 | **25.0%** | 1 | **31.2%** | 1 | **23.3%** | 1 |
| GAMO1 | Gates of the Mountains W | **10.2%** | 4 | 6.4% | 4 | **15.1%** | 3 | 9.6% | 4 |
| GLAC1 | Glacier NP | **13.2%** | 4 | 8.9% | 4 | **35.6%** | 1 | **25.2%** | 1 |
| MELA1 | Medicine Lake NWRW | 5.8% | 5 | 3.1% | 5 | 5.9% | 4 | 3.2% | 5 |
| MONT1 | Bob Marshall W, Mission Mountains W, Scapegoat W | **10.0%** | 4 | 7.2% | 4 | **19.6%** | 1 | **13.6%** | 4 |
| SULA1 | Anaconda-Pintler W, Selway-Bitterroot W | **16.2%** | 3 | **10.6%** | 5 | 9.2% | 5 | 5.4% | 5 |
| ULBE1 | UL Bend NWRW | 5.2% | 5 | 2.8% | 5 | 13.9% | 3 | 8.4% | 5 |
| **Wyoming** | | | | | | | | | |
| BRID1 | Bridger W, Fitzpatrick W | 3.1% | 8 | 2.9% | 8 | 2.0% | 8 | 1.1% | 10 |
| NOAB1 | North Absaroka W, Washakie W | 4.6% | 6 | 3.0% | 6 | 4.8% | 7 | 2.7% | 8 |
| YELL2 | Grand Teton NP, Red Rock Lakes NWRW, Teton W, Yellowstone NP | 9.4% | 3 | 6.0% | 4 | 6.0% | 5 | 3.6% | 8 |

# Chapter 9 Reasonable Progress Goals for Washington's Class I Areas

This chapter sets Reasonable Progress Goals (RPG) first for the Most Impaired Days at all of the state's mandatory Class I Areas and then for the Least Impaired Days. The RPGs are summarized at the end of the chapter.

## 9.1 Introduction

The Regional Haze Rule (RHR) requires Washington to establish RPGs (expressed in deciviews (dv)) for the 8 mandatory Class I Areas within the state. The RPGs are meant to provide for an improvement in visibility on the Most Impaired Days and ensure no degradation in visibility on the Least Impaired Days.

In the establishment of RPGs, the RHR requires Washington to consider both the Uniform Rate of Progress (URP) needed to attain natural conditions by 2064 and the four factors required by the Clean Air Act (CAA) to determine Reasonable Progress. These four statutory factors are costs of compliance, the time necessary for compliance, energy and non-air impacts of compliance, and the remaining useful life of any potentially affected sources.[1]

Ecology's evaluation of RPGs relies on technical data and analysis developed by the Western Regional Air Partnership (WRAP) and available through the WRAP's Technical Support System (TSS). The source apportionment analyses discussed in Chapter 8 and the Class I Area Summary Table for each mandatory Class I Area were especially helpful. Class I Area Summary Tables for Washington's mandatory Class I Areas are reproduced in Appendix E. The TSS may be accessed through http://vista.cira.colostate.edu/tss/.

## 9.2 Most Impaired Days

### 9.2.1 Olympic National Park

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

**Baseline and Projected Visibility**

Visibility conditions at Olympic National Park are monitored at the Interagency Monitoring of Protected Visual Environments (IMPROVE) site OLYM1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 16.74 dv and calculated natural conditions are 8.44 dv, a difference of 8.30 dv.

[1] CAA §169A(g)(1)

This foundational State Implementation Plan (SIP) covers the first control period, 2005-2018. WRAP modeling (2018 Preliminary Reasonable Progress a, referred to as "PRP18a") projects 2018 visibility of 16.38 dv, which is a visibility improvement of 0.36 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would be improved 1.93 dv to 14.81 dv by 2018, a 23% improvement in visibility. Because the anticipated rate of progress is slower than the URP, more analysis is required to determine the RPG for Olympic National Park.

**Progress in Reducing Visibility Impairing Pollutants**

As discussed in Chapter 6, WRAP's PRP18a modeling reflects "controls on the books" and visibility improvements from some, but not all, Best Available Retrofit Technology (BART) sources throughout the West.

Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large reductions in Washington's emissions of Sulfur Dioxide ($SO_2$) (95%) and Nitrogen Oxides ($NO_x$) (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection resulting from engine and fuel rules.

WRAP's PRP18a modeling incorporated only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for Electrical Generating Units (EGUs) but uses actual limits where BART is already effective. In 2003 the Environmental Protection Agency (EPA) determined BART for $SO_2$ and particulate matter for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's Reasonably Attributable Visibility Impairment (RAVI) SIP. This BART determination is reflected in the PRP18a inventory. The 2000-2004 baseline inventories reflect partial control conditions at the power plant.

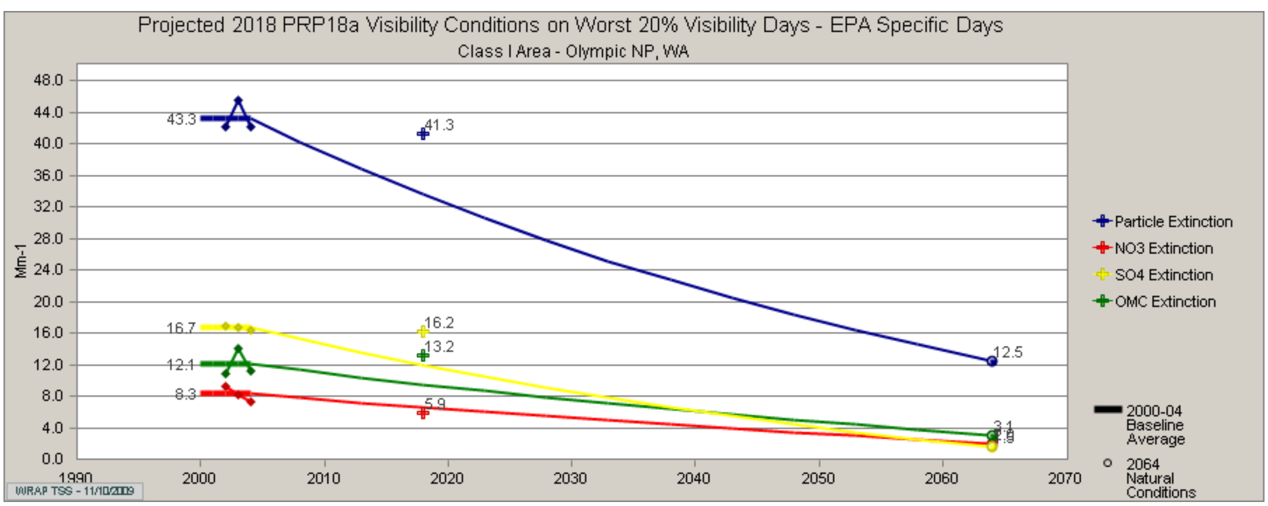



**Figure 9-1 Projected 2018 Visibility Conditions on the Most Impaired Days in Olympic National Park**

Ecology analyzed projected visibility impacts of sulfate, Organic Mass Carbon (OMC), and nitrate at OLYM1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-1). At OLYM1 these three visibility-impairing pollutants plus Rayleigh scattering were responsible for 88% of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

***Sulfate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for sulfate from 16.67 to 16.24 Inverse Megameters ($Mm^{-1}$), a visibility improvement of 0.43 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 11.93 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's Weighted Emissions Potential (WEP) analysis of upwind emissions indicates only a 14% decrease in the upwind direction (see Appendix E for the Olympic National Park Summary Table). While the statewide emissions decrease should be more than sufficient to support the 23% decrease in dv needed to meet the uniform glide path, the upwind emissions decrease is insufficient. This is not surprising as WRAP's Particulate Matter Source Apportionment Technology (PSAT) analysis for 2018 indicates that in order of importance, outside domain, Canada, and Pacific offshore contribute about two-thirds of the sulfate concentrations on the Most Impaired Days at OLYM1. These three regions are outside the control of the state of Washington.

***Organic Matter Carbon:*** WRAP's PRP18a modeling projects an increase in the extinction coefficient for OMC from 12.06 to 13.23 $Mm^{-1}$, a visibility degradation of 1.17 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 9.51 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of Primary Organic Aerosols (POA) and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of Volatile Organic Compounds (VOCs). The formation of OMC from VOC**s** depends not only on the total amount of emissions but on the reactivity of individual VOCs and favorable ambient conditions for condensation or photo-oxidation. Washington's VOC emission inventory is much larger than the organic carbon (POA) inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for POA. Statewide emissions of Organic Carbon (OC) presented in section 6.4 are projected to increase by 4% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis projects a much greater increase human-caused weighted emissions of 22% in the upwind direction (see Appendix E for the Olympic National Park Summary Tables). The WEP analysis indicates the projected increase is primarily from area sources. The increase results from population growth.

Emission inventories presented in section 6.3 indicate that while total VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion. These emissions increase due to population growth.

Emissions increases in area sources do not mean that these sources are not controlled. It simply means that that there are more individual sources comprising the area sources as a result of population increase. Briefly the situation is as follows:

> *Solvent utilization:* All types of solvent utilization are regulated through federal and state rules.
>
> *Residential wood combustion:* Washington has a more stringent woodstove emission standard than EPA. The standard is applicable to all stoves sold in the state. When funding is available, the state and local air agencies have implemented and continue to implement woodstove change-out programs to replace older wood stoves with new, cleaner burning stoves or alternative heating sources.
>
> Washington law provides for mandatory curtailment of woodstove use when forecast meteorological conditions are predicted to cause the Fine Particulate Matter ($PM_{2.5}$) standard to be exceeded (RCW 70.94.473). The law has been strengthened as Particulate Matter (PM) standards have become more stringent. The latest changes to the woodstove burn-ban program went into effect in 2008.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 8.3 to 5.91 $Mm^{-1}$, a visibility improvement of 4.39 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 6.60 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a similar decrease in weighted emissions of 42% in the upwind direction (see Appendix E for the Olympic National Park Summary Tables). The reductions are due primarily to a projected large decrease in nitrate emissions from on-road and off-road mobile sources. Even with this large reduction of nitrate emissions within Washington, WRAP's PSAT analysis indicates that over half the nitrate impact on OLYM1 comes, in order of importance, from Canada, Pacific offshore, and outside domain.

***Summary:*** Ecology concludes from this analysis that progress is being made in reducing visibility impairing pollutants impacting Olympic National Park. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

**Four-Factor Analysis**

The RHR specifies that a state must consider the four factors specified by the Clean Air Act in determining the RPG for a Class I Area. These four statutory factors are:

- Costs of compliance
- Time necessary for compliance
- Energy and non-air quality impacts of compliance
- Remaining useful life of any potentially affected sources

Ecology decided to develop a set of Four-Factor Analyses for point sources of $SO_2$ and $NO_x$ for the 8 mandatory Class I Areas in Washington to meet this requirement. The work done by Ecology on the Four-Factor Analyses is summarized here and described in Appendix F.

The purpose of a Four-Factor Analysis is to evaluate a source or source category for potential controls. Ecology focused its examination of potential sources for Four-Factor Analysis on the PRP18a inventory, which reflects the implementation of controls during the first Regional Haze (RH) planning period.

IMPROVE monitoring shows that Ammonium Sulfate ($SO_4$) and Ammonium Nitrate ($NO_3$) are two of the most significant pollutants impairing visibility in Washington's mandatory Class I Areas. The WRAP projects that Washington's share of visibility impairment from each will remain significant in 2018 and largely anthropogenic in origin. $SO_4$ is attributable largely to point sources with a relatively minor contribution from area and mobile sources. $NO_3$ is attributable largely to mobile and point sources with a relatively unimportant contribution from area sources. The relative importance of point sources results in part from the significant reduction in $NO_x$ from mobile sources by 2018 due to engine rules. So Ecology decided to turn its focus to $NO_x$ reductions from point sources.

Ecology examined projected 2018 $SO_2$ and $NO_x$ emissions from specific industries and emission source categories as defined by Standard Classification Codes (SCCs). $SO_2$ and $NO_x$ are precursors of $SO_4$ and $NO_3$, respectively. As a first step, Ecology identified the major category SSCs projected to have the highest 2018 emissions of $SO_2$ and $NO_x$. The resulting 3 major source categories are industrial processes, external combustion boilers, and internal combustion engines. Emissions of both $SO_2$ and $NO_x$ from individual specific industries and emission source categories within these 3 major categories vary greatly.

Ecology decided to consider any specific industry or emissions source category emitting 1,000 tons or more per year of either $SO_2$ or $NO_x$ as "significant". Ecology deemed some of the resulting 15 specific industries and emission source categories as better prospective opportunities for emission reductions to improve visibility than others. This conclusion was based in part on BART determinations on individual sources subject to BART in some of the specific industries and emission source categories. Ecology decided to focus its four-factor analyses on the resulting set of 10 specific industries and emission source categories. The final list selected for four factor analyses is provided in Table 9-1.

**Table 9-1 Specific Industries or Emission Source Categories Selected for a Four-Factor Analysis**

| Specific Industry or Emission Source Category | Significant Specific $SO_2$ Industry or Emissions Source Category? | Significant Specific $NO_x$ Industry or Emissions Source Category? |
|---|---|---|
| | | |
| **Industrial Processes** | | |
| Primary Metal Production | | |
| Aluminum Ore Electro-Reduction | Yes | No |
| Petroleum Industry | | |
| Process Heaters | Yes | Yes |
| Catalytic Cracking Units | Yes | Yes |
| Pulp and Paper and Wood Products | | |
| Sulfate (Kraft) Pulping | Yes | Yes |
| Sulfite Pulping | No | Yes |
| Mineral Products | | |
| Cement (Wet Process) | Yes | Yes |
| Cement (Dry Process) | No | Yes |
| Glass Manufacture | No | Yes |
| | | |
| **External Combustion Boilers** | | |
| Industrial | | |
| Wood/Bark Waste | Yes | Yes |
| Residual Oil | Yes | No |
| Natural Gas | No | Yes |

Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 11 selected specific industries and emission source categories are located along the Interstate 5 (I-5) corridor in western Washington and are capable of contributing to visibility impairment at more than one mandatory Class I Areas. I-5 runs in an essentially north-south direction between the Canadian and Oregon borders west of the Cascade Mountains in what is sometimes referred to as the Puget Sound trough. Seven of Washington's eight Class I Areas border the Puget Sound trough. The eighth mandatory Class I Area is located largely on the eastern side of the crest of the Cascades Mountains.

Two sources in the set of 11 specific industries and emission source categories lie to the east of the Cascade Mountains in eastern Washington. These are Alcoa Wenatchee Works, an aluminum electro-ore reduction plant, and Boise Inc. Wallula, a pulp and paper plant. A visibility analysis for Alcoa Wenatchee Works (which was BART-eligible) showed that it contributed to visibility impairment essentially at Alpine Lakes Wilderness but did not meet the 0.5 dv significance level that would have made the Alcoa Wenatchee Works subject to BART. Boise Inc. Wallula has the potential to contribute to impairment at more than one mandatory Class I Area.

The set of four-factor analyses indicates there is the potential for $SO_2$ and $NO_x$ emission reductions from a number of individual sources, principally boilers (oil-, natural gas-, and wood-fired), process heaters, and Fluidized Catalytic Cracking Unit (FCCU)/Carbon Monoxide (CO) boiler systems. This identification sets the stage for future development of $SO_2$ and $NO_x$ limitations for individual sources. Washington State law requires Ecology to develop new requirements for an existing emission source category through a formal rulemaking action.[2] Ecology can issue a new rule (or revise an existing one) to require the installation of new emission controls.

The process in state law called Reasonably Available Control Technology (RACT) requires a detailed evaluation of the characteristics of each existing source covered by the rule process along with an evaluation of the efficacy of installation of various control equipment. The result of the process is a rule requiring all units of the defined source category to achieve a set of defined emission limitations. The rule will allow the sources a limited time to upgrade the controls to meet the new or revised emission standards. Washington State law does include an economic hardship provision. A company that demonstrates it meets criteria for economic hardship is allowed either an extended time to achieve compliance or an alternate, source-specific emission limitation.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_x$. Because of the process required to develop and establish RACT limits, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's Long-Term Strategy (LTS) in Chapter 10.

**2018 Reasonable Progress Goal for the Most Impaired Days**

Ecology concludes that 16.38 dv is the 2018 RPG for Olympic National Park in light of controls on the books, implementation of BART, the impact of out-of-state emissions, and the four-factor analysis. At this rate it would take Olympic National Park 323 years from the end of the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions in Washington State and controls on Canadian and Pacific offshore emissions.

### 9.2.2 North Cascades National Park and Glacier Peak Wilderness

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

Baseline and Projected Visibility

Visibility conditions at North Cascades National Park and Glacier Peak Wilderness are monitored at the IMPROVE site NOCA1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 16.01 dv and calculated natural conditions are 8.39 dv, a difference of 7.62 dv.

[2] §70.94.154 RCW

This foundational SIP covers the first control period, 2005-2018. The WRAP's modeling projects 2018 visibility of 17.24 dv, which is a visibility degradation of 1.23 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would instead be improved 1.78 dv to 14.23 dv by 2018, a 24% improvement in visibility.

On May 25, 2010, during the formal consultation on the draft RH SIP required by the RHR, the Federal Land Managers (FLMs) informed Ecology that North Cascades National Park and Glacier Peak Wilderness were the only mandatory Class I Areas in the country where visibility impairment is projected to increase in 2018.

The projected visibility impairment for the 2 mandatory Class I areas is the sum of the projected impairment of the individual visibility-impairing pollutants. It follows that to understand why the WRAP's modeling projected increased visibility impairment; Ecology needs to analyze the projected impacts of individual visibility-impairing pollutants. The results of Ecology's analysis are summarized below in Ecology's overview of progress in reducing visibility-impairing pollutants.

**Progress in Reducing Visibility Impairing Pollutants**

WRAP's PRP18a modeling reflects "controls on the books" and, to some extent, projected implementation of BART. Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large statewide reductions in $SO_2$ (95%) and $NO_x$ (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection as a result of engine and fuel rules.

WRAP's PRP18a modeling incorporated only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for EGUs but uses actual limits for $SO_2$ where BART is already effective. In 2003 the EPA determined BART for $SO_2$ and particulate matters for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's RAVI SIP. This BART determination is reflected in the 2018 inventory. The 2000-2004 baseline inventory reflects partial $SO_2$ control conditions at the power plant because controls were being installed during this period.

Ecology analyzed projected visibility impacts of sulfate, OMC, and nitrate at NOCA1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-2). At NOCA1 these 3 visibility-impairing pollutants plus Rayleigh scattering were responsible for 91% of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

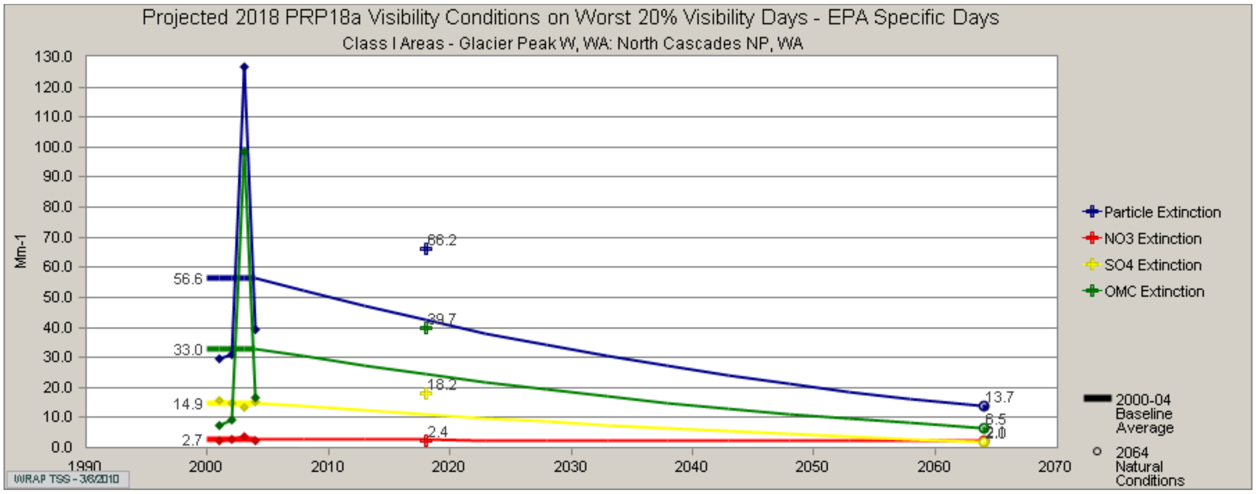



**Figure 9-2 Projected 2018 Visibility Conditions on the Most Impaired Days in North Cascades National Park and Glacier Peak Wilderness**

***Sulfate:*** The WRAP's PRP18a modeling projects an increase in the extinction coefficient for sulfate from 14.87 to 18.19 $Mm^{-1}$, a visibility degradation of 3.32 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 10.99 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in total on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's WEP analysis of upwind emissions indicates only a 10% weighted emissions decrease in the upwind direction (see Appendix E for the Glacier Peak Wilderness, North Cascades National Park Summary Table). While the statewide emissions decrease should be more than sufficient to support the 23% decrease in dv needed to meet the uniform glide path, the upwind emissions reduction indicated by the WEP analysis is insufficient. In fact, the 2018 increase in visibility-impairment projected by the WRAP modeling would appear to indicate a significant increase in sulfate emissions.

The WRAP's PSAT analysis for 2018 indicates that outside domain, Canada, and Pacific offshore contribute more than two-thirds of the sulfate concentrations monitored at the NOCA1 IMPROVE site on the Most Impaired Days. At 29% overall, Washington's contribution is also significant. Anthropogenic sources constitute 28% of Washington's 29% total contribution. Point sources, the dominant type of anthropogenic sources, contribute 24% of the 28% anthropogenic contribution while area and mobile sources contribute 3% and 1% respectively (see Appendix F, Table 1).

The general identification of the source regions contributing to the NOCA1 IMPROVE monitor on the Most Impaired Days still leaves the basic question of the source area or areas of any increase in sulfate emissions unanswered.

The commonly used technique for identification of source areas impacting a monitor site is back trajectories. The WRAP developed back trajectories for the WEP Analyses presented in the WRAP's TSS. Back trajectories use meteorological data to estimate the most likely central paths of air parcels to a monitor. The method essentially follows air parcels backwards from the monitor for a specific period of time. Back trajectories account for the impact of wind speed and wind direction but do not account for emissions, chemical transformation, dispersion, and deposition of pollutants.

The WRAP compiled back trajectories into residence time maps. The residence time analysis computed the amount of time that an air parcel was over each grid cell on the Most Impaired Days, summed these by 1° latitude and longitude grids, and plotted the results to show the relative time spent by air parcels over geographic areas before reaching the monitor. The resulting residence time maps are indicative of general flow patters but do not necessarily imply an area contributed significantly to the monitor because the methodology does not account for emissions and removal processes.

Ecology consulted with the WRAP staff and Air Resource Specialists, Inc. (ARS), the WRAP contractor which developed the residence time analysis. ARS recompiled the analysis for the NOCA1 IMPROVE monitor on the Most Impaired Days into 0.25° latitude and longitude grids. The results are presented below in Figure 9-3.

The residence time analysis indicates that the NOCA1 IMPROVE monitor is potentially most impacted by relatively nearby sources in Washington's Whatcom and Skagit counties and neighboring southwestern British Columbia. The broader area next most likely to potentially impact the NOCA1 monitor includes a larger area of northwest Washington, the lower British Columbia coast, and the south portion of British Columbia's Vancouver Island.

Ecology's examination of emission inventory information in the WRAP's TSS did not indicate large emission increases in these areas. Ecology concluded that the increased visibility impairment projected by the WRAP modeling apparently is the result of the comparatively long residence times of air parcels close to the NOCA1 monitor combined with the presence of large point source emissions of $SO_2$, the precursor of sulfate.

Further investigation of sulfur emissions from nearby sources in Whatcom and Skagit counties led Ecology to an important finding. The WRAP's PRP18a 2018 emission projections used in this RH SIP do not include major emission reductions from sulfur reduction projects at 3 oil refineries in these 2 counties.[3]

Table 9-2 provides a comparison between the WRAP's inventories and projected 2018 360 ton/year decrease in $SO_2$ emissions and Ecology's investigation that shows a 9,826 ton/year decrease in $SO_2$ emissions in 2008. The differences between the WRAP's inventories and Ecology's finding may be attributable in part to Ecology's lack of involvement in the WRAP's inventory development between 2002 when the Legislature rescinded funding for visibility and 2007 when the Legislature restored funding for RH SIP development.

[3] The sulfur reductions are not reflected in the WRAP's later PRP18b 2018 emission projections either.

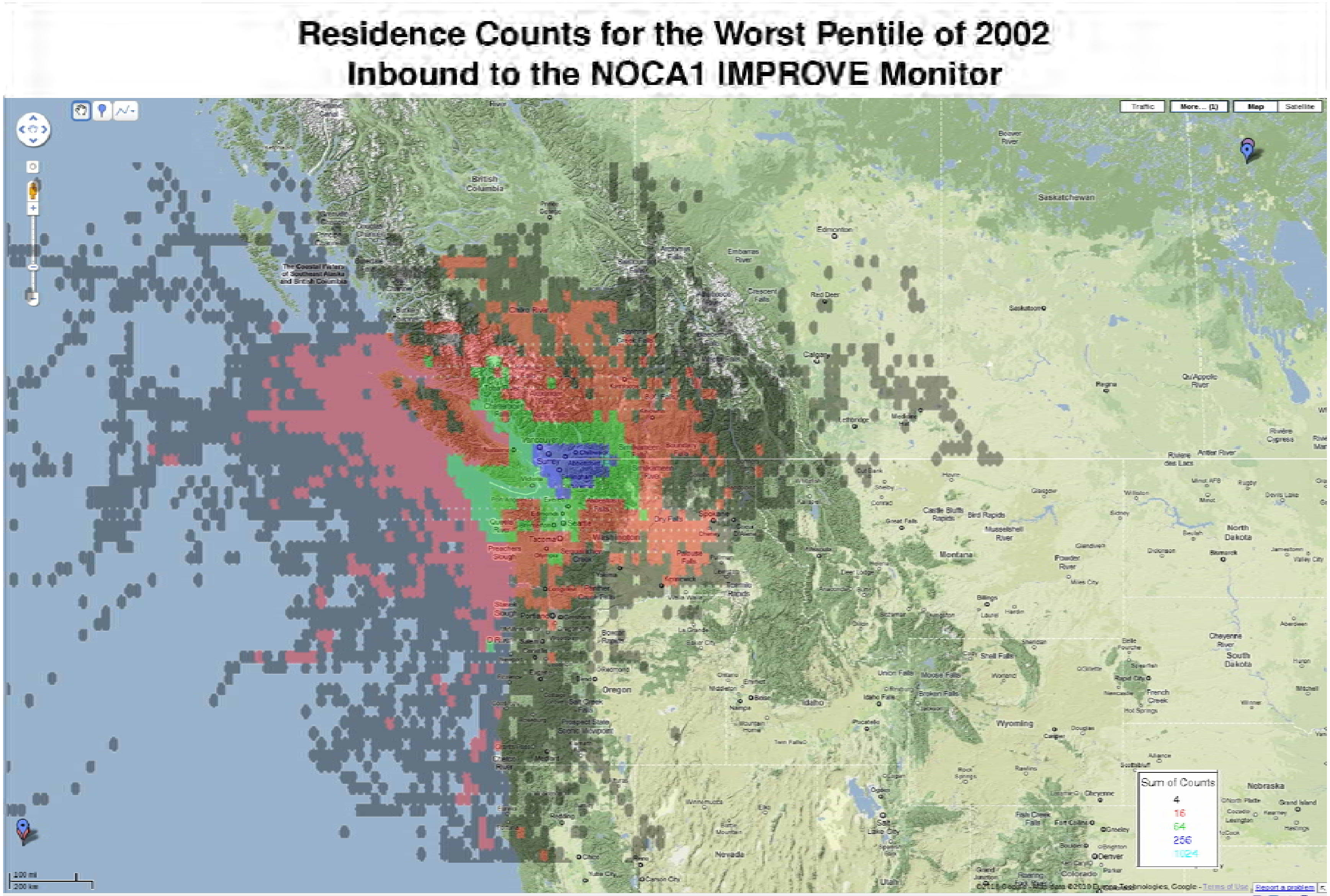



**Figure 9-3 Residence Time of Air Parcels to the NOCA1 Interagency Monitoring of Protected Visual Environments Monitor on the Most Impaired Days**

**Table 9-2 2018 Point Source Sulfur Dioxide Emissions Analysis, Skagit and Whatcom Counties**

| **Oil Refinery (County)** | **$SO_2$ (tons/year)** | | | | | |
|---|---|---|---|---|---|---|
| | The WRAP's Inventories | | | Ecology's Analysis | | |
| | Plan02d (2000-2004) | PRP18a (2018) | Emission Increase (2005-2018) | Plan02d (2000-2004) | Emission Inventory (2008) | Uncredited Emission Reductions |
| **Conoco-Phillips (Whatcom County)** | 2,286 | 2,641 | 355 | 2,286 | 245 | (2,041) |
| | | | | $SO_2$ Emission Reduction Projects<br>Wet Gas Scrubber (FCCU-CO Boiler)<br>S-Zorb Process Cat Gasoline Desulfurizer<br>Sulfur Recovery Unit | | |
| **Shell (Puget Sound Refining) (Skagit County)** | 3,494 | 2,444 | (1,050) | 3,494 | 449 | (3,045) |
| | | | | $SO_2$ Emission Reduction Projects<br>Sulfur Recovery Unit Tail Gas System<br>Wet Gas Scrubber (CO Boiler) | | |
| **Tesoro (Skagit County)** | 5,345 | 5,680 | 335 | 5,345 | 605 | (4,740) |
| | | | | $SO_2$ Emission Reduction Projects<br>Wet Gas Scrubber (CO Boiler) | | |
| **TOTALS** | **11,125** | **10,765** | **(360)** | **11,125** | **1,299** | **(9,826)** |

Ecology's emissions information comes from the Northwest Clean Air Agency (NWCAA) and is available on-line at http://www.nwcleanair.org/. NWCAA is the Washington local air quality agency with jurisdiction over the oil refineries. NWCAA regulates and permits the refineries except for issuance of Prevention of Significant Deterioration (PSD) permits, which are issued by Ecology. NWCAA compiles an annual emissions inventory for the major point sources in its jurisdiction. The 2008 inventory is the latest available inventory.

A brief overview of the major sulfur reduction projects at the 3 refineries is as follows:

- Conoco Phillips had 3 major projects associated with a large-scale upgrade of the refinery to make low-sulfur gasoline. First, as part of the replacement of the Catalytic Cracking Unit with a FCCU in 2003, a Wet Gas Scrubber (WGS) was installed to control $SO_2$ from the FCCU-CO Boiler system. Second, a Cat Gasoline Desulfurizer (CGD) using S-Zorb Sulfur Reduction Technology was constructed in 2003. Finally, a new Sulfur Recovery Unit (SRU) was installed in 2006 for increased reliability and additional sulfur removal capacity.

- Shell (Puget Sound Refining) had 2 major projects. A SRU Tail Gas Unit (TGU) was constructed in 2004 and a WGS was installed on the FCCU in 2006.

- Tesoro had one major project. A WGS was installed on the Catalytic Cracking Unit in 2005.

Inclusion of the major sulfur reduction projects at the oil refineries in the PRP18a inventory would increase the reduction in statewide emissions between the baseline period and 2018 from around 40% to over 50%

***Organic Matter Carbon:*** The WRAP's PRP18a modeling projects an increase in the extinction coefficient for OMC from 33.02 to 39.74 $Mm^{-1}$, a visibility degradation of 6.72 $Mm^{-1}$. The OMC light extinction for 2018 is over half of the total projected light extinction of 77.23 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 24.39 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. Primary organic aerosols are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs. Washington's VOC emission inventory is much larger than the organic carbon (POA) inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for primary organic aerosols. Statewide emissions of POA are projected to increase by 4% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a similar total increase in weighted emissions of 6% and a human-generated weighted emissions increase of 12% in the upwind direction (see Appendix E for the Glacier Peak Wilderness, North Cascades National Park Summary Table).

The WEP analysis indicates that the dominant source of POA impacting these two mandatory Class I Areas in the 2000-2004 baseline period is natural fire. Visibility impairment due to natural fire is very variable from year-to-year. Baseline conditions are significantly elevated by very high fire emissions in 2003. In the WRAP's 2018 modeling, natural fire was projected to remain at 2000-2004 baseline levels and locations. Ecology believes this treatment of natural fire results in an overestimate of the projected 2018 visibility impairment caused by natural fire because of the inordinately high impacts from natural fire in 2003.

Emission inventories presented in section 6.3 indicate that while total statewide VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion.

The large increase in area source emissions reflects the impact of population growth has on the total amount of emissions despite controls on "individual" areas sources such as a can of paint or a woodstove. Solvent utilization is regulated through federal and state rules. Washington has more stringent woodstove emission standards than EPA and a mandatory curtailment requirement which has been strengthened to require curtailments at lower particulate matter concentrations as particulate matter standards have become more stringent.

The WEP analysis also indicates that North Cascades National Park and Glacier Peak Wilderness are impacted by emissions, primarily area source emissions, from Canada.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 2.69 to 2.11 $Mm^{-1}$, a visibility improvement of 0.58 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 2.56 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a smaller decrease of 37%. in total weighted emissions in the upwind direction and 39% in anthropogenic emissions (see Appendix E for the Glacier Peak Wilderness, North Cascades National Park Summary Table). The reductions are due primarily to a projected large decrease in nitrate emissions from on-road and off-road mobile sources. Even with this large reduction of nitrate emissions within Washington, WRAP's PSAT analysis indicates that half the nitrate impact on NOCA1 comes, in order of importance, from Canada, outside domain, and Pacific offshore.

***Summary:*** There are issues with regard to the 2018 visibility at North Cascades National Park and Glacier Peak Wilderness projected by the WRAP's modeling. Major reductions in $SO_2$ emissions from oil refineries are not reflected in the PRP18a emissions inventory. There is uncertainty about the reasonableness of the projected natural fire emissions, and the influence on visibility of areas outside of Washington (outside domain, Canada, and Pacific offshore). Ecology concludes from the analysis provided above that overall Washington is making progress albeit limited in reducing visibility impairing pollutants. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

**Four-Factor Analysis**

The RHR specifies that a state must consider the four factors specified by the CAA in determining the RPG for a Class I Area. Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 10 selected specific industries and emission source categories are located along the I-5 corridor in western Washington and are capable of contributing to visibility impairment at more than one of Washington's mandatory Class I Areas.

The work done by Ecology on the Four-Factor Analyses is summarized in the Four-Factor Analysis subsection of section 9.2.1 Olympic National Park and described in Appendix F.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_x$. Because of the process required by state law to establish and require RACT limits, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's LTS in Chapter 10.

**2018 Reasonable Progress Goal for the Most Impaired Days**

Generally, modeled visibility impairment serves as a point of reference for setting the 2018 RPG. However, there are issues with the WRAP modeling for North Cascades National Park and Glacier Peak Wilderness. The modeling projects increased visibility impairment in 2018

First, the PRP18a $SO_2$ inventory projected for 2018 does not include existing major $SO_2$ reductions at 3 large oil refineries. These reductions are 27 times larger than the small reduction indicated by the inventory. The 3 refineries are located in the area indicated by the WRAP's Residence Time Analysis to have the greatest potential for directly impacting the NOCA1 IMPROVE monitor.

Secondly, the modeled 2018 OMC concentration at NOCA1 is heavily influenced by the extraordinarily high fire year of 2003. This high fire year significantly increased the 2001-2004 baseline concentration. Adjusting the baseline concentration by the Relative Response Factor (RRF) based on model results to project the 2018 concentration increases the already high OMC concentration. The intent of the WRAP modeling was to leave natural fire, which heavily influences OMC, unchanged from the baseline. Ecology supports this assumption. Ecology does not expect natural fire to have so great a influence on visibility impairment in 2018 as fire had during the baseline period because of the 2003 fires.

Since the RHR requires that the RPG provide for an improvement in visibility for the Most Impaired Days[4], Ecology decided to investigate the possibility of making adjustments to the modeled 2018 projection. Ecology started by examining the most recent data for the NOCA1 monitor available from the IMPROVE website, http://vista.cira.colostate.edu/improve/. Important aspects of these data for 2005-2008 are compared and contrasted with baseline conditions in Table 9-3 below.

[4] 40 CFR 51.308(d)(1)

**Table 9-3 NOCA1 Baseline and Current Conditions, Most Impaired Days**

| YEAR | Ammonium Sulfate Extinction | OMC Extinction | Total Light Extinction | Deciviews (dv) |
|---|---|---|---|---|
| | | | | |
| Baseline Conditions (2000-2004) | | | | |
| 2000 | n/a | n/a | n/a | n/a |
| 2001 | 15.62 | 7.58 | 40.78 | 13.80 |
| 2002 | 14.90 | 9.03 | 41.88 | 14.10 |
| 2003 | 13.58 | 98.67 | 137.72 | 20.50 |
| 2004 | 15.38 | 16.82 | 50.17 | 15.70 |
| Baseline Conditions | 14.87 | 33.02 | 67.64 | 16.01 |
| | | | | |
| Current Conditions (2005-2008) | | | | |
| 2005 | 12.91 | 6.41 | 36.65 | 12.88 |
| 2006 | 14.75 | 9.40 | 42.51 | 14.36 |
| 2007 | 13.45 | 5.91 | 36.16 | 12.64 |
| 2008 | 12.40 | 7.30 | 36.96 | 12.92 |
| Current Conditions | 13.38 | 7.25 | 38.07 | 13.20 |

The data for 2005-2008 shows improved visibility compared with the 2000-2004 baseline. The mean sulfate extinction for 2005-2008 is lower than the 2000-2004 baseline. This result is consistent with major reductions in sulfur emissions from the oil refineries. The mean OMC extinction is considerably lower. Current conditions reflect little fire influence and undoubtedly are unrealistically low. Baseline conditions were highly influenced by the high fire year of 2003.

Ecology consulted with the WRAP's technical program manager and WRAP consultant Air Resource Specialists, Inc. about modifying the WRAP modeling results. The WRAP's 2018 visibility projections use Plan02d and PRP18a modeling results applied in a relative sense to 2000-2004 monitoring data. This involves projection of 2018 visibility through the calculation of a relative response factor (RRF) for each visibility-impairing pollutant from modeling results followed by application of the RRFs to monitored baseline conditions. As a consequence, the 2018 visibility projection can be modified by applying revised RRFs.

Air Resource Specialists calculated an updated RRF for sulfate based on 2005-2008 monitoring data and revised the RRF for OMC to 1.0 to represent no increase in OMC. The net effect on the 2018 projection is a visibility improvement of almost 0.4 dv to 15.62 dv. Appendix E contains more information about the revised 2018 visibility projection for NOCA1.

Ecology concludes that 15.62 dv is the 2018 RPG for North Cascades National Park and Glacier Peak Wilderness in light of controls on the books, implementation of BART, the impact of out-of-state emissions, and the four-factor analysis. At this rate it would take North Cascades National park and Glacier Peak Wilderness 274 years from the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions within Washington State and controls on Canadian and Pacific offshore emissions.

## 9.2.3 Alpine Lakes Wilderness

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

**Baseline and Projected Visibility**

Visibility conditions at Alpine Lakes Wilderness are monitored at the IMPROVE site SNPA1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 17.84 dv and calculated natural conditions are 8.43 dv, a difference of 9.41 dv.

This foundational SIP covers the first control period, 2005-2018. WRAP modeling projects 2018 visibility of 16.32 dv, a visibility improvement of 1.52 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would be improved 2.20 dv to 15.64 dv by 2018, a 23% improvement in visibility. Because the anticipated rate of progress is slower than the uniform rate of progress, more analysis is required to determine the RPG for Alpine Lakes Wilderness.

**Progress in Reducing Visibility Impairing Pollutants**

WRAP's PRP18a modeling reflects "controls on the books" and, to some extent, projected implementation of BART. Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large statewide reductions in $SO_2$ (95%) and $NO_x$ (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection resulting from engine and fuel rules.

WRAP's PRP18a modeling incorporated only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for EGUs but uses actual limits where BART is already effective. In 2003 the EPA determined BART for $SO_2$ and particulate matters for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's RAVI SIP. This BART determination is reflected in the 2018 inventory. The 2000-2004 baseline inventory reflects partial control conditions at the power plant.

Ecology analyzed projected visibility impacts of sulfate, OMC, and nitrate at SNPA1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-4). At SNPA1 these three visibility-impairing pollutants plus Rayleigh scattering were responsible for 89% of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

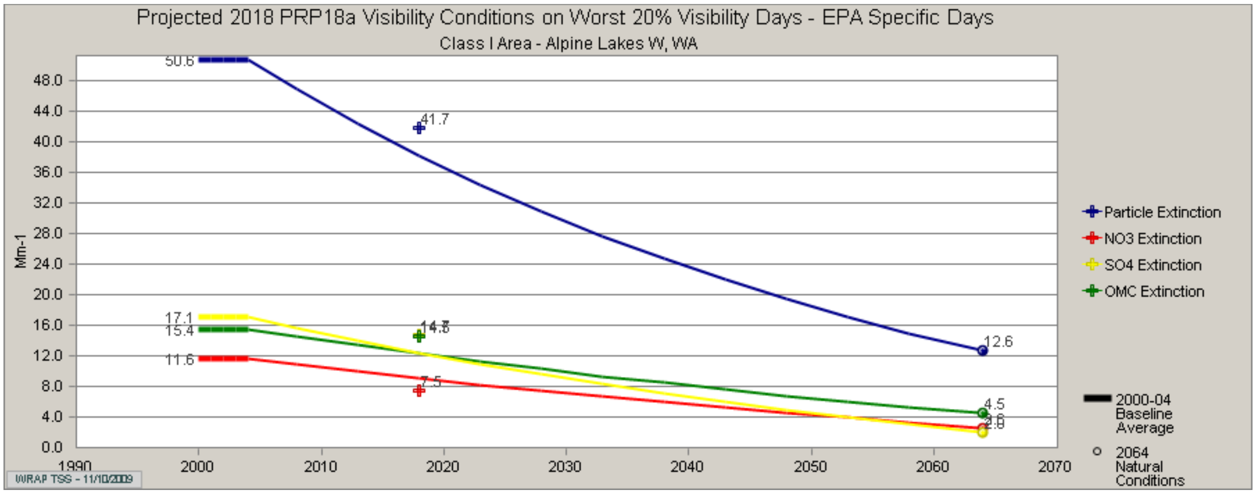



**Figure 9-4 Projected 2018 Visibility Conditions on the Most Impaired Days in Alpine Lakes Wilderness**

***Sulfate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for sulfate from 17.08 to 14.66 inverse $Mm^{-1}$, a visibility improvement of 2.42 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 12.40 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's WEP analysis of upwind emissions indicates a smaller 32% weighted emissions decrease in the upwind direction (see Appendix E for the Alpine Lakes Wilderness Summary Table). Both the magnitudes of the statewide and the upwind emissions decreases should be sufficient to meet the 23% dv decrease needed to meet the uniform glide path for $SO_2$. Still, the projected improvement in visibility by 2018 is only a little more than half the improvement needed to meet the uniform glide path.

WRAP's PSAT analysis for 2018 indicates that despite a large decrease in mobile source emissions in Washington, the source areas outside domain, Canada, and Pacific offshore contribute more than two-thirds of sulfate concentrations at SNPA1 on the Most Impaired Days. All of these regions are outside of the control of the state of Washington.

***Organic Matter Carbon:*** WRAP's PRP18a modeling projects a decrease in the extinction coefficient for OMC from 15.41 to 14.52 $Mm^{-1}$, a visibility improvement of 0.89 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 12.27 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs. Washington's VOC emission inventory is much larger than the organic carbon POA inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for primary organic aerosols. Statewide emissions of primary organic aerosols are projected to increase by 4% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a small decrease of 4% in human-generated weighted emissions in the upwind direction (see Appendix E for the Alpine Lakes Wilderness Summary Table). The decrease is dominated by reductions in on-road and off-road mobile source emissions in Washington. The decrease also includes significant reductions in anthropogenic fire, point, and area source emissions.

Emission inventories presented in section 6.3 indicate that while total VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion.

The large increase in area source emissions reflects the impact of population growth has on the total amount of emissions despite controls on "individual" areas sources such as a woodstove or can of paint. Solvent utilization is regulated through federal and state rules. Washington has more stringent woodstove emission standards than EPA and a mandatory curtailment requirement which has been strengthened to require curtailments at lower particulate matter concentrations as particulate matter standards have become more stringent.

The WEP analysis also indicates that Alpine Lakes Wilderness is impacted by emissions from Canada.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 11.56 to 7.49 $Mm^{-1}$, a visibility improvement of 4.07 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 9.03 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates an even larger decrease in human-generated weighted emissions of 51% in the upwind direction (see Appendix E for the Alpine Lakes Wilderness Summary Tables). The reductions are due primarily to a large decrease in nitrate emissions from mobile sources.

***Summary:*** Ecology concludes from this analysis that overall Washington is making progress in reducing visibility impairing pollutants impacting Alpine Lakes Wilderness. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

### Four-Factor Analysis

The RHR specifies that a state must consider the four factors specified by the CAA in determining the RPG for a Class I Area. Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 10 selected specific industries and emission source categories are located along the I-5 corridor in western Washington and are capable of contributing to visibility impairment at more than one mandatory Class I Areas.

The work done by Ecology on the Four-Factor Analyses is summarized in the Four-Factor Analysis subsection of section 9.2.1 Olympic National Park and described in Appendix F.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_X$. Because of the process Ecology is required to follow, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's LTS in Chapter 10.

### 2018 Reasonable Progress Goal for the Most Impaired Days

Ecology concludes that 16.32 dv is the 2018 RPG for Alpine Lakes Wilderness in light of controls on the books, implementation of BART, the impact of out-of-state emissions, and the four-factor analysis. At this rate it would take Alpine Lakes Wilderness 87 years from the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions in Washington State and controls on Canadian and Pacific offshore emissions.

## 9.2.4 Mount Rainier National Park

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

### Baseline and Projected Visibility

Visibility conditions at Mount Rainier National Park are monitored at the IMPROVE site MORA1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 18.24 dv and calculated natural conditions are 8.54 dv, a difference of 9.70 dv.

This foundational SIP covers the first control period, 2005-2018. WRAP modeling projects 2018 visibility of 16.66 dv, which is a visibility improvement of 1.58 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would be improved 2.26 dv to 15.98 dv by 2018, a 23% improvement in visibility. Because the anticipated rate of progress is slower than the uniform rate of progress, more analysis is required to determine the RPG for Mount Rainier National Park.

**Progress in Reducing Visibility Impairing Pollutants**

WRAP's PRP18a modeling reflects "controls on the books" and, to some extent, projected implementation of BART. Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large statewide reductions in $SO_2$ (95%) and $NO_x$ (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection resulting from engine and fuel rules.

WRAP's PRP18a modeling incorporated only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for EGUs but uses actual limits where BART is already effective. In 2003 the EPA determined BART for $SO_2$ and particulate matters for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's RAVI SIP. This BART determination is reflected in the 2018 inventory. The 2000-2004 baseline inventory reflects partial control conditions at the power plant.

Ecology analyzed projected visibility impacts of sulfate, OMC, and nitrate at MORA1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-5). At MORA1 these three visibility-impairing pollutants plus Rayleigh scattering were responsible for 89% of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

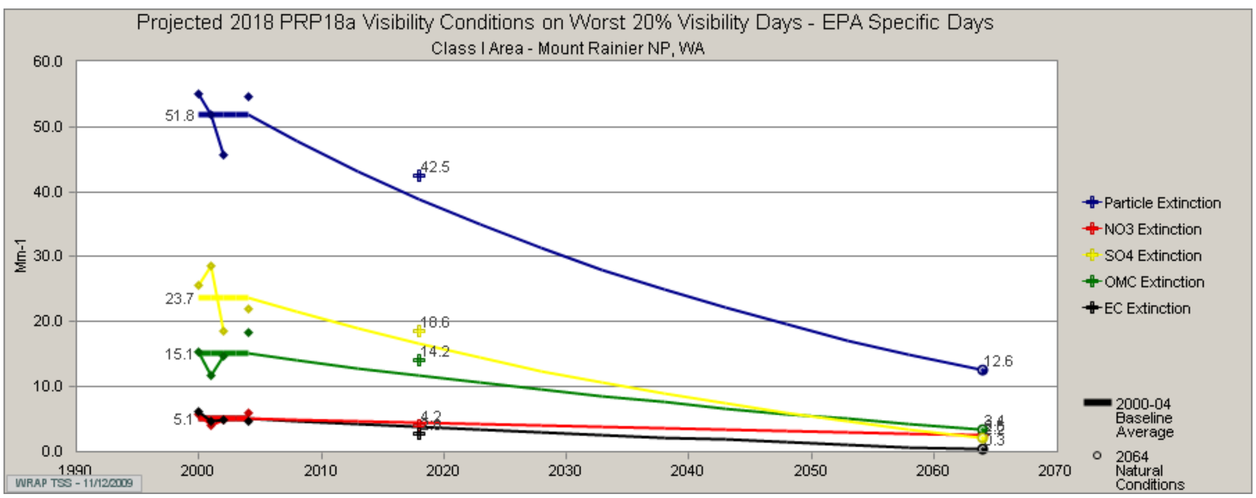



**Figure 9-5 Projected 2018 Visibility Conditions on the Most Impaired Days in Mount Rainier National Park**

***Sulfate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for sulfate from 23.7 to 18.55 $Mm^{-1}$, a visibility improvement of 5.15 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 16.58 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's WEP analysis of upwind emissions indicates a larger 49%.weighted emissions decrease in the upwind direction (see Appendix E for the Mount Rainier National Park Summary Table). Both the magnitudes of the statewide and the upwind emissions decreases should be sufficient to meet the 23% dv decrease needed to meet the uniform glide path for $SO_2$. Still, the projected improvement in visibility by 2018 is only about 70% of the improvement needed to meet the uniform glide path.

WRAP's PSAT analysis for 2018 indicates that despite a large decrease in mobile and point source emissions within Washington, the source areas outside domain, Canada, and Pacific offshore contribute over 60% of the sulfate concentrations on the Most Impaired Days at MORA1. Emissions from outside domain, Canada, and Pacific offshore are outside of the control of the state of Washington.

***Organic Matter Carbon:*** WRAP's PRP18a modeling projects a decrease in the extinction coefficient for OMC from 15.06 to 14.18$Mm^{-1}$, a visibility improvement of 0.88 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 11.67 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs. Washington's VOC emission inventory is much larger than the organic carbon POA inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for POA. Statewide emissions of POA are projected to increase by 4% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a decrease in human-generated weighted emissions of 8% in the upwind direction (see Appendix E for the Mount Rainier Summary Tables). This decrease is dominated by reductions in area source emissions.

Emission inventories presented in section 6.3 indicate that while total VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion.

The large increase in area source emissions reflects the impact of population growth has on the total amount of emissions despite controls on "individual" areas sources such as a woodstove or can of paint. Solvent utilization is regulated through federal and state rules. Washington has more stringent woodstove emission standards than EPA and a mandatory curtailment requirement which has been strengthened to require curtailments at lower particulate matter concentrations as PM standards have become more stringent.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 5.14 to 4.15 $Mm^{-1}$, a visibility improvement of 0.99 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 4.51 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates an even larger decrease of 51% in human-generated weighted emissions in the upwind direction (see Appendix E for the Mount Rainier Summary Tables). The reductions are due primarily to a large decrease in nitrate emissions from mobile sources.

***Summary:*** Ecology concludes from this analysis that overall Washington is making progress in reducing visibility impairing pollutants impacting Mount Rainier National Park. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

**Four-Factor Analysis**

The RHR specifies that a state must consider the four factors specified by the CAA in determining the RPG for a Class I Area. Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 10 selected specific industries and emission source categories are located along the I-5 corridor in western Washington and are capable of contributing to visibility impairment at more than one mandatory Class I Areas.

The work done by Ecology on the Four-Factor Analyses is summarized in the Four-Factor Analysis subsection of section 9.2.1 Olympic National Park and described in Appendix F.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_x$. Because of the process Ecology is required to follow, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's LTS in Chapter 10.

**2018 Reasonable Progress Goal for the Most Impaired Days**

Ecology concludes that 16.66 dv is the 2018 RPG for Mount Rainier National Park in light of controls on the books, implementation of BART, the impact of out-of- state emissions, and the four-factor analysis. At this rate it would take Mount Rainier National Park 86 years from the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions in Washington State and controls on Canadian and Pacific offshore emissions.

## 9.2.5 Goat Rocks Wilderness and Mount Adams Wilderness

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

**Baseline and Projected Visibility**

Visibility conditions at Goat Rocks Wilderness and Mount Adams Wilderness are monitored at the IMPROVE site WHPA1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 12.76 dv and calculated natural conditions are 8.35 dv, a difference of 4.41 dv.

This foundational SIP covers the first control period, 2005-2018. WRAP modeling projects 2018 visibility of 11.79 dv, which is a visibility improvement of 0.97 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would be improved 1.03 dv to 11.73 dv by 2018, a 23% improvement in visibility. Because the anticipated rate of progress is slower than the URP, more analysis is required to determine the RPG for Goat Rocks Wilderness and Mount Adams Wilderness.

**Progress in Reducing Visibility Impairing Pollutants**

WRAP's PRP18a modeling reflects "controls on the books" and, to some extent, projected implementation of BART. Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large statewide reductions in $SO_2$ (95%) and $NO_x$ (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection resulting from engine and fuel rules.

WRAP's PRP18a modeling incorporates only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for EGUs but uses actual limits where BART is already effective. In 2003 the EPA determined BART for $SO_2$ and particulate matters for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's RAVI SIP. This BART determination is reflected in the 2018 inventory. The 2000-2004 baseline inventory reflects partial control conditions at the power plant.

Ecology analyzed projected visibility impacts of sulfate, OMC, and nitrate at WHPA1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-6). At WHPA1 these three visibility-impairing pollutants plus Rayleigh scattering were responsible for 87% of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

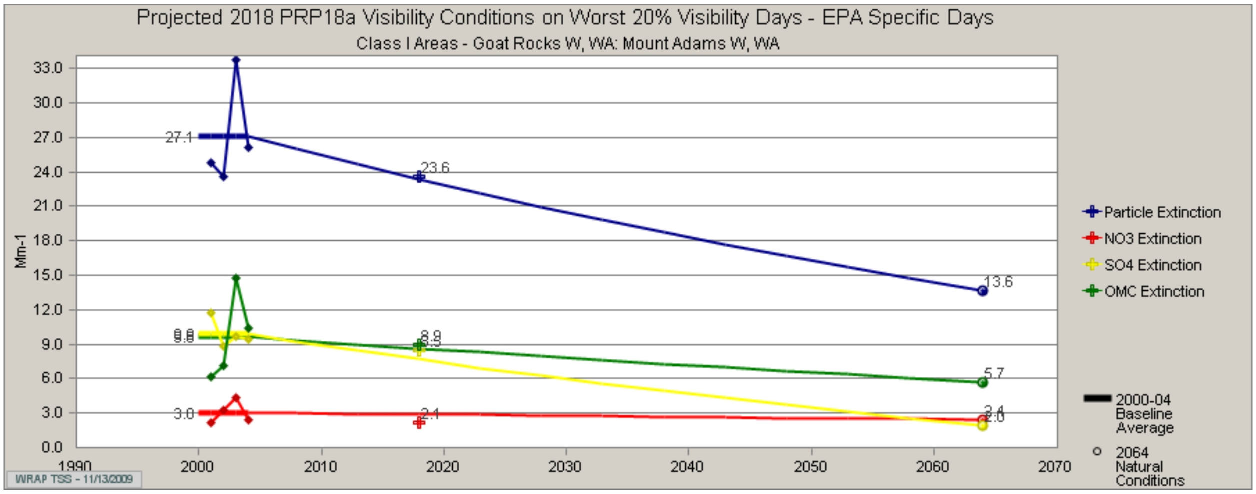



**Figure 9-6 Projected 2018 Visibility Conditions on the Most Impaired Days in Goat Rocks Wilderness and Mount Adams Wilderness**

***Sulfate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for sulfate from 9.92 to 8.52 $Mm^{-1}$, a visibility improvement of 1.40 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 7.69 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's WEP analysis of upwind emissions indicates a slightly larger 42% weighted emissions decrease in the upwind direction (see Appendix E for the Goat Rocks Wilderness, Mount Adams Wilderness Summary Table). Both the magnitudes of the statewide and the upwind emissions decreases should be sufficient to meet the 23% dv decrease needed to meet the uniform glide path for $SO_2$. Still, the projected improvement in visibility by 2018 is only 63% of the improvement needed to meet the uniform glide path.

WRAP's PSAT analysis for 2018 indicates that despite a large decrease in mobile and point source emissions within Washington, the source areas outside domain, Canada, and Pacific offshore contribute over 70% of the sulfate concentrations on the Most Impaired Days at WHPA1. Emissions from outside domain, Canada, and Pacific offshore are outside of the control of the state of Washington.

***Organic Matter Carbon:*** WRAP's PRP18a modeling projects a decrease in the extinction coefficient for OMC from 9.63 to 8.93 $Mm^{-1}$, a visibility improvement of 0.70 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 8.63 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs. Washington's VOC emission inventory is much larger than the organic carbon POA inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for POA. Statewide emissions of POA are projected to increase by 4% between the 2000-2004 baseline period and 2018. However, WRAP's WEP analysis of upwind emissions indicates no change in human-generated emissions in the upwind direction (see Appendix E for the Goat Rocks Wilderness and Mount Adams Wilderness). The WEP analysis indicates significant reductions in Washington State emissions from point sources, off-road and on-road mobile sources, and anthropogenic fires. To a large extent these reductions are counterbalanced by a major increase in area source emissions. The 2018 decreases include the permanent closure of Goldendale Aluminum, a BART-eligible source that was determined not to be subject to BART.

Emission inventories presented in section 6.3 indicate that while total VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion.

The large increase in area source emissions reflects the impact of population growth has on the total amount of emissions despite controls on "individual" areas sources such as a woodstove or can of paint. Solvent utilization is regulated through federal and state rules. Washington has more stringent woodstove emission standards than EPA and a mandatory curtailment requirement which has been strengthened to require curtailments at lower particulate matter concentrations as particulate matter standards have become more stringent.

The WEP analysis also indicates that the upwind direction includes the Portland, OR metropolitan area. Portland is projected to have increased area source emissions.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 3.05 to 2.14 $Mm^{-1}$, a visibility improvement of 0.91 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 2.90 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates an even larger decrease of 49% in human-generated weighted emissions in the upwind direction (see Appendix E for the Goat Rocks Wilderness and Mount Adams Wilderness Summary Tables). The reductions are due primarily to a large decrease in nitrate emissions from mobile sources.

***Summary:*** Ecology concludes from this analysis that overall Washington is making progress in reducing visibility impairing pollutants impacting Goat Rocks Wilderness and Mount Adams Wilderness. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

**Four-Factor Analysis**

The RHR specifies that a state must consider the four factors specified by the CAA in determining the RPG for a Class I Area. Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 10 selected specific industries and emission source categories are located along the I-5 corridor in western Washington and are capable of contributing to visibility impairment at more than one mandatory Class I Areas.

The work done by Ecology on the Four-Factor Analyses is summarized in the Four-Factor Analysis subsection of section 9.2.1 Olympic National Park and described in Appendix F.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_X$. Because of the process Ecology is required to follow, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's LTS in Chapter 10.

**2018 Reasonable Progress Goal for the Most Impaired Days**

Ecology concludes that 11.79 dv is the 2018 RPG for Goat Rocks Wilderness and Mount Adams Wilderness in light of controls on the books, BART implementation, the impact of out-of-the-state emissions, and the four-factor analysis. At this rate it would take Goat Rocks Wilderness and Mount Adams Wilderness 64 years from the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions in Washington State and controls on Canadian, Pacific offshore, and Oregon emissions.

### 9.2.6 Pasayten Wilderness

Establishing the RPG involves the determination of baseline and projected visibility, examination of the progress that has been made in reducing visibility impairing pollutants, and consideration of the four statutory factors.

**Baseline and Projected Visibility**

Visibility conditions at Pasayten Wilderness are monitored at the IMPROVE site PASA1. The monitored 2000-2004 baseline conditions at this site on the Most Impaired Days are 15.23 dv and calculated natural conditions are 8.25 dv, a difference of 6.98 dv.

This foundational SIP covers the first control period, 2005-2018. WRAP modeling projects 2018 visibility of 15.09 dv, which is a visibility improvement of 0.14 dv. If uniform progress were made on achieving natural conditions by 2064, visibility would be improved 1.63 dv to 13.60 dv by 2018, a 23% improvement in visibility. Because the anticipated rate of progress is slower than the URP, more analysis is required to determine the RPG for Pasayten Wilderness.

**Progress in Reducing Visibility Impairing Pollutants**

WRAP's PRP18a modeling reflects "controls on the books" and, to some extent, projected implementation of BART. Controls on the books are existing legally adopted controls that will reduce visibility impairing pollutants during the first control period 2005-2018. Prominent examples are large statewide reductions in $SO_2$ (95%) and $NO_x$ (64%) from on-road and off-road mobile sources between the 2000-2004 baseline and the 2018 projection resulting from engine and fuel rules.

WRAP's PRP18a modeling incorporated only limited impacts of BART because states were still working on draft BART determinations when WRAP finalized the PRP18a inventory. The PRP18a inventory includes presumptive $SO_2$ limits for EGUs but uses actual limits where BART is already effective. In 2003 the EPA determined BART for $SO_2$ and particulate matters for Washington's only coal-fired power plant as part of EPA's approval of the 1999 update to the state's RAVI SIP. This BART determination is reflected in the 2018 inventory. The 2000-2004 baseline inventory reflects partial control conditions at the power plant.

Ecology analyzed projected visibility impacts of sulfate, OMC, Elemental Carbon (EC), and nitrate at PASA1 to characterize progress in reducing visibility impairing pollutants (see Figure 9-7). At PASA1 these four visibility-impairing pollutants plus Rayleigh scattering were responsible for 94 % of the total light extinction for the Most Impaired Days during the 2000-2004 baseline period.

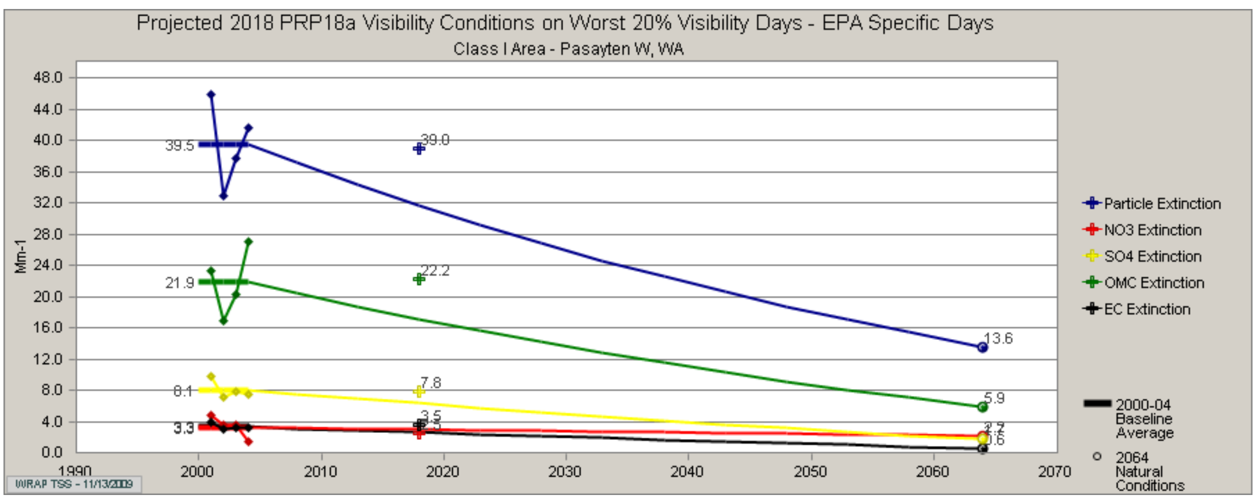



**Figure 9-7 Projected 2018 Visibility Conditions on the Most Impaired Days in Pasayten Wilderness**

***Sulfate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for sulfate from 8.06 to 7.82 $Mm^{-1}$, a visibility improvement of 0.24 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for sulfate of 6.32 $Mm^{-1}$.

Statewide emissions of $SO_2$ are projected to decline almost 40% between the 2000-2004 baseline period and 2018. Basically this decline results from a 29% reduction in point source emissions and a 95% reduction in on-road and off-road mobile source emissions. The mobile source reduction reflects the removal of sulfur from on-road and off-road fuels.

WRAP's WEP analysis of upwind emissions indicates only an 18% decrease in human-generated weighted emissions in the upwind direction (see Appendix E for the Pasayten Wilderness Summary Table). The reduction is due primarily to a reduction in the sulfur content of fuels for mobile sources.

While the statewide emissions decrease should be more than sufficient to support the 23% decrease in dv needed to meet the uniform glide path, the upwind emissions reduction indicated by the WEP analysis is insufficient. Further, WRAP's PSAT analysis for 2018 indicates that Outside Domain and Canada contribute more than three-fourths of the sulfate concentrations at PASA1 on the Most Impaired Days. These source areas are outside of the control of the state of Washington.

***Organic Matter Carbon:*** WRAP's PRP18a modeling projects an increase in the extinction coefficient for OMC from 21.9 to 22.18 $Mm^{-1}$, an increase in visibility impairment of 0.28 $Mm^{-1}$. In 2018 the OMC light extinction is 45% of the total projected light extinction of 48.95 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for OMC of 17.12 $Mm^{-1}$.

OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs. Washington's VOC emission inventory is much larger than the organic carbon POA inventory. The Plan02d totals are 1,042,867 and 50,273 tons per year, respectively (see Chapter 6).

The only source apportionment analysis available for OMC is the WEP analysis developed by the WRAP for primary organic aerosols. Statewide emissions of POA are projected to increase by 4% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind weighted emissions indicates a similar increase of 3% in overall emissions and an increase of 10% in human-generated weighted emissions (see Appendix E). The WEP analysis projects that much of this increase will come from Puget Sound and the Vancouver, Canada area.

The WEP analysis in TSS indicates natural fire was the dominant source of emissions of primary organic compounds from Washington impacting the Pasayten Wilderness in the 2000-2004 baseline period. The visibility impairment due to natural fire was variable from year-to-year with the largest impacts occurring in 2001 and 2004. In the WRAP's 2018 modeling, natural fire was projected continue at 2000-2004 baseline levels and thus remains the dominant source. The projected human-caused increase in 2018 emissions from Washington State reflects major growth in emissions of area sources.

Emission inventories presented in section 6.3 indicate that while total VOC emissions are projected to decrease by 1% between the 2000-2004 baseline period and 2018, area sources of VOCs increase by 67%. Area sources are the largest human-generated source category of VOCs in 2018. Area source VOCs are dominated by emissions from solvent utilization and residential wood combustion.

The large increase in area source emissions reflects the impact of population growth has on the total amount of emissions despite controls on "individual' areas sources such as a woodstove or can of paint. Solvent utilization is regulated through federal and state rules. Washington has more stringent woodstove emission standards than EPA and a mandatory curtailment requirement which has been strengthened to require curtailments at lower particulate matter concentrations as particulate matter standards have become more stringent.

The WEP analysis also shows that the Pasayten Wilderness is also impacted by Canadian emissions, primarily area source emissions.

***Elemental Carbon:*** WRAP's PRP18a modeling projects an increase in the extinction coefficient for EC from 3.32 to 3.53 $Mm^{-1}$, an increase in visibility impairment of 0.21 $Mm^{-1}$. Adherence to the uniform glide path would result in a 2018 extinction coefficient for EC of 2.61 $Mm^{-1}$.

Statewide emissions of EC are projected to decrease by 25% between the 2000-2004 baseline period and 2018. However, WRAP's WEP analysis of upwind weighted emissions indicates an overall 14% decrease and much larger decrease in human-generated emissions of 33% (see Appendix E for the Pasayten Wilderness Summary Tables). The WEP analysis in TSS projects most of this increase will come from Puget Sound and the Vancouver, Canada area.

The WEP analysis indicates natural fire was the dominant source of EC impacting the Pasayten Wilderness in the 2000-2004 baseline period. In the WRAP's 2018 modeling, natural fire was projected to remain at 2000-2004 baseline levels and thus remains the dominant source.

The WEP analysis indicates on-road and off-road mobile sources and area sources were responsible for most of the remainder of the EC in the 2000-2004 baseline period. The projected 2018 decrease of 33% in human-caused weighted emissions basically reflects the major reduction in mobile sources emissions resulting from federal rules that is somewhat offset by significant growth in emissions of area sources.

The WEP analysis indicates significant area source emissions from Canada. Though weighted Canadian emissions decrease slightly between the 2000-2005 baseline period and 2018, Canada continues to contribute EC emissions, particularly from off-road mobile source and area source emissions, to the Pasayten Wilderness and is apparently responsible for the projected increase in visibility impairment in 2018 due to elemental carbon.

***Nitrate:*** WRAP's PRP18a modeling projects a reduction in the extinction coefficient for nitrate from 3.28 to 2.45 $Mm^{-1}$, a visibility improvement of 0.83 $Mm^{-1}$. Adherence to the uniform glide path would result in a higher 2018 extinction coefficient for nitrate of 3.02 $Mm^{-1}$.

Statewide emissions of nitrate are projected to decrease by 46% between the 2000-2004 baseline period and 2018. WRAP's WEP analysis of upwind emissions indicates a decrease in human-caused emissions of 41% in the upwind direction (see Appendix E for the Pasayten Wilderness Summary Tables). The reductions are due primarily to large decrease in nitrate emissions from mobile sources.

***Summary:*** Ecology concludes from the analysis provided above that overall Washington is making progress in reducing visibility impairing pollutants impacting Pasayten Wilderness. At the same time Ecology acknowledges some ambiguity exists with regard to projected 2018 visibility at Pasayten Wilderness because of uncertainty about the reasonableness of the projected natural fire emissions. The question still remains, is this progress reasonable? Ecology relied on a four-factor analysis to address this issue.

**Four-Factor Analysis**

The RHR specifies that a state must consider the four factors specified by the CAA in determining the RPG for a Class I Area. Ecology developed a single set of four-factor analyses for Washington's 8 mandatory Class I Areas. Basically the individual sources in the 10 selected specific industries and emission source categories are located along the I-5 corridor in western Washington and are capable of contributing to visibility impairment at more than one mandatory Class I Areas.

The work done by Ecology on the Four-Factor Analyses is summarized in the Four-Factor Analysis subsection of section 9.2.1 Olympic National Park and described in Appendix F.

Ecology commits to proceeding with establishing and requiring controls on point sources of $SO_2$ and $NO_X$. Because of the process Ecology is required to follow, Ecology concludes that further controls are not reasonable at this time. Development of controls is discussed further as part of Washington's LTS in Chapter 10.

**2018 Reasonable Progress Goal for the Most Impaired Days**

Ecology concludes that 15.09 dv is the 2018 RPG for Pasayten Wilderness in light of controls on the books, BART implementation, the impact of out-of-state emissions, and the four-factor analysis. At this rate it would take Pasayten Wilderness 698 years from the 2000-2004 baseline period to reach natural visibility conditions. Improving progress toward the natural visibility conditions in the future will require controls on visibility impairing emissions in Washington State and controls on Canadian emissions.

## 9.3 Least Impaired Days

### 9.3.1 Olympic National Park

**Baseline and Projected Visibility**

Visibility conditions at Olympic National Park are monitored at the IMPROVE site OLYM1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 6.02 dv and calculated natural visibility conditions are 2.7 dv, a difference of 3.32 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 5.82 dv (Figure 9-8).

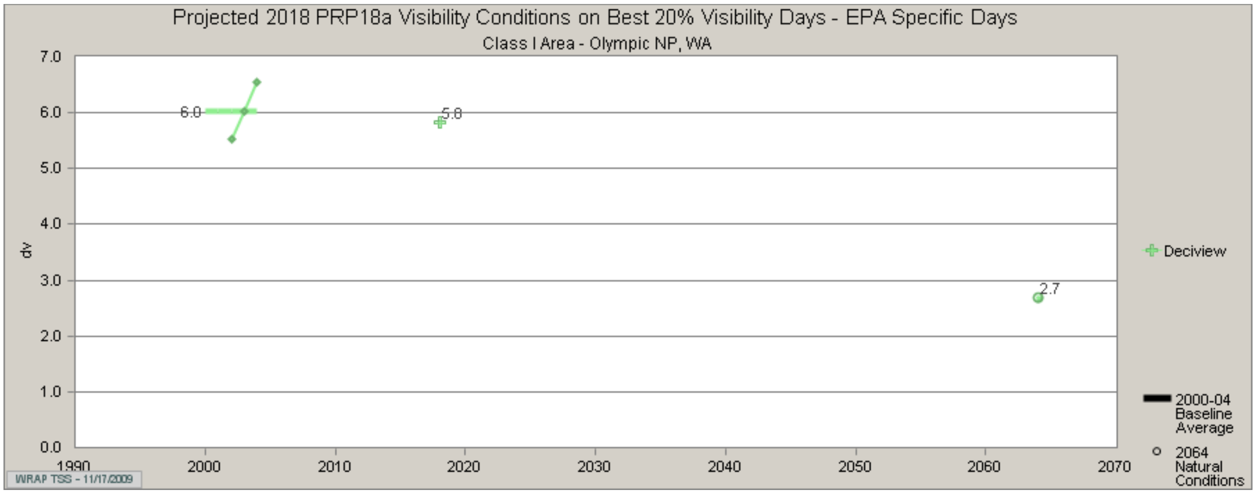



**Figure 9-8 Projected Visibility Conditions on the Least Impaired Days in Olympic National Park**

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 6.02 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 6.02 dv as the 2018 RPG for Olympic National Park for the Least Impaired Days.

## 9.3.2 North Cascades National Park and Glacier Peak Wilderness

**Baseline and Projected Visibility**

Visibility conditions at North Cascades National Park and Glacier Peak Wilderness are monitored at the IMPROVE site NOCA1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 3.37 dv and calculated natural visibility conditions are 1.93 dv, a difference of 1.44 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 3.24 dv (Figure 9-9).

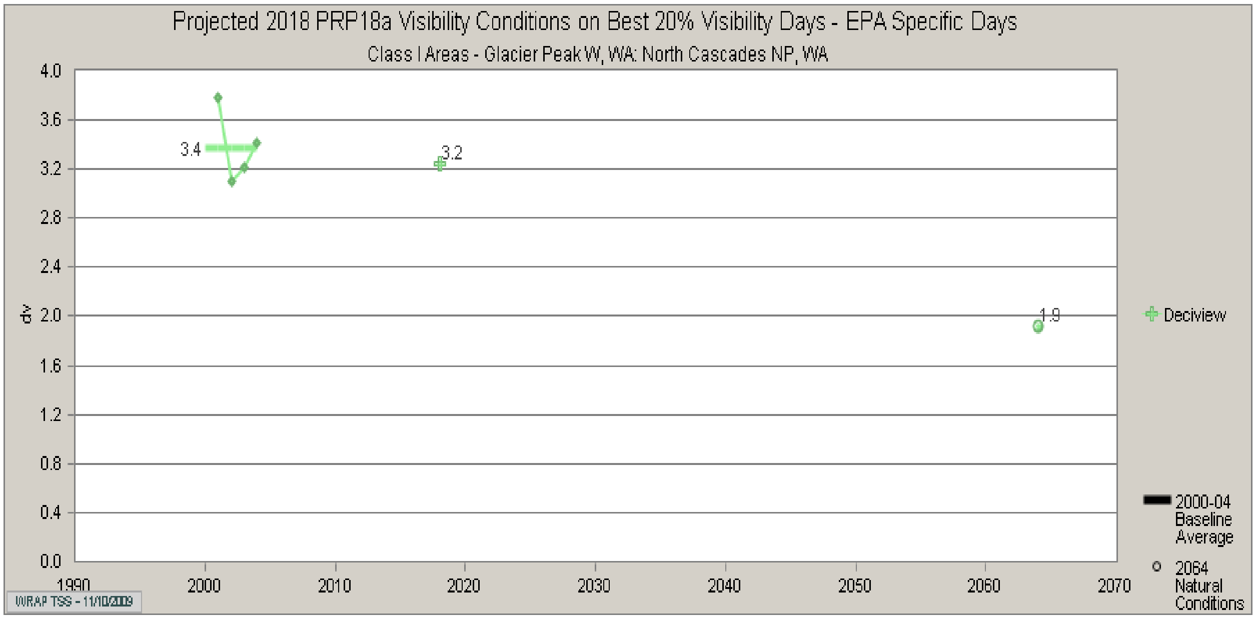



**Figure 9-9 Projected Visibility Conditions on the Least Impaired Days in North Cascades National Park and Glacier Peak Wilderness**

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 3.37 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 3.37 dv as the 2018 RPG for North Cascades National Park and Glacier Peak Wilderness for the Least Impaired Days.

### 9.3.3 Alpine Lakes Wilderness

**Baseline and Projected Visibility**

Visibility conditions at Alpine Lakes Wilderness are monitored at the IMPROVE site SNPA1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 5.5 dv and calculated natural visibility conditions are 2.33 dv, a difference of 3.17 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 4.86 dv (Figure 9-10).

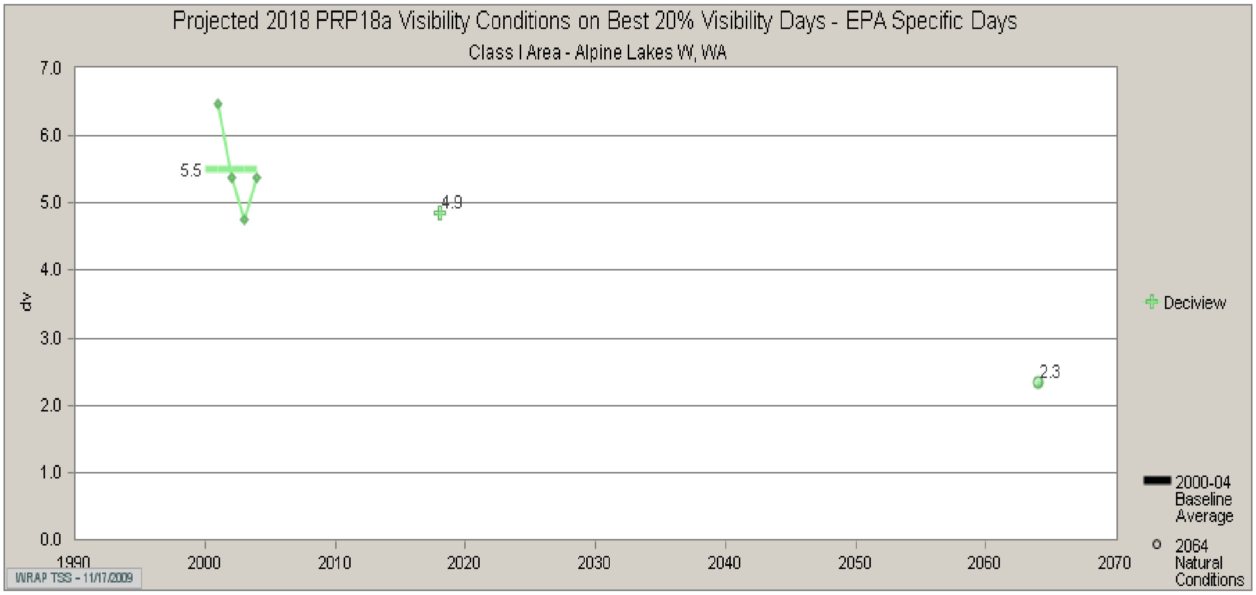



**Figure 9-10 Projected Visibility Conditions on the Least Impaired Days in Alpine Lakes Wilderness**

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 5.5 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 5.5 dv as the 2018 RPG for Alpine Lakes Wilderness for the Least Impaired Days.

## 9.3.4 Mount Rainier National Park

**Baseline and Projected Visibility**

Visibility conditions at Mount Rainier National Park are monitored at IMPROVE site MORA1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 5.47 dv and calculated natural visibility conditions are 2.56 dv, a difference of 2.91 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 4.83 dv (Figure 9-11).

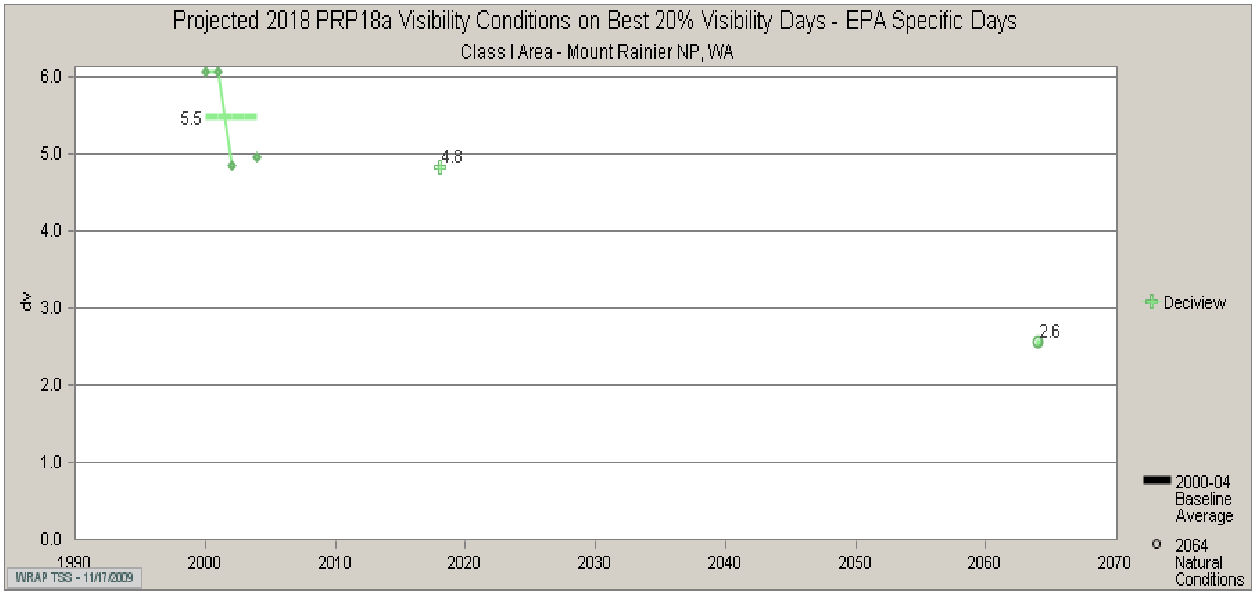



**Figure 9-11 Projected Visibility Conditions on the Least Impaired Days in Mount Rainier National Park**

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 5.47 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 5.47 dv as the 2018 RPG for Mount Rainier National Park for the Least Impaired Days.

### 9.3.5 Goat Rocks Wilderness and Mount Adams Wilderness

**Baseline and Projected Visibility**

Visibility conditions at Goat Rocks Wilderness and Mount Adams Wilderness are monitored at IMPROVE site WHPA1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 1.66 dv and calculated natural visibility conditions are 0.82 dv, a difference of 0.84 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 1.47 dv (Figure 9-12).

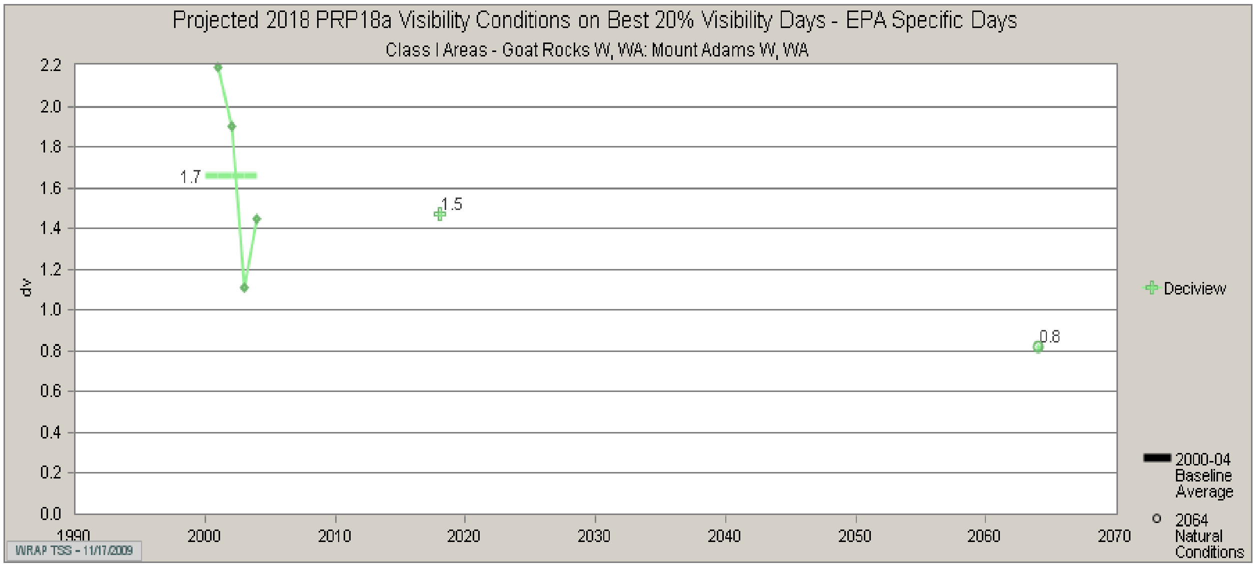



**Figure 9-12 Projected Visibility Conditions on the Least Impaired Days in Goat Rocks Wilderness and Mount Adams Wilderness**

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 1.66 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 1.66 dv as the 2018 RPG for Goat Rocks Wilderness and Mount Adams Wilderness for the Least Impaired Days.

## 9.3.6 Pasayten Wilderness

**Baseline and Projected Visibility**

Visibility conditions at Pasayten Wilderness are monitored at the IMPROVE site PASA1. The monitored 2000-2004 baseline conditions at this site on the Least Impaired Days are 2.73 dv and calculated natural visibility conditions are 1.16 dv, a difference of 1.57 dv.

This foundational SIP covers the first control period, 2005-2018. PRP18a WRAP modeling projects 2018 visibility of 1.89 dv (Figure 9-13).

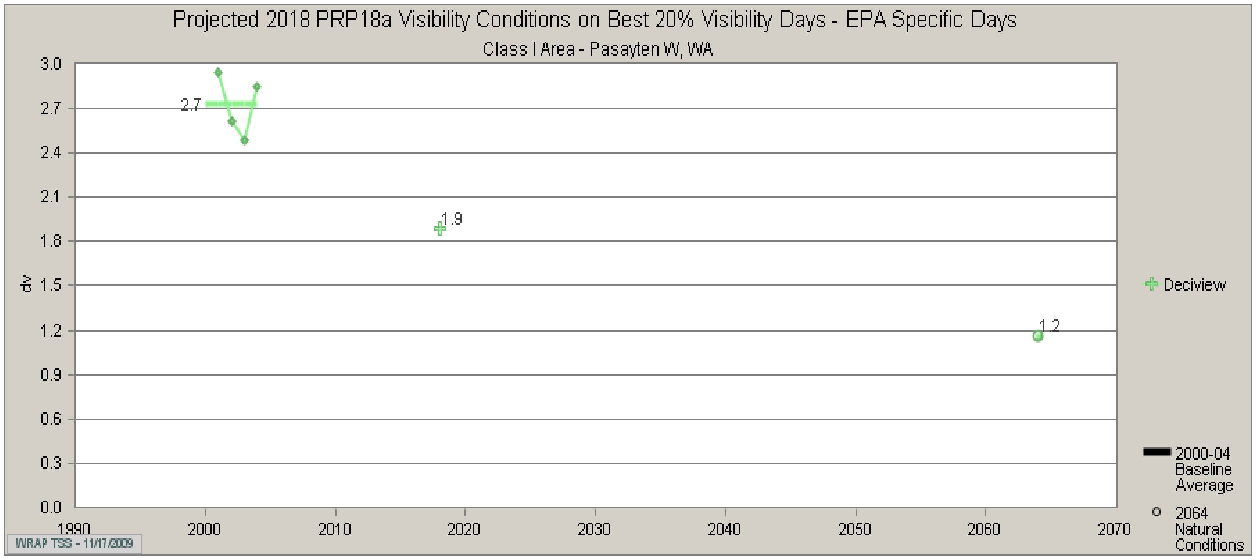



Figure 9-13 Projected Visibility Conditions on the Least Impaired Days in Pasayten Wilderness

**2018 Reasonable Progress Goal for the Least Impaired Days**

The RHR requires the state to establish a RPG that ensures no degradation of visibility on the Least Impaired Days. This requirement may be satisfied by maintaining the baseline visibility of 2.73 dv. WRAP modeling indicates that this is achievable.

Ecology establishes 2.73 dv as the 2018 RPG for Pasayten Wilderness for the Least Impaired Days.

## 9.4 Summary

Ecology established RPG for the Most Impaired Days and the Least Impaired Days as required by the RHR. These are summarized in Table 9-4.

**Table 9-4 2018 Reasonable Progress Goals for Washington's Class I Areas**

| Mandatory Class I Areas | Most Impaired Days | | | | Least Impaired Days | |
|---|---|---|---|---|---|---|
| | 2000-2004 Baseline Conditions (dv) | Uniform Glide Path 2018 Target (dv) | 2018 Reasonable Progress Goal (dv) | Years from Baseline to Attain Natural Conditions at Reasonable Progress | 2000-2004 Baseline Conditions (dv) | 2018 Reasonable Progress Goal (dv) |
| Olympic National Park | 16.74 | 14.81 | 16.38 | 323 | 6.02 | 6.02 |
| North Cascades National Park & Glacier Peak Wilderness | 16.01 | 14.23 | 15.62 | 274 | 3.37 | 3.37 |
| Alpine Lakes Wilderness | 17.84 | 15.64 | 16.32 | 87 | 5.5 | 5.5 |
| Mount Rainier National Park | 18.24 | 15.98 | 16.66 | 86 | 5.47 | 5.47 |
| Goat Rocks Wilderness & Mount Adams Wilderness | 12.76 | 11.73 | 11.79 | 64 | 1.66 | 1.66 |
| Pasayten Wilderness | 15.23 | 13.60 | 15.09 | 698 | 2.73 | 2.73 |

In establishing RPG for the Most Impaired Days, Ecology considered controls on the books, implementation of BART, the impact of out-of-state emissions, and a four-factor analysis of significant source categories in the state of Washington.

Ecology also considered a modification of projected 2018 visibility at North Cascades National Park and Glacier Peak Wilderness. The modification was made to better reflect the impact of $SO_2$ reductions at relatively nearby oil refineries and the assumption of constant natural fire emissions. The modifications provided Ecology with a basis for establishing a RPG that that projects visibility improvement for these 2 Class I Areas.

Ecology's analysis of the state's mandatory Class I Areas determined that emissions from Canada play a significant role. Likewise, Pacific offshore emissions play a significant role in all mandatory Class I Areas except Pasayten Wilderness. Washington's mandatory Class I Areas will not be able to attain natural conditions without controls on Canadian and Pacific offshore emissions. Lack of controls will continue to hamper our ability to achieve the uniform glide path in the future and lengthen the time needed to reach natural conditions. Canadian and Pacific offshore controls are discussed further in the LTS.

Three mandatory Class I Areas — North Cascades National Park, Glacier Peak Wilderness, and Pasayten Wilderness — are significantly impacted by natural fire. WRAP's analysis projected baseline period fire emissions to 2018 without any change. If such projections are assumed to be reasonable estimates of the impacts of fire in 2018, the magnitude of fire impacts is so great that unless actual fire impacts decrease significantly in the future or natural conditions are reinterpreted sometime to allow for increased smoke impacts, the 3 mandatory Class I Areas will not be able to achieve natural conditions.

Under the RHR, RPG for the Least Impaired Days are required to ensure no degradation of visibility.  Ecology set the RPG at baseline visibility conditions.  The WRAP's modeling analysis indicates these goals will be met.

# Chapter 10 Long Term Strategy for Visibility Improvement

This chapter presents Washington State's Long Term Strategy for Visibility Improvement. The strategy is a comprehensive strategy addressing both Regional Haze (RH) and Reasonably Attributable Visibility Impairment (RAVI).

## 10.1 Introduction

The Clean Air Act requires a visibility State Implementation Plan (SIP) to contain a long-term (10-to-15 year) strategy for making reasonable progress toward the national goal of remedying any existing visibility impairment in mandatory Class I Areas resulting from human-caused air pollution and preventing future visibility impairment.[1]

The state of Washington has chosen to develop a comprehensive strategy addressing both RH and RAVI as its Long-Term Strategy for Visibility Improvement in this foundational RH SIP. The Environmental Protection Agency's (EPA) rules for protection of visibility allow each state to submit a Long-Term Strategy in its foundational RH SIP that addresses both visibility impairment from RH and RAVI.[2] The result is a single comprehensive state strategy that integrates RH and RAVI requirements. The comprehensive strategy is updated on the schedule set by the Regional Haze Rule (RHR) for RH SIP updates.

Washington's RAVI SIP focused on point sources and silvicultural smoke management. Most notably, the 1999 update to the RAVI SIP included the Reasonable Available Control Technology (RACT) emission limits for the Centralia Power Plant, and then operated by PacifiCorp, now owned by the TransAlta, Centralia Generation, LLC, as reasonable progress. EPA approved the RACT emission limits for sulfur and particulate matter as meeting Best Available Retrofit Technology (BART) requirements.

Though silvicultural smoke is not a point source (and not required to be addressed under RAVI), Washington recognized silvicultural smoke was having major impacts on visibility as well as health impacts. Washington chose to address silvicultural smoke proactively. Ecology coordinated with the Washington State Department of Natural Resources (DNR) to update the state smoke management plan and included DNR's updated silvicultural smoke management plan for the state of Washington into the 1999 update to Washington's RAVI SIP.

The 1999 updates to Washington's RAVI SIP were approved by EPA in 2003.[3]

## 10.2 Overview of Washington's Long-Term Strategy

Washington's Long-Term Strategy (LTS) for this foundational RH SIP applies to mandatory Class I Areas both within the state and outside the state where emissions from the state are reasonably anticipated to contribute to visibility impairment. The strategy is designed to achieve

[1] Clean Air Act, §169A(b)(2)(B)
[2] 40 CFR 51.306(c)
[3] 68 FR 34821, June 11, 2003

the Reasonable Progress Goals (RPGs) established by this foundational RH SIP for mandatory Class I Areas inside Washington and the RPGs established by other states for mandatory Class I Areas outside of Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment. The RPGs serve as benchmarks for progress in meeting the national visibility goal by 2064.

Washington's comprehensive LTS focuses on the implementation of BART, already adopted federal and state controls on sources of visibility-impairing pollutants, and the evaluation and development of additional controls on non-BART point sources. The LTS covers the period from 2005 to 2018. The technical basis for western states' RH SIPs developed by the Western Regional Air Partnership (WRAP), BART, and the unique circumstances of Washington's involvement in the Regional Haze Program all played a role in the development of the LTS.

EPA promulgated the RHR on July 1, 1999. In the preamble EPA stated the following:

> *The EPA believes that the technical tools and our scientific understanding of visibility impairment are now sufficiently refined to move forward with a national program addressing regional haze in Class I areas.*[4]

Still, it took a lot of work that extended over years even for the WRAP, which had been a pre-existing regional planning organization (the Grand Canyon Visibility Transport Commission), to resolve technical and policy issues, develop technical background and analyses, and provide individual member states with the technical information needed for development of state RH SIPs.

The WRAP developed the Technical Support System (TSS) to serve as the gateway to the technical information that forms the basis of western state RH SIPs. The TSS provides information on visibility monitoring, emission inventories, source apportionment, and 2018 visibility projections. Further information on TSS is contained in Appendix G. The TSS may be accessed through http://vista.cira.colostate.edu/tss/ .

Ecology participated actively in the WRAP until July 2002 when the State Legislature cut funding for Ecology's full range of visibility activities (including planning, monitoring, and special projects). The State Legislature's cut of all visibility funding was part of a major reduction in state spending in response to an economic downturn which seriously reduced state revenues. Eventually the State Legislature restored funding effective July 2007 solely for activities needed to develop the RH SIP. The restoration did not include all visibility-related activities.

After Ecology resumed active participation in RH planning, Ecology focused its efforts on BART and on gaining an understanding of the technical basis developed by the WRAP for RH at Washington State's 8 mandatory Class I Areas. This dual focus resulted from Ecology's recognition that as the foundational RH SIP, this SIP has 3 major components: RPGs, the LTS, and BART. RPG and the LTS depend upon the technical information and analyses in TSS and consultation between the states and other stakeholders provided by the WRAP.

[4] 64 FR at 35717, July 1, 1999

As a result of Ecology's own evaluation and analysis of the WRAP's technical basis for the RH SIP, Ecology decided how to proceed with future control of visibility-impairing pollutants affecting mandatory Class I Areas.

Before we begin the discussion, it is useful to remind the reader that about the differences between emitted visibility-impairing pollutants and monitored visibility-impairing pollutants. Once emitted, particles and gases may go through chemical changes before they are captured by an air sampler. For this reason, the chemical species causing visibility-impairment may not be the same chemical species that were emitted. Table 10-1 below compares emitted visibility-impairing pollutants with the particles measured by Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor.

**Table 10-1 Emitted and Monitored Visibility-Impairing Pollutants**

| Emitted Aerosol | Monitored Particle |
|---|---|
| Sulfur Dioxide ($SO_2$) | Sulfate ($SO_4$) |
| Nitrogen Oxides ($NO_X$) | Nitrate ($NO_3$) |
| Organic Carbon (OC) | Organic Mass Carbon (OMC) |
| Volatile Organic Compounds (VOCs) | Organic Mass Carbon (OMC) |
| Elemental Carbon (EC) | Elemental Carbon (EC) |
| Fine Soil | Fine Soil |
| Coarse Matter (CM) | Coarse Matter (CM) |
| Sea Salt | Sea Salt |

First of all, Ecology recognizes that BART and already adopted federal and state controls are important for making reasonable progress by 2018.

The PRP18a modeling used for the technical basis for this RH SIP includes the following BART limits:

- Presumptive Sulfur Dioxide ($SO_2$) BART for Electrical Generating Units (EGUs) in the WRAP region or, if lower, current controls
- Known BART controls in the WRAP region

Since the PRP18a modeling was completed Washington and almost all WRAP states have completed BART determinations. Washington is requiring its sources to implement BART limits by the date specified in the compliance order for each BART source.

Already adopted rules that are reflected in 2018a emission inventories and PRP18a modeling include the following:

- Mobile source controls
    - R Heavy Duty Diesel (2007) Engine Standard
    - R Tier 2 Tailpipe Standards
    - R Large Spark Ignition and Recreational Vehicle Rule
    - R Nonroad Diesel Rule

   - R Low sulfur fuel requirements for gasoline engines, on-road diesel engines, off-road diesel engines, and locomotives
- Combustion Turbine and Industrial Boiler/Process Heater/Reciprocating Internal Combustion Engine (RICE) Maximum Achievable Control Technology (MACT)
- Permits and state/EPA consent agreements generally as of 2006
- Reductions in 2000-04 average fire emissions due to Emissions Reduction Techniques in Smoke Management Programs
- Ozone and Coarse Particulate Matter ($PM_{10}$) SIPs in place in the WRAP region
- State oil and gas emissions control programs

Of special importance are federal fuel and engine rules for on-road and non-road vehicles. These result in the following large projected percent decreases in visibility-impairing emissions from mobile sources in Washington by 2018:

- Sulfur dioxide ($SO_2$) , 95%
- Nitrogen Oxides ($NO_X$), 64%
- Volatile Organic Compounds (VOCs), 56%
- Organic Carbon (OC) (also called Primary Organic Aerosols (POA)), 25%
- Elemental Carbon (EC), 65%

Some federal rules, which will lead to emission reductions and visibility improvement, are too recent to have been taken into account of in the 2018a inventories or the PRP18a modeling. These include the following:

- Refinery MACT
- Boiler MACT
- Various area source MACTs
- Stationary Spark Ignition Internal Combustion Engine Rules
- Commercial, Industrial, Solid Waste Incinerator New Source Performance Standards (NSPS)
- Locomotive and Marine Diesel Emission Standards for engines with a cylinder displacement of less than 30 liters
- International Maritime Organization (IMO) rules reducing $NO_2$ and $SO_2$ emissions from commercial marine vessels
- Corresponding EPA rules for Category 3 Marine Diesel Engines with a cylinder displacement equal to or greater than 30 liters

Ecology expects additional federal rules currently in development will provide assistance for reasonable progress toward the 2064 natural visibility goal. These include the revised Utility Boiler MACT and in 2017 Tier 3 Tailpipe Standards.

Secondly, Washington recognizes the need to focus on the Most Impaired Days. Not only is visibility impairment and the impact of visibility pollutants much worse on the Most Impaired Days but reduction of pollutants on these days is the only way to ensure reasonable progress in remedying existing impairment. Ecology is dealing with the Least Impaired Days under the assumption that emissions reductions impacting the Most Impaired Days will maintain or improve visibility on the Least Impaired Days. WRAP modeling projecting 2018 visibility impairment confirms this assumption.

Third, Ecology concludes that Washington should focus controls primarily on sulfate and secondarily on nitrate during the 2005-2018 control period. On the Most Impaired Days, at 4 of the state's 6 IMPROVE sites, sulfate is the major pollutant contributing to total light extinction (including Rayleigh scattering) in the baseline period. Sulfate at these sites ranges from 27 to 38% of the total light extinction. In the 2018 projections, sulfate remains the major pollutant contributing to total light extinction at 3 of the 6 IMPROVE sites. Sulfate ranges from 28 to 35% of total light extinction at these 3 sites and contributes 25% to total light extinction at a fourth site.

Nitrate contributes more than 10% of total light extinction only at 2 IMPROVE sites (OLYM1 and SNPA1) within Washington in both the baseline period and in 2018 visibility projections. On the other hand, nitrate makes a larger and more widespread impact on mandatory Class I Areas outside the state than sulfate on both the Most Impaired Days and the Least Impaired Days. Nitrate and sulfate emissions from Washington make reasonably anticipated contributions of 10% or more to the total modeled concentrations impacting certain mandatory Class I Areas in Oregon, Idaho, and Montana.

Fourth, Ecology recognized that the Organic Mass Carbons (OMC) fraction on IMPROVE filters is an important contributor to total light extinction but in two different ways with very different implications. OMC measured by IMPROVE monitoring is composed of POA and secondary organic compounds. POA are directly emitted as particulates. Secondary organic compounds are formed from condensation or photo-oxidization of VOCs.

The first way OMC is an important contributor to light extinction is related to fire. OMC is the dominant contributor to total light extinction on the Most Impaired Days at Washington's 2 IMPROVE monitoring sites that are most impacted by natural fire (NOCA1 and PASA1). Contributions of 44 and 49% of total light extinction in the baseline period increase slightly to projected contributions of 45 and 51% in 2018 under an emissions scenario that holds fire constant during the first planning period. Based in this information, it does not appear possible for North Cascades National Park, Glacier Peak Wilderness, and Pasayten Wilderness to reach natural conditions unless contributions of OMC from natural fires to total light extinction can be greatly reduced. This is problematic as our ability to reduce and control wildfires are limited.

The analysis of NOCA1 monitoring data in section 5.2 shows that when data from the high wildfire year of 2003 is excluded, OMC is no longer the predominant visibility-impairing species during "most impaired days". Instead, sulfates from anthropogenic sources become the predominant visibility-impairing species.

The importance of fire for maintaining healthy forest ecosystems has been recognized in governmental and non-governmental programs and in evolving policies supporting prescribed fire and providing options for more widespread use of fire for prescription purposes. Overall, the result is that more smoke (and OMC) from prescribed fires can be expected. Smoke management plans and programs are used to reduce the impacts of smoke on visibility.

Washington State's programs for smoke management are discussed below in section 10.4. Whether prescribed fire programs will mitigate visibility impairment due to wildfire and reduce the total amount of smoke affecting visibility over the long-term is uncertain.

An important consideration is that climate change models predict a drier Pacific Northwest in the future. This would lead to drier forest conditions which are more conducive to wildfire. A median scenario developed by the University of Washington predicts that due to changes in summer precipitation and temperature, the area burned within the Columbia Basin in the northwestern United States will increase from about 425,000 acres annually during the period of 1916-2006, to 0.8 million acres in the 2020*s*, to 1.1 million acres in the 2040*s*.[5]

There has been discussion in the WRAP and elsewhere about the reinterpretation of natural conditions to reflect more smoky conditions where the ecological role of fire is more dominant. While EPA has defined natural conditions as having no visibility impairment due to human-caused emissions, the Federal Land Managers (FLMs) and others believe that conditions will be smokier in the future as the ecological role of fire is re-established.

Ecology questions whether the scientific understanding of the role of fire and its impact on natural conditions is advanced enough to redefine natural conditions at this time. Since there is still over 50 years remaining to reach the RHR's goal of natural conditions, there is plenty of time to improve scientific understanding and consider appropriate revisions. Ecology's focus for North Cascades National Park, Glacier Peak Wilderness, and Pasayten Wilderness in this foundational SIP period will therefore be two-fold: (1) sulfate and nitrate reductions and (2) tracking fire impacts.

The second way OMC is an important contributor to light extinction is emissions from area sources. OMC causes 22 to 26% of total light extinction in the baseline period and 25 to 28% in 2018 visibility projections at the other 4 IMPROVE monitors. Washington's VOC emission inventory is much larger than the OC (POA) inventory both in the 2000-2004 baseline period and in 2018. Area sources, the largest human-generated source category of VOCs in 2018, are dominated by emissions from solvent utilization and residential wood combustion. Both of these reflect the impact of population growth has on the total amount of emissions. The total emissions would be even larger if there were no controls on the individual units comprising the areas sources. Further discussion of Washington State's program for residential wood combustion is found in section 10.4 below.

Finally, Ecology's analysis shows that emissions from outside of Washington play a significant role in visibility impairment in Washington's mandatory Class I Areas. These include emissions from outside the WRAP region. WRAP has characterized these outside emissions as regional contributions from outside domain, Canada, and Pacific offshore. All are beyond direct control by the state of Washington.

Outside domain consists of the background air concentrations of visibility-impairing pollutants contributed by the rest of the world. As such it represents visibility impairment from the rest of

[5] The Climate Impacts Group, University of Washington, *Evaluating Washington's Future in a Changing Climate*, June 2009.

the world and cannot be reduced as a result of actions by the state of Washington or any single jurisdiction. It is expected to increase over the next 50 years.

On the other hand, Canadian emissions can be controlled — by Canada. Both Canada and the United States have committed to reducing cross-border air pollution and recognizing significant human health and ecosystems effects, including RH, associated with fine particulate matter and its precursors. Both countries made a commitment to negotiating a Particulate Matter Annex to the United States-Canada Air Quality Agreement while actively developing and implementing emission reduction programs. Negotiations on the Annex were held in 2007 and 2008. Significant reductions in human-caused and wildfire emissions from Canada are needed for mandatory Class I Areas in Washington to reach natural conditions.

Pacific offshore emissions reflect emissions from offshore commercial marine shipping. The WRAP acknowledges that marine vessel emissions affect Washington's Class I areas.[6]

EPA adopted regulations for US–flagged large ocean going vessels in December 2009. The International Maritime Organization (IMO) has both approved the Western North America emissions control area and is in the process of implementing fuel sulfur content and engine regulations for large marine vessels.

Commercial marine shipping has been added to the discussion of factors involved in the LTS in section 10.4. Significant reductions in these emissions are needed for mandatory Class I Areas in Washington to reach natural conditions.

Due to the geographic location of Washington and the dominant weather patterns, emissions from other states are generally not significant contributors to visibility impairment in Washington's mandatory Class I Areas. The exception is Oregon.

Particulate Matter Source Apportionment Technology (PSAT) modeling shows Oregon contributes 10% or more of sulfate on the Least Impaired Days to 3 IMPROVE monitors (MORA1, WHPA1, and PASA1) in both 2002 and 2018. PSAT modeling also projects Oregon contributes 10% or more of sulfate to the other 3 IMPROVE monitors (OLYM1, NOCA1, and SNPA1) in 2018. Similarly PSAT modeling shows Oregon contributes more than 10% of nitrate on the Least Impaired Days to all of Washington's IMPROVE monitors in both 2002 and 2018.

The Weighted Emissions Potential (WEP) analysis indicates that POA from Oregon impacts Washington's southernmost IMPROVE monitor, WHPA1, on the Most Impaired Days and the Least Impaired Days and the MORA1 IMPROVE monitor on the Least Impaired Days. Visibility impairment on the Least Impaired Days at both IMPROVE monitors is attributable mainly to area sources, especially in the Portland area, and to natural fire. Area sources in the Portland area contribute to impairment at WHPA1 on the Most Impaired Days.

The Long-Term Strategies of both Washington and Oregon focus on the Most Impaired Days under the assumption that emissions reductions impacting the Most Impaired Days will maintain or improve visibility on the Least Impaired Days.

[6] http://vista.cira.colostate.edu/docs/wrap/emissions/OffshoreEmissions.doc

*Bottomline*. The RHR established the goal of achieving natural conditions by 2064. There are obstacles to achieving this goal. Most importantly, significant sources of visibility-impairing emissions are outside of the jurisdiction of the state. Further there is some uncertainty about the level of visibility representing natural conditions because of increased fire resulting from climate change and the re-institution of prescription burning that mimics natural fire cycles in the Northwestern US forests. Re-evaluation of natural conditions may be appropriate at some time in the future.

Still, as of 2010, 54 years remain to reach the RHR's goal of natural conditions. If the goal is to be met, Washington has to do its share by accepting the responsibility for developing additional controls on emissions of visibility-impairing emissions from sources within the state. The next section discusses Washington's plans to control emissions within the state.

## 10.3 Plans for Further Controls on Visibility-Impairing Pollutants

The purpose of developing a Four-Factor Analysis is to evaluate a source or source category for potential controls. The Four Factors, which are a statutory requirement of Section 169A (g)(1) of the Clean air Act, are sometimes referred to as "the four statutory factors". The factors area as follows:

- Costs of compliance
- Time needed for compliance
- Energy and non-air quality environmental impacts of compliance
- Remaining useful life of a facility

Ecology developed a set of Four-Factor Analyses for significant sources of $SO_2$ and $NO_X$. Ecology deemed a specific industry or emission source category that emits 1,000 tons or more of $SO_2$ or $NO_x$ a year as significant. The set of Four-Factor Analyses is found in Appendix F and summarized in the Four-Factor Analysis subsection of section 9.2.1 of Chapter 9. Table 10-2 below presents an overview of the specific industries and emission source categories and the associated emissions of $SO_2$ and $NO_x$.

The set of four-factor analyses indicates there is the potential for $SO_2$ and $NO_x$ emission reductions from a number of individual sources, principally boilers (oil-, natural gas-, and wood-fired), process heaters, and Fluidized Catalytic Cracking Unit (FCCU)/Carbon Monoxide (CO) boiler systems. This identification sets the stage for development of $SO_2$ and $NO_x$ limitations for individual sources.

A provision of Washington State's Clean Air Act (RCW 70.94.154) requires existing sources to use RACT. The RACT provision requires Ecology to develop new requirements for an existing emission source category through formal rulemaking action. The result of the process is a rule requiring all units of the defined source category to achieve a set of defined emission limitations.

**Table 10-2 Specific Industries or Emission Source Categories Selected for Further Evaluation**

| Specific Industry or Emission Source Category | Significant Specific $SO_2$ Industry or Emissions Source Category? | Significant Specific $NO_X$ Industry or Emissions Source Category? | Total $SO_s$ Emissions (tons per year) | Total $NO_X$ Emissions (tons per year) |
|---|---|---|---|---|
| **Industrial Processes** | | | | |
| Primary Metal Production | | | | |
| Aluminum Ore Electro-Reduction | Yes | No | 8,193 | 149 |
| Petroleum Industry | | | | |
| Process Heaters | Yes | Yes | 2,764 | 3,668 |
| Catalytic Cracking Units | Yes | Yes | 1,571 | "Large"[a] |
| Pulp and Paper and Wood Products | | | | |
| Sulfate (Kraft) Pulping | Yes | Yes | 5,081 | 3,769 |
| Sulfite Pulping | No | Yes | 378 | 1,296 |
| Mineral Products | | | | |
| Cement (Wet Process) | Yes | Yes | 1,209 | 3,528 |
| Cement (Dry Process) | No | Yes | 312 | 1,597 |
| Glass Manufacture | No | Yes | 317 | 1,620 |
| | | | | |
| **External Combustion Boilers** | | | | |
| Industrial | | | | |
| Wood/Bark Waste | Yes | Yes | 1,820 | 5,176 |
| Residual Oil | Yes | No | 1.569 | 419 |
| Natural Gas | No | Yes | 8 | 2,123 |

* While catalytic cracking units do not directly emit any air pollutants, the associated catalyst regeneration systems and carbon monoxide boilers that control the emissions from the catalyst regenerators produce large quantities of $NO_X$. This $NO_X$ is the product of the combustion of the carbon monoxide from the catalyst regeneration process and combustion of ammonia that may be included in the refinery gas used to supplement the carbon monoxide supplied as fuel by the regenerator to the carbon monoxide boiler.

Ecology can issue a new rule (or revise an existing one) to require the installation of new emission controls. A RACT rule allows sources a limited time (generally 2 to 3 years) to upgrade controls to meet the new or revised emission standards.

Washington State law has an economic hardship provision. A company that demonstrates it meets criteria for economic hardship is allowed either an extended time to achieve compliance or an alternate, source-specific emission limitation.

Development of a RACT rule takes a significant expenditure of time and resources. Ecology proposes to proceed by first doing technical analysis of the set of 5 identified specific industries and emission source categories to gain a better understanding of the existing levels of controls on individual point sources and the potential opportunities for additional controls. This may be accompanied by modeling of visibility impacts and evaluating the potential for visibility improvement. Ecology will use these analyses to prioritize the specific industries and emission source categories for RACT evaluation.

Ecology estimates that it will take a year to develop background information for a RACT rule and an additional 9 to 18 months to develop the rule itself. As a best case, Ecology estimates 2 RACT rules could be developed in a 5-year period at current staffing levels. Depending upon the source categories chosen for RACT rules, Ecology may choose to develop the rules one after the other or at the same time. Ecology's general schedule for RACT rule development is as follows:

- Technical analysis and prioritization, January 2011- December 2011
- Development of the first RACT rule, January 2012 – June 2014
- Development of the second RACT rule, July 2014-December 2016

Our current expectation is that sources will be given 2 to 3 years to meet the requirement s of a new RACT rule.

## 10.4 Factors Involved in the Long-Term Strategy

The RHR requires states to consider 7 factors (labeled "RHR factor" below) in developing a LTS.[7] As discussed above, Ecology is adding 2 additional factors (labeled "Ecology factor"), residential wood combustion and commercial marine shipping.

1. Emission reductions due to ongoing air pollution control programs, including measures to address RAVI (RHR factor)

   Current state and federal rules and state and local air agency permits limit visibility-impairing emissions from point, area, on-road, and non-road mobile sources. The emission reductions from most rules and permits in existence in 2006 are reflected in the projected 2018 emission inventory.

[7] 40 CFR 51.308(d)(3)(v)

Permitted limits include sulfur and particulate matter limits resulting from the RACT evaluation of the TransAlta Centralia Generation, LLC coal-fired power plant. These limits were approved by EPA as meeting BART requirements on June 11, 2003.[8]

Future major and minor new sources or modifications to existing sources will need to meet state permitting requirements; including meeting Best Available Control Technology (BACT) emission limits, to obtain a permit. Major New Source Review (NSR) permits include requirements to meet Air Quality Related Values protection criteria established by the FLMs for Class I Areas.

Ecology and local air pollution control authorities in Washington take every opportunity to reduce emissions from existing emission units and to minimize the growth in new emissions through our state NSR program. This program requires the imposition of BACT emission reductions for all new sources and modifications that result in the increase of emissions.

Under other requirements of state law[9], when a company decides to modify or replace an existing emission control system, Ecology or the local air pollution control authority must assure that the modified or replacement control system meets a RACT level of emissions control. This process results in a reduction in emissions from a stationary source, though not so dramatic a reduction as might be achieved through the NSR program. Processing modifications and replacements of control equipment is an ongoing workload and from year-to-year the emission reductions are unpredictable.

EPA approved the state's silvicultural Smoke Management Plan (SMP) on June 11, 2003 as part of the state's RAVI SIP. Additional information is provided under RHR factor 5.

2. Emission reductions to mitigate the impacts of construction activities (RHR factor)

   Construction activities as a source of air pollution are regulated under the jurisdiction of Ecology or a local air quality agency. Construction activities are addressed by state air quality rules.[10] Local air quality agencies and local governments have additional rules and policies governing mitigation of air pollution from construction activities.

   Construction activities have not been identified as contributing to visibility impairment in mandatory Class I Areas in Washington. Impacts occur close to the construction site. Washington's mandatory Class I Areas are relatively far from urban areas.

3. Emission limitations and schedules of compliance to achieve the RPG (RHR factor)

   In addition to existing federal and state rules, BART plays a role in achieving the emission reductions being used to achieve 2018 RPG. Ecology prepared and issued administrative orders to the sources subject to BART. Each order, which is enforceable

[8] 68 FR at 34824, June 11, 2003
[9] RCW 70.94.153
[10] WAC 173-400-040(3) and (8).

under state law, requires compliance with the BART determination by a specified date. The final orders are being submitted to EPA for federal approval as part of the state's RH SIP.

4. Source retirement and replacement schedules (RHR factor)

   Ecology is not aware of any scheduled and documented source retirement or replacement of point sources emitting visibility-impairing pollutants. Source retirement and replacement schedules are not part of this long-term strategy. If Ecology receives documentation of source retirement and replacement schedules in the future, the resulting reductions in visibility-impairing pollutants will be incorporated into the LTS during periodic updates to the RH SIP.

5. Smoke management techniques for agriculture and forestry management purposes including plans as they currently exist within the state for these purposes (RHR factor)

   Under Washington State law, Ecology and the local air agencies have authority to regulate agricultural burning. State law recognizes the need to protect public health and welfare, including visibility, while also allowing for agricultural burning that is reasonably necessary. The state has established controls for agricultural burning to minimize adverse health and environmental impacts. The state works with a variety of stakeholders including agricultural burners, agricultural interests groups, and air quality interest groups to encourage development, research, and use of alternatives to burning.

   Under state law, Ecology chairs and works with the Agricultural Burning Practices and Research Task Force (Ag Burn Task Force). The Ag Burn Task Force works toward reducing emissions from agricultural burning. This group develops Best Management Practices to reduce emissions from agricultural activities and identifies and, when funding is available, funds research into viable alternatives to field burning.

   Under state law[11] the Washington State DNR serves as the SMP administrator and is responsible for managing smoke emissions from silvicultural forest burning. The plan "applies to all persons, landowners, companies, state and federal land management agencies, and others who do outdoor burning in Washington State on lands where DNR provides fire protection or where such burning occurs on federally managed, unimproved forestlands and tribal lands of participating Indian nations in the state"[12].

   Although prescribed burning from forestry activities is not considered a stationary source, Washington proactively addressed this source in its RAVI SIP because of significant impacts on visibility from prescribed burn plumes. Washington incorporated the state's SMP into the September 1999 revisions to the RAVI SIP.

6. Residential wood combustion program and controls including woodstove change-outs (Ecology factor)

[11] Revised Code of Washington 70.94.6536
[12] 1998 Smoke Management Plan, page 5

Residential wood smoke is a significant source of air pollution—including visibility-impairing pollutants—in Washington. Over time the state has developed and implemented a program to address this source and now has a mature residential wood combustion program. Some aspects of the program include:

- Emission standards for woodstoves and fireplaces that are more restrictive than current EPA standards
- A burn-ban program that limits use of wood-burning home heating devices and outdoor burning when fine particulate levels are elevated in the cooler months
- To the extent that funding is available, woodstove change out programs are implemented to replace older, more polluting woodstoves with cleaner, more efficient heating devices

Ecology is currently working with EPA and other states to update emission standards for home heating devices.

7. Controls on emissions from commercial marine shipping (Ecology factor)

The WRAP acknowledges that marine vessel emissions affect Washington's Class I areas.[13] Ecology's analysis of WRAP technical information confirms that mandatory Class I Areas in Washington are impacted by visibility-impairing emissions from outside the state including Pacific offshore emissions from commercial marine shipping.

Washington is also impacted by shipping through the Strait of Juan de Fuca, which separates Vancouver Island, British Columbia from the north shore of Washington's Olympic Peninsula. These emissions however are not in WRAP emission inventories. Neither the Pacific offshore emissions nor in-shore emissions (which are assigned to Washington counties) include Canadian vessel traffic within and just outside the Strait of Juan de Fuca. The Canadian vessel traffic goes to and from Canadian ports, primarily the Port Metro Vancouver, the largest port on the West coast of the United States and Canada.

After the WRAP had finalized the emission inventories and modeling of 2018 visibility impacts, EPA finalized a coordinated strategy for addressing pollution from oceangoing vessels. This strategy includes the following components:

(1) EPA regulations for controlling emissions from US flagged vessels and vessels that purchase fuel in the United States
(2) The U.S. government's international efforts to reduce air pollution from oceangoing vessels through the designation of an Emission Control Area (ECA) off the West and the East Coasts of the United States
(3) New international standards for marine diesel engines.

[13] http://vista.cira.colostate.edu/docs/wrap/emissions/OffshoreEmissions.doc

EPA adopted the more rigorous engine and fuel standards for new marine diesel engines with per cylinder displacement at or above 30 liters (called Category 3 marine diesel engines) in December 2009. Category 3 marine diesel engines serve as the main propulsion engines on oceangoing vessels.

The EPA rule applies to new engines installed on U.S.-flagged vessels beginning in 2011. The rule requires more efficient use of such current technologies as engine cooling, engine timing, and advanced computer controls. It is expected to reduce $NO_x$ levels by 15 to 25%. Beginning in 2016 the rule requires the use of high-efficiency emissions control technology, including Selective Catalytic Reduction (SCR), to reduce $NO_x$ by 80% below current levels.

EPA revised the diesel fuel program to forbid the production and sale of marine fuel oil above 0.1% (1,000 ppm) sulfur for use in the waters within the proposed ECA. The program provides for the production and sale of less than or equal to 0.1% sulfur fuel for use in Category 3 marine vessels with some limited exceptions that do not affect West Coast marine shipping.

The IMO, a specialized agency of the United Nations, is taking a series of actions to reduce harmful emissions from ships. Amendments to the existing IMO regulations were adopted in October 2008 to allow for tighter controls in ECAs if needed to prevent, reduce, and control emissions. The revised regulations and will enter into force on July 1, 2010.

In July 2009, the IMO adopted in principle an ECA extending 200 nautical miles from the West and East Coasts of the United States and Canada. The ECA, which is expected to enter into force as early as August 2012, will reduce the allowed sulfur content of marine diesel fuel from 1.50% to 1.00% (15,000 ppm to 10,000 ppm) and further reduce the sulfur content to 0.10% (1,000 ppm) effective January 1, 2015. In practice, implementation of the ECA means that ships entering the ECA need to use IMO compliant fuel for the duration of their voyage that is within the ECA, including time in port as well as voyages whose routes pass through the area without calling on a port.

Ships constructed in 2016 or later will need to comply with stringent $NO_X$ limits when operating within the ECA. Compliance is expected to necessitate the use of after-treatment technology, such as SCR.

The EPA and IMO regulations will start to benefit visibility in Washington’s mandatory Class I Areas only in the final years of the 2005-2018 control period. As neither EPA nor IMO regulations were adopted at the time that PRP18a modeling was performed, the WRAP did not include any anticipated reductions in visibility-impairing pollutants from commercial marine shipping in modeling for this SIP. The reductions will be reflected in modeling for the next control SIP covering the 2018-2028 planning period, which is due in 2018 under the RHR.

8. Enforceability of emission limitations and control measures (RHR factor)

Emission limits on stationary point sources are enforceable as a matter of state law. The authority to require proper operation and maintenance of control equipment is found in the following rules:

- Chapter 173-400 Washington Administrative Code (WAC), General regulations for air pollution sources
- Chapter 173-401 WAC, Operating permit regulation
- Chapter 173-405 WAC, Kraft pulping mills
- Chapter 173-410 WAC, Sulfite pulping mills
- Chapter 173-415 WAC, Primary aluminum plants
- Chapter 173-434 WAC, Solid waste incinerator facilities
- Local air agency rules for point sources

Ecology and local air agencies rely on field inspections to ensure compliance with the requirements.

Ecology issued administrative orders to implement BART at the sources subject to BART. The orders will later be incorporated into the source's Title V permit by the agency with jurisdiction over the source (either Ecology or a local air agency).

Existing federal and state rules are enforceable by the agency issuing the rules.

9. The anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the first control period which ends in 2018 (RHR factor)

   The WRAP modeled the PRP18a inventory used for this SIP to determine the expected net effect of projected changes to visibility due to emission changes over the control period for the foundational RH SIP ending in 2018. The effects reflect the implementation of controls on the books and presumptive $SO_2$ BART for Electrical Generating Units (EGUs) where BART had not been determined.

   As discussed above in section 9.2.2, while the WRAP modeling for North Cascades National Park and Glacier Peak Wilderness projects increased visibility impairment for the Most Impaired Days in 2018, there are issues with the modeling results. A modified projection prepared by Air Resource Specialists, Inc. for the state of Washington and the WRAP indicates a visibility improvement. Ecology accepted that the modified result for the Most Impaired Days as a more realistic estimate of 2018 visibility.

Table 10-3 below presents the net effects of emission changes on visibility. The net effect for the Most Impaired Days was considered in establishing RPGs for Washington's mandatory Class I Areas. The modeling results for the Least Impaired Days show that the no degradation goal can be met.

**Table 10-3 Anticipated Net Effect on Visibility of Emission Reductions over the First Control Period**

| Class I Area | Most Impaired Days | | | Least Impaired Days | | |
|---|---|---|---|---|---|---|
| | 2000-2004 Baseline Conditions (dv) | 2018 Projected Visibility (dv) | Net Effect (dv) | 2000-2004 Baseline Conditions (dv) | 2018 Projected Visibility (dv) | Net Effect (dv) |
| Olympic National Park | 16.74 | 16.38 | (0.36) | 6.02 | 5.82 | (0.20) |
| North Cascades National Park and Glacier Peak Wilderness | 16.01 | 15.62 | (0.39) | 3.37 | 3.24 | (0.13) |
| Alpine Lakes Wilderness | 17.84 | 16.32 | (1.52) | 5.5 | 4.86 | (0.64) |
| Mount Rainier National Park | 18.24 | 16.66 | (1.58) | 5.47 | 4.83 | (0.64) |
| Goat Rocks Wilderness and Mount Adams Wilderness | 12.76 | 11.79 | (0.97) | 1.66 | 1.47 | (0.19) |
| Pasayten Wilderness | 15.23 | 15.09 | (0.14) | 2.73 | 1.89 | (0.84) |

NOTE: Parentheses indicate reductions (in deciviews) of visibility impairment or, in other words, the amount of visibility improvement.

## 10.5 Development of Washington's Long-Term Strategy

The RHR requires consultation between states on the development of coordinated emission management strategies. This requirement applies both to mandatory Class I Areas within Washington and to mandatory Class I Areas outside Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment.

Participation in the WRAP has fostered a regionally consistent approach to haze planning in the western states and provided a sound mechanism for consultation. Consultation among the 15 western states within WRAP has occurred through meetings of WRAP committees, workgroups, and forums with participation by conference calls, face-to-face meetings, and workshops. The result is that western states have agreed upon the RPGs being set for 2018 and the appropriateness of the strategies to achieve the RPGs for all mandatory Class 1 Areas in the WRAP region. As result of coordination through the WRAP, this foundational RH SIP reflects Washington's implementation of a regionally consistent approach to addressing visibility impairment in the West.

## 10.6 Summary

Washington State's LTS for Visibility Improvement is a comprehensive strategy that addresses both RH and RAVI. The LTS applies to mandatory Class I Areas both within Washington and outside Washington where emissions from the state are reasonably anticipated to contribute to visibility impairment.

The LTS is designed to achieve the RPGs established by this foundational RH SIP for mandatory Class I Areas inside Washington and the RPGs established by other states for mandatory Class I Areas outside of Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment. The RPGs serve as benchmarks for progress in meeting the national visibility goal by 2064. Washington will update its comprehensive LTS on the schedule set by the RHR for RH SIP updates.

The LTS for this foundational RH SIP is based on the following considerations:

A. Already adopted federal and state controls, especially federal fuel and engine rules for on-road and non-road vehicles, are important for making reasonable progress by 2018.
B. The focus should be on the Most Impaired Days.
C. Washington should focus controls primarily on sulfate and secondarily on nitrate.
D. In the 2000-2005 baseline period, OMC was an important contributor to total light extinction but in two different ways with two quite different implications.
    a. It does not appear possible for Pasayten Wilderness, North Cascades National Park, and Glacier Peak Wilderness to reach natural conditions unless contributions of OMC from natural fire to total light extinction can be greatly reduced.
    b. Projected 2018 OMC in Washington's other mandatory Class I federal areas reflects the impact of population increase on area source emissions despite existing controls on the individual area source units.
E. Regional contributions from outside domain, Canada, and Pacific offshore play a significant role in visibility impairment in Washington's mandatory Class I Areas but are beyond the direct control of the state of Washington.

The bottomline is that if the goal of natural conditions is to be met, Washington has to do its share by accepting the state's responsibility for developing additional controls on those sources of visibility-impairing emissions. During this first control period, Ecology intends to pursue the RACT strategy discussed above in section 10.3 in order to reduce impacts from visibility-imparing emissions on Class I areas.

Ecology also will identify for EPA, to the extent practicable, the sources or source areas of visibility-impairing emissions in Canada that contribute to visibility impairment in Washington's Class I areas.

# Chapter 11 Best Available Retrofit Technology

This chapter discusses the application of Best Available Retrofit Technology (BART) in Washington for sources that cause or contribute to visibility impairment in any mandatory Class I Area.

## 11.1 Overview

The Regional Haze Rule (RHR)[1] requires the installation of BART controls on a specific set of existing stationary sources. This involves identification of:

- BART-eligible sources
- Sources subject to BART (an engineering analysis)
- Determination of BART controls

A BART-eligible source is one which meets the following three criteria:

1. Contains an emission unit from one of 26 source categories identified in the Clean Air Act (CAA) and regulations.
2. The emission unit was in existence on August 7, 1977; however, not in operation before August 7, 1962 or the emission unit was in operation prior to August 7, 1962 and was reconstructed between August 7, 1962 and August 7, 1977.
3. The potential emissions from all the emission units are currently 250 tons per year or more of a visibility-impairing air pollutant.

Each BART-eligible source must be evaluated to determine if the source causes or contributes to visibility impairment at one or more mandatory Class I Areas. The Environmental Protection Agency (EPA) guidelines directed that states review Sulfur Dioxide ($SO_2$), Nitrogen Oxides ($NO_x$) and Particulate Matter (PM) emissions in determining whether sources cause or contribute to visibility impairment. States may use their best judgment to determine whether volatile organic compounds or ammonia emissions are likely to have an impact on visibility in an area.

A 1.0 Deciview (dv) change is equal to a generally perceptible change in visibility to most people. A single BART-eligible source that is responsible for a 1.0 dv change or more is considered to "cause" visibility impairment. The threshold for "contribute to" can vary between states. The limit of perceptible change is 0.5 dv. In the preamble to the 2005 Final RHR Amendments, the EPA indicates that the threshold for "contribute to" that is used for BART applicability should be no higher than 0.5 dv.

For the BART modeling conducted in Washington, Ecology chose 0.5 dv as the threshold for contributing to visibility impairment because it is the limit of perceptible change. This is consistent with neighboring states Idaho and Oregon, with whom Washington developed the three-state BART Modeling Protocol. More information on the BART Modeling Protocol is presented in Section 11.3 and Appendix H.

[1] 40 CFR 51.308(e)

Each BART-eligible source in Washington was required to model its actual emissions to determine whether the emissions from the BART-eligible emission units caused or contributed to visibility impairment. BART-eligible sources whose modeled emissions caused or contributed to visibility impairment were "subject to BART." Sources identified as subject to BART are required, through a BART engineering analysis, to identify what types of controls, if any, should be placed on the source. The results of this analysis form the basis for a determining what BART controls must be installed.

The RHR requires states to consider the following factors in the analysis used to determine BART:

1. The technology available,
2. The costs of compliance,
3. The energy and non-air quality environmental impacts of compliance,
4. Any existing pollution control equipment in use at the source,
5. The remaining useful life of the source, and
6. The degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

Upon determination of BART, each source is required to install and operate BART as expeditiously as practicable, but in no event later than 5 years after approval of the State Implementation Plan (SIP).

## 11.2 Best Available Retrofit Technology–Eligible Sources in Washington

The BART-eligible sources were identified using the methodology in the *Guidelines for BART Determinations under the RHR* or "Guidelines" found in 40 CFR 51, Appendix Y.

The Western Regional Air Partnership (WRAP) assisted Washington in evaluating which of the thousands of sources in Washington might be BART-eligible. WRAP contracted with the Eastern Research Group (ERG) to evaluate the potential BART-eligible sources in each state within the WRAP to provide the list of potentially BART-eligible sources to the states to make final determinations of BART-eligibility. ERG prepared a report for WRAP called *Identification of BART-Eligible Sources in the WRAP Region*. The study identified over 117 facilities in Washington that reported actual emissions of $NO_x$, $SO_2$, or Course Particle Matter ($PM_{10}$) above 100 tons and were identified in the National Emission Inventory as being in one or more of the 26 BART source categories.

In this study WRAP worked with Ecology staff to review Washington sources under the three BART-eligibility criteria. Out of this review, 29 sources were identified as needing more in-depth review to determine BART-eligibility. These 29 sources were categorized as:

1. Definitely BART-eligible
2. Likely BART-eligible
3. Potentially BART-eligible
4. Clearly not BART-eligible, and

5. Do not know.

Ecology then took ERG's final list for Washington and evaluated in detail the "likely," "potentially," and "do not know" sources list to determine which if any were BART-eligible. Staff reviewed historical written reports such as compliance reports, inspection reports, source test reports, Notice of Construction applications and permits, Air Operating Permit support documents, National Pollutant Discharge Elimination System (NPDES) permit Fact Sheets, and for many facilities, U.S. Geological Survey (USGS) Mineral Reports. Additional information having to do with exact dates in 1962 or 1977 for specific emission units was acquired directly from each source.

Out of the 29, a total of 15 sources were actually BART-eligible. Table 11-1 lists these 15 facilities and Figure 11-1 indicates their locations. These 15 sources were required to demonstrate whether their emissions caused or contributed to visibility impairment in one or more mandatory Class I Areas. If the source chose not to model its emissions, Ecology assumed the source was subject to BART. The 14 sources that did not meet the BART-eligibility criteria are listed in Table 11-2.

**Table 11-1 Best Available Retrofit Technology-Eligible Sources in Washington**

| BART-Eligible Source | BART Category |
|---|---|
| Graymont Western US INC[2] (Tacoma) | Lime plants |
| TransAlta Centralia Generation, LLC | Fossil fuel-fired steam electric plants with a heat input greater than 250 MMBtu per hour |
| Longview Fibre Co - Longview | Kraft Pulp Mills |
| Weyerhaeuser Co - Longview | Kraft Pulp Mills |
| Fort James Camas LLC (now Georgia Pacific Corporation - Camas) | Kraft Pulp Mills |
| Goldendale Aluminum | Primary Aluminum Ore Reduction Plants |
| Port Townsend Paper Co | Kraft Pulp Mills |
| Simpson Tacoma Kraft | Kraft Pulp Mills |
| Lafarge North America (Seattle) | Portland Cement Plants |
| Intalco (Ferndale) | Primary Aluminum Ore Reduction Plants |
| Alcoa Wenatchee Works | Primary Aluminum Ore Reduction Plants |
| BP Cherry Point Refinery (Ferndale) | Petroleum Refineries |
| Tesoro Refining and Marketing (Anacortes) | Petroleum Refineries |
| Puget Sound Refining Company | Petroleum Refineries |
| Conoco-Philips Company (Ferndale) | Petroleum Refineries |

[2] This source is located within the boundary of the Puyallup Indian Reservation but regulated by the local air quality agency under the terms of the Puyallup Tribe of Indians Settlement Act of 1989, 25 U.S.C. 1773.

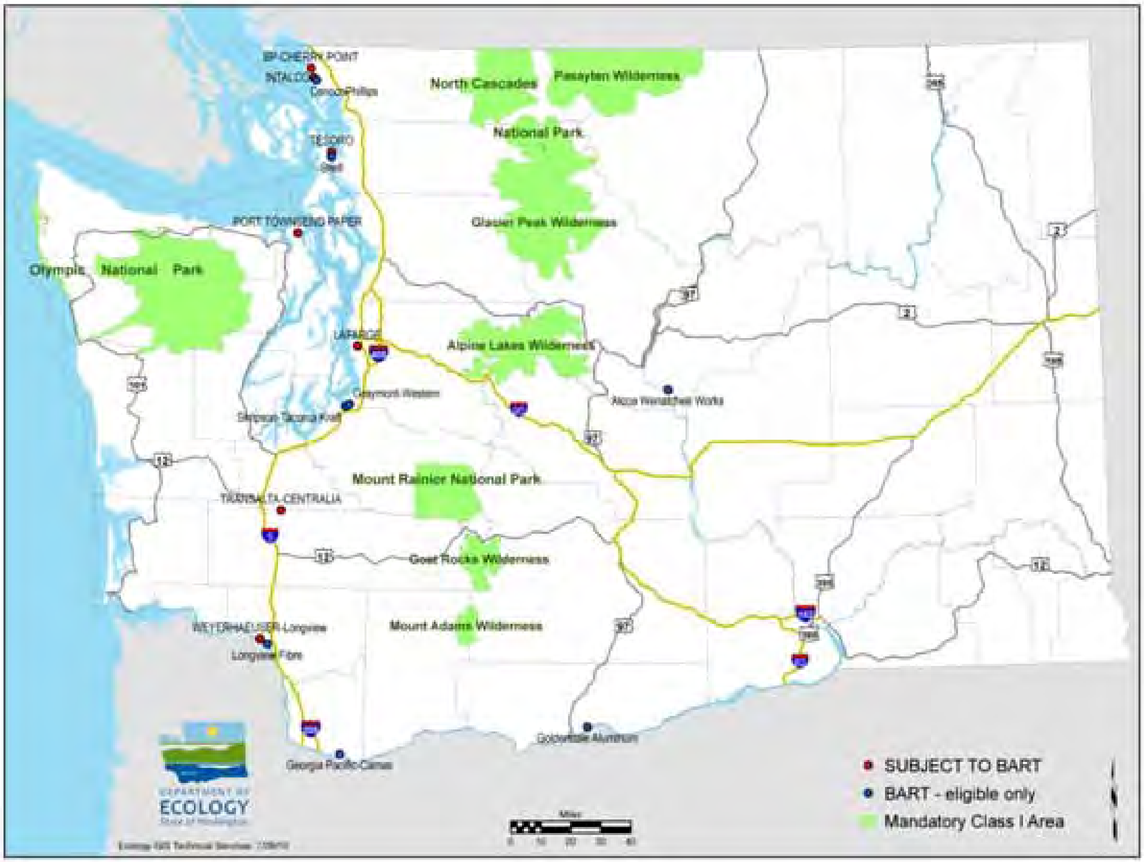



**Figure 11-1 Locations of Best Available Retrofit Technology-Eligible Sources and Sources Subject to Best Available Retrofit Technology**

**Table 11-2 Sources that Did Not Meet the Best Available Retrofit Technology-Eligibility Criteria**

| **Source and Location** | **Reason(s) this source was not BART-eligible** |
|---|---|
| Prodica LLC, Kennewick | The age-eligible units have a potential to emit of less than 250 tons per year for any visibility-impairing pollutant. |
| Boise Cascade – Wallula, Wallula | One boiler started operation before August 7, 1962. All other boilers at this source were replaced after 1979. |
| General Chemical Corporation, Anacortes | The age-eligible units have a potential to emit of less than 250 tons per year for any visibility-impairing pollutant. |
| U.S. Oil & Refining Company, Tacoma | Only one small process heater remains from the age-eligible time frame, but does not have qualifying emissions. |
| University of Washington Power Plant & Hospital, Seattle | The only age and size qualifying boiler has a potential to emit of less than 250 tons per year for any visibility-impairing pollutant. |
| BF Goodrich Kalama Inc, Kalama | The units that were age-eligible have a potential to emit of less than 250 tons per year for any visibility-impairing pollutant. |
| Kaiser Aluminum Mead Works, Mead | This source shutdown in 2001, most equipment was sold off, and it is no longer in operation. |
| Kimberly-Clark Corporation, Everett | This is a sulfite pulp mill. Source does not fall under any of the 26 source categories for BART. Also, the natural gas boiler heat input capacity is limited to less than 250 million BTU/hour. |
| Vanalco Inc, Vancouver | This source is no longer operating. The units that were age-eligible have a potential to emit of less than 250 tons per year for any visibility-impairing pollutant. |
| Ash Grove Cement Company (E Marginal), Seattle | There are no emission units at this source from the age-eligible timeframe. |
| Kaiser Aluminum & Chemical Corporation (Trentwood), Spokane | This is a secondary aluminum facility. Source does not fall under any of the 26 source categories for BART. There are no emission units at this source from the age-eligible timeframe. No boiler over 250 million BTU/ hour input. |
| Vaagen Brothers Lumber, Colville | Wood-fired boiler with no fossil fuel capability. Source does not fall under any of the 26 source categories for BART. |
| Birmingham Steel Corporation - West Seattle (now called Nucor Steel), Seattle | There are no emission units at this source from the age-eligible timeframe. |
| Simmons Densified Fuels Inc, Yakima | This source makes wood pellet fuel. Source does not fall under any of the 26 source categories for BART. |

## 11.3 Washington-Oregon-Idaho Best Available Retrofit Technology Modeling Protocol

Ecology worked with the states of Oregon and Idaho in concert with EPA Region 10, the U.S. Department of the Interior Fish and Wildlife Service, U.S. Department of the Interior National Park Service, and the U.S. Department of Agriculture Forest Service to develop a unified protocol for the states and individual companies to use for modeling. The final protocol was based on a number of other BART modeling protocols and modified by local experience with the complex topography of the three states. The BART Modeling Protocol addresses both BART exemption modeling and BART determination modeling. The former addresses whether a source causes or contributes to visibility impairment in any Class I Area; the latter, visibility improvement from potential controls. A copy of the protocol can be found in Appendix H.

The protocol developed utilized the California Puff Model (CALPUFF) model version 6.0, level 060331. The meteorological data file was generated from prognostic, 12 km gridded data for 2003, 2004, and 2005. The prognostic data files provided to the contractor to produce the modeling file contained missing data. The missing data was filled in by the contractor running Meteorological Mesoscale 5 (MM5) in prognostic mode. The 12 km gridded meteorological data was processed through California Meteorological Model (CALMET) to produce a 4 km gridded data set. The resulting meteorological data file was provided to all of the companies in the three states for their use in modeling for BART purposes.

The three state modeling protocols contained a few specific deviations from the modeling protocols developed by most organizations for their Regional Haze (RH) modeling. Specific differences utilized were:

- Use of three years of 4 km resolution gridded meteorological input data based on prognostic meteorological modeling
- Only meteorological site cloud cover observations were used, all other site measurements were not included
- Use of 4 km topographical data
- Establishment of a 17 ppb ambient ammonia concentration
- Use of both the $98^{th}$ percentile delta deciview value per year and for the 3 year period of modeling for evaluating whether a source would cause or contribute to visibility impairment

## 11.4 Summary of Washington Best Available Retrofit Technology Modeling Results

Ecology requested the 14 operating BART-eligible sources listed in Table 11-1 to provide evidence using the regional modeling protocol that their BART-eligible emission units did not cause or contribute to visibility impairment. Goldendale Aluminum was no longer operating so Ecology did not request modeling evidence. If a company did not provide the appropriate evidence, Ecology assumed that the facility was subject to BART and would be required to submit a BART Engineering Analysis. Ecology relied on modeling done by EPA Region 10 for Goldendale Aluminum which had not operated since spring 2001.

Eight of the facilities also used an hourly ozone data file developed by the State of Oregon and one of Oregon's BART-eligible facilities. Two of the facilities located near the Canadian border amended the ozone data file with ozone monitoring data from British Columbia.

BART-eligible sources responsible for a 0.5 dv change or more in visibility at any mandatory Class I Area are subject to a full BART engineering analysis to determine what, if any, BART controls must be installed. BART-eligible sources that do not cause or contribute to visibility impairment at a threshold greater than 0.5 dv are exempt from BART.

## 11.4.1 Sources that Did Not Meet the Best Available Retrofit Technology Eligibility Criteria

The modeled visibility impact of each source on mandatory Class I Areas within 300 km was used to determine which of the 14 BART-eligible sources were not subject to BART. Eight sources modeled below the 0.5 dv threshold for contributing to visibility impairment and were not required to perform a BART engineering analysis. The maximum annual $8^{th}$ high dv value for the three year period of 2003 through 2005 and the maximum modeled visibility impact for each facility are shown in Table 11-3 below along with the corresponding impacted Class I Areas.

Alcoa Wenatchee Works proposed, and Ecology accepted, refinements to the three-state modeling protocol because the use of a smaller grid size provided more realistic results in this area of very complex terrain. A summary is provided here and more detailed discussion of the Alcoa Wenatchee Works exemption modeling is located in Appendix I.

This particular BART-eligible aluminum smelter is located on the east side of the Cascade Range in a constricted, canyon-like section of the Columbia River Valley near Wenatchee. Terrain in this region is complex. Elevations vary from 200 meters (m) elevation Mean Sea Level (MSL) in the vicinity of the smelter to 2500 m elevation at some peaks within the Alpine Lakes Wilderness.

Initial modeling runs using the 4-km grid resolution specified by the three-state Modeling Protocol raised questions about the impacts of the Alcoa aluminum smelter on Alpine Lakes Wilderness, the only impacted mandatory Class I Area. Close examination of the surface wind fields showed numerous locations where the modeled wind directions did not reflect the effects of the topography. Alcoa Wenatchee Works believed that the apparent errors in the wind field were due to unresolved features of the complex terrain and proposed an alternative meteorological data file utilizing a finer grid size than the 4-km grid size specified by the three-state modeling protocol. A 0.5-km grid size was proposed to better characterize the topographical setting of the facility and the narrow mountain valleys and elevation changes that the emissions from the plant would encounter to impact the Alpine Lakes Wilderness.

Comparing the results of the 0.5-km modeling with the 4-km modeling shows that the finer grid spacing did not produce large changes in the magnitude or timing of the highest impacts, but did show an important difference in the spatial location of impacts between the 4-km grid and the finer grid. Impacts occur at the eastern and southern boundaries of Alpine Lakes Wilderness during the winter for both the 4-km and 0.5-km grid spacing's. Impacts occur at the western boundary, which is west of the Cascade Crest, only at the 4-km grid spacing. Appendix I discusses Ecology's acceptance of the use of the finer gridded meteorological data and the use of an alternate version of CALPUFF.

**Table 11-3 Sources Not Required to Perform a Best Available Retrofit Technology Engineering Analysis**

| Source Information | | Maximum Visibility Impact Information | | | | |
|---|---|---|---|---|---|---|
| Facility Name | # of BART-Eligible Units | dv value to determine if source is subject to BART (8th highest day's dv) | Location of impact on 8th highest day | Day and year 8th highest dv value occurred | Maximum dv impact on any one day in 3 year period | Location (within 300 km) of maximum impact for the 3 yr period |
| Alcoa Wenatchee Works | 12 | 0.379 | Alpine Lakes | 354, 2004 | 0.845 | Alpine Lakes |
| Conoco-Phillips | 8 | 0.424 | Olympic NP | 324, 2005 | 0.901 | Olympic NP |
| Fort James Camas LLC (now Georgia Pacific-Camas) | 4 | 0.434 | Mt Hood | 270, 2004 | 1.106 | Mt Hood |
| Goldendale Aluminum[3] | 2 | 0.22 | Mt Adams | Not Available | 0.31 | Goat Rocks |
| Graymont Western US Inc | 1 | 0.166 | Mt Rainier NP | 49, 2005 | 0.644 | Mt Rainier NP |
| Longview Fibre Co - Longview | 6 | 0.46 | Mt Hood | 138, 2003 | 1.031 | Mt Hood |
| Puget Sound Refining Company | 9 | 0.454 | Olympic NP | 348, 2005 | 1.246 | Olympic NP |
| Simpson Tacoma Kraft | 3 | 0.463 | Mt Rainier NP | 174, 2004 | 1.81 | Mt Rainier NP |

## 11.4.2 Sources that Met the Best Available Retrofit Technology Eligibility Criteria

Seven BART-eligible sources modeled above the 0.5 dv visibility impairment threshold and were subject to a full BART engineering analysis. These facilities are listed in Table 11-4. The table also lists the maximum annual 8$^{th}$ highest day for the 2003 to 2005 modeled period and the maximum dv impact modeled at any Class I Area within 300 km of the source along with the impacted mandatory Class I Areas.

[3] Goldendale Aluminum impact modeling was done by EPA Region 10 utilizing the Modeling Protocol. Because the Goldendale Aluminum plant had not operated since 2001, the company was not requested to perform its own modeling. The plant is currently in the process of being dismantled.

**Table 11-4 Sources Subject to Best Available Retrofit Technology**

| Source Information | | Maximum Visibility Impact Information | | | | |
|---|---|---|---|---|---|---|
| Facility Name | # of Units Subject to BART | dv value to determine that the source is subject to BART (8th highest day's dv) | Location of impact on 8th highest day | Day and year 8th highest dv value occurred | Maximum dv impact on any one day in 3 year period | Location (within 300 km) of maximum impact for the 3 yr period |
| BP Cherry Point Refinery | 26 | 0.901 | Olympic NP | 53, 2005 | 2.108 | Olympic NP |
| INTALCO Aluminum Corp - Ferndale | 19 | 2.363 | Olympic NP | 57,2003 | 4.672 | Olympic NP |
| Tesoro Refining and Marketing Co | 14 | 1.722 | Olympic NP | 342, 2005 | 2.932 | Olympic NP |
| Port Townsend Paper Co | 4 | 1.18 | Olympic NP | 98, 2004 | 1.97 | Olympic NP |
| Lafarge North America | 2 | 3.16 | Olympic NP | 95, 2004 | 6.99 | Olympic NP |
| TransAlta Centralia Generation, LLC | 3 | 5.548 | Mt Rainier NP | 57, 2003 | 9.928 | Olympic NP |
| Weyerhaeuser Co - Longview | 3 | 0.973 | Mt Rainier NP | 177, 2004 | 2.146 | Mt Rainier NP |

Tables 11-5 though 11-12 shows more detailed visibility impact modeling information results for the facilities subject to BART. These tables are taken from Section 3 of the Technical Support Document for each BART determination. These tables include the modeled impact of the BART-eligible units at each facility on all Class I Areas within 300 km of the facility, even when the 98$^{th}$ percentile values are below the 0.5 dv contribute to visibility threshold. When the modeled impact for the 98$^{th}$ percentile value is above the 0.5 dv contribute threshold, the value is shaded.

**BP Cherry Point Refinery**

BP Cherry Point Refinery is a petroleum refinery located near Ferndale, WA. More detailed evaluation of the modeling results indicates that the primary pollutant affecting visibility is $NO_x$, especially during the wintertime.

**Table 11-5 BP Cherry Point Refinery**

| Mandatory Class I Area | Visibility Criterion | Modeled Impact |
|---|---|---|
| Alpine Lakes Wilderness | Max 98% value (max. annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.294<br>0.260 |
| Glacier Peak Wilderness | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.290<br>0.248 |
| Goat Rocks Wilderness | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.122<br>0.110 |
| Mt. Adams Wilderness | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.083<br>0.082 |
| Mt. Rainier National Park | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.279<br>0.222 |
| North Cascades National Park | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.370<br>0.365 |
| Olympic National Park | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.901<br>0.842 |
| Pasayten Wilderness | Max 98% value (Max annual 8th high)<br>3-yrs Combined 98% value (22nd high) | 0.215<br>0.196 |

## Intalco

Intalco is a primary aluminum smelter located near Ferndale, WA. Intalco is predominantly a source of $SO_2$ from the smelting of aluminum.

**Table 11-6 Intalco**

| Mandatory Class I Area | 2003 | | 2004 | | 2005 | |
|---|---|---|---|---|---|---|
| | Modeled 98$^{th}$ Percentile (deciview) | Number of Days Exceeding 0.5 dv | Modeled 98$^{th}$ Percentile (deciview) | Number of Days Exceeding 0.5 dv | Modeled 98$^{th}$ Percentile (deciview) | Number of Days Exceeding 0.5 dv |
| Alpine Lakes Wilderness Area | 1.244 | 36 | 0.965 | 37 | 0.881 | 23 |
| Goat Rocks Wilderness Area | 0.500 | 8 | 0.579 | 10 | 0.317 | 3 |
| Glacier Peak Wilderness Area | 1.161 | 37 | 1.156 | 38 | 0.736 | 23 |
| Mount Adams Wilderness Area | 0.456 | 7 | 0.472 | 6 | 0.357 | 2 |
| Mount Rainier National Park | 0.843 | 22 | 1.052 | 26 | 0.629 | 15 |
| North Cascades National Park | 1.376 | 65 | 1.395 | 56 | 1.138 | 32 |
| Olympic National Park | 2.363 | 59 | 1.858 | 53 | 2.136 | 45 |
| Pasayten Wilderness Area | 0.866 | 30 | 0.871 | 33 | 0.659 | 13 |

## Tesoro Refining and Marketing

Tesoro Refining and Marketing is primarily a source of $SO_2$ and $NO_x$ from the combustion of fuels in refining the petroleum to final products.

**Table 11-7 Tesoro Refining and Marketing**

| Mandatory Class I Area | Visibility Criterion | Modeled Impact |
|---|---|---|
| Alpine Lakes Wilderness | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.917<br>0.810 |
| Glacier Peak Wilderness | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.908<br>0.847 |
| Goat Rocks Wilderness | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.293<br>0.281 |
| Mt. Adams Wilderness | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.255<br>0.228 |
| Mt. Rainier National Park | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.712<br>0.643 |
| North Cascades National Park | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 1.001<br>0.915 |
| Olympic National Park | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 1.722<br>1.399 |
| Pasayten Wilderness | Max 98% value (8th high)<br>3 years combined 98% value (22nd high) | 0.497<br>0.497 |

**Port Townsend Paper Co**

This is a kraft pulp mill located near Port Townsend on the northeast corner of the Olympic Peninsula.

**Table 11-8 Initial Modeling Results at Port Townsend Paper Co**

| Mandatory Class I Area | Max. 98% value (8th high) for 2003 | Max. 98% value (8th high) for 2004 | Max. 98% value (8th high) for 2005 |
|---|---|---|---|
| Alpine Lakes Wilderness Area | 0.264 | 0.281 | 0.313 |
| Glacier Peak Wilderness Area | 0.226 | 0.238 | 0.258 |
| Goat Rocks Wilderness Area | 0.137 | 0.128 | 0.134 |
| Mount Adams Wilderness Area | 0.128 | 0.124 | 0.105 |
| Mount Rainier National Park | 0.272 | 0.231 | 0.211 |
| North Cascades National Park | 0.196 | 0.248 | 0.236 |
| Olympic National Park | 1.767 | 1.983 | 1.919 |
| Pasayten Wilderness Area | 0.120 | 0.147 | 0.123 |

After initial modeling, Port Townsend Paper Co. re-evaluated the actual emissions used in the model. More accurate emission rates were developed and utilized that better reflected the actual emissions at the plant. The details of this process are contained in the BART analysis submitted by Port Townsend Paper Co. The re-evaluation resulted in some small reduction in the modeled actual emission rates. Only the effects on Olympic National Park were evaluated since this was the only Class I Area that had a modeled visibility impact above the 0.5 dv threshold.

**Table 11-9 Impacts on Olympic National Park Using More Accurate Emission Rates**

| Visibility Criterion | dv Value |
|---|---|
| Max Annual 98% value (8th high) | 1.500 |
| 3 Years Combined 98% value (22nd high) | 1.306 |

Based on the modeling performed, the Port Townsend Paper Co. facility causes visibility impairment in Olympic National Park. Emissions from the plant do not cause or contribute to visibility impairment at any other Class I areas. Analysis of the modeling results indicates that:

- $SO_2$ and $NO_x$ each contribute about 40% of the modeled visibility impact
- $NO_x$ impacts dominate during the winter
- $SO_2$ impacts dominate during the summer

### Lafarge North America

This cement plant is located in Seattle, WA in the central Puget Sound and as a result its emissions affect many Class I Areas. Visibility impairment from Lafarge comes primarily from $NO_x$ and $SO_2$, both of which result from the combustion of fuel to make cement.

**Table 11-10 Lafarge North America 3-Year Visibility Impacts**

| Mandatory Class I Area | Visibility Criterion | Modeled Impact |
|---|---|---|
| Alpine Lakes Wilderness | Max 98% value (Max annual 8th high) | 2.07 |
| | 3-yrs Combined 98% value (22nd high) | 2.06 |
| Glacier Peak Wilderness | Max 98% value (Max annual 8th high) | 1.62 |
| | 3-yrs Combined 98% value (22nd high) | 1.43 |
| Goat Rocks Wilderness | Max 98% value (Max annual 8th high) | 0.92 |
| | 3-yrs Combined 98% value (22nd high) | 0.85 |
| Mt. Adams Wilderness | Max 98% value ((Max annual 8th high) | 0.78 |
| | 3-yrs Combined 98% value (22nd high) | 0.76 |
| Mt. Hood Wilderness | Max 98% value(Max annual 8th high) | 0.65 |
| | 3-yrs Combined 98% value (22nd high) | 0.62 |
| Mt. Rainier National Park | Max 98% value(Max annual 8th high) | 2.04 |
| | 3-yrs Combined 98% value (22nd high) | 1.78 |
| North Cascades National Park | Max 98% value (Max annual 8th high) | 1.48 |
| | 3-yrs Combined 98% value (22nd high) | 1.27 |
| Olympic National Park | Max 98% value (Max annual 8th high) | 3.16 |
| | 3-yrs Combined 98% value (22nd high) | 2.96 |
| Pasayten Wilderness | Max 98% value (Max annual 8th high) | 0.82 |
| | 3-yrs Combined 98% value (22nd high) | 0.72 |

### TransAlta Centralia Generation, LLC

TransAlta Centralia Generation is a coal-fired power plant located east of Centralia, WA. This is the largest source of $NO_x$ in the state. Due to its large quantity of emissions, tall stacks, and location, its $NO_x$ emissions affect all Class I Areas within 300 km of the plant.

**Table 11-11 TransAlta Centralia Generation, LLC**

| Mandatory Class I Area | Visibility Criterion | Modeled Impact of Control Scenario 2: Flex Fuel |
|---|---|---|
| Alpine Lakes Wilderness | Max 98% value (Max annual 8th high) | 3.564 |
| | 3-yrs Combined 98% value (22nd high) | 2.994 |
| Glacier Peak Wilderness | Max 98% value (Max annual 8th high) | 2.403 |
| | 3-yrs Combined 98% value (22nd high) | 1.905 |
| Goat Rocks Wilderness | Max 98% value (Max annual 8th high) | 3.676 |
| | 3-yrs Combined 98% value (22nd high) | 3.108 |
| Mt. Adams Wilderness | Max 98% value (Max annual 8th high) | 2.646 |
| | 3-yrs Combined 98% value (22nd high) | 2.591 |
| Mt. Hood Wilderness | Max 98% value (Max annual 8th high) | 2.346 |
| | 3-yrs Combined 98% value (22nd high) | 1.997 |
| Mt. Jefferson Wilderness | Max 98% value (Max annual 8th high) | 1.399 |
| | 3-yrs Combined 98% value (22nd high) | 1.267 |
| Mt. Rainier National Park | Max 98% value (Max annual 8th high) | 4.318 |
| | 3-yrs Combined 98% value (22nd high) | 4.225 |
| Mt. Washington Wilderness | Max 98% value (Max annual 8th high) | 1.323 |
| | 3-yrs Combined 98% value (22nd high) | 0.872 |
| North Cascades National Park | Max 98% value (Max annual 8th high) | 1.852 |
| | 3-yrs Combined 98% value (22nd high) | 1.486 |
| Olympic National Park | Max 98% value (Max annual 8th high) | 3.192 |
| | 3-yrs Combined 98% value (22nd high) | 2.991 |
| Pasayten Wilderness | Max 98% value (Max annual 8th high) | 1.287 |
| | 3-yrs Combined 98% value (22nd high) | 0.999 |
| Three Sisters Wilderness | Max 98% value (Max annual 8th high) | 1.333 |
| | 3-yrs Combined 98% value (22nd high) | 0.993 |

## Weyerhaeuser Co-Longview

This source is an integrated pulp mill producing kraft, thermomechanical, and recycled pulp and paper. The primary BART-eligible emission units at this facility are combustion sources, mostly sources of $NO_x$ and to a lesser extent $SO_2$.

**Table 11-12 Weyerhaeuser Co - Longview**

| Mandatory Class I Area | Max. 98% value ($8^{th}$ high) for 2003 | Max. 98% value ($8^{th}$ high) for 2004 | Max. 98% value ($8^{th}$ high) for 2005 | 3-years combined 98% value ($22^{nd}$ high) |
|---|---|---|---|---|
| North Cascades National Park | 0.127 | 0.223 | 0.227 | 0.218 |
| Glacier Peak Wilderness Area | 0.214 | 0.287 | 0.206 | 0.248 |
| Olympic National Park | 0.470 | 0.654 | 0.638 | 0.583 |
| Alpine Lakes Wilderness Area | 0.274 | 0.513 | 0.398 | 0.400 |
| Mount Rainier National Park | 0.540 | 0.973 | 0.572 | 0.595 |
| Goat Rocks Wilderness Area | 0.384 | 0.535 | 0.457 | 0.457 |
| Mount Adams Wilderness Area | 0.433 | 0.440 | 0.436 | 0.440 |
| Mount Hood Wilderness Area | 0.725 | 0.677 | 0.628 | 0.689 |
| Mount Jefferson Wilderness Area | 0.440 | 0.375 | 0.287 | 0.367 |
| Mount Washington Wilderness Area | 0.303 | 0.345 | 0.229 | 0.289 |
| Three Sisters Wilderness Area | 0.340 | 0.361 | 0.257 | 0.291 |
| Diamond Peak Wilderness Area | 0.203 | 0.224 | 0.148 | 0.192 |

## 11.5 Summary of Best Available Retrofit Technology Engineering Analysis

A full BART engineering analysis was completed by each company for each facility determined to be subject to BART. The companies utilized the criteria in the EPA BART Guidance in 40 Code of Federal Regulations (CFR) Part 51, Appendix Y which Ecology provided to the companies with annotations. The annotations were included to assist the companies with providing the correct information to Ecology. The annotated version is included in Appendix J. The companies used this information and proposed their determination of appropriate BART controls for each BART-eligible emission unit at their facilities.

Ecology evaluated the company produced analyses and proposed BART controls for each emission unit. Emission limitations for BART were established by Ecology on a case-by-case basis taking into consideration all 6 factors specified in 40 CFR 51.308(e)(1)(11)(A):

1. The technology available,
2. The costs of compliance,
3. The energy and non-air quality environmental impacts of compliance,
4. Any pollution control equipment in use or in existence at the source or unit,
5. The remaining useful life of the unit, and
6. The degree of improvement in visibility which may reasonably be anticipated to result from the use of control technology.

Each of the draft BART determinations was subject to a public comment period and hearing. A copy of the public notices, comments received, and Ecology's response to those comments is included in Appendix L. Copies of the final BART determination technical support documents and compliance orders issued to each company are included in Appendix L.

The designated BART controls, associated emission limits and compliance deadlines are enforceable regulatory orders issued under Washington law. The requirements of these orders will be incorporated into their respective Air Operating Permits (AOP) as required by the state AOP regulation. These emissions reductions cannot be used as credits in the determination of net emission increase in determining the applicability of Prevention of Significant Deterioration.

All plants required to reduce emissions will have installed BART controls by the end of 2015 under terms of their regulatory orders. The end of 2015 is assumed to be the 5 years after the RH SIP is approved.

### 11.5.1 Intalco, BP Cherry Point Refinery, Port Townsend Paper Co, and Weyerhaeuser Co-Longview

For Intalco, BP Cherry Point Refinery, Port Townsend Paper Co, and Weyerhaeuser Co-Longview the control measures identified by Ecology as appropriate BART controls are either already installed and in operation on the emission units subject to BART or will be installed and operating by the end of 2015. For control equipment currently installed, much of the equipment was recently installed to account for requirements of:

- New source review Best Available Control Technology (BACT),
- Recently issued federal Maximum Achievable Control Technology (MACT), or
- Recent federal Consent Decree requirements.

## 11.5.2 Tesoro Marketing and Refining

Tesoro Marketing and Refining (Tesoro) is a petroleum refinery with many process heaters fueled by refinery fuel gas and in a few cases also with fuel oil. Tesoro identified three heaters or groups of heaters for which replacement of the original conventional design burners with new low or ultra low $NO_x$ burners was both technically and economically feasible. One heater, which is subject to BART, will have controls installed by 2015. The BART required heater burner replacement will reduce plant $NO_x$ emissions by 62 tons per year.

Due to the time needed for the design approval process and the major maintenance cycle at the refinery, the installation of $NO_x$ controls on other emissions units was determined to not to meet BART requirements. This determination is detailed in the Technical Support Document for the TESORO BART Determination in Appendix L.

In addition to the installation of ultra low $NO_x$ burners, one unit with the capability to burn fuel oil is taking a limitation on the usage of fuel oil in that heater to reduce the emissions of $NO_x$, $SO_2$ and particulate matter. Additional information is available in the BART determination.

Other recent emission reduction projects at the plant are being recognized as part of BART. The primary projects are the installation of a wet gas scrubber on the carbon monoxide boilers/catalyst regenerator system and improvements to the efficiency of the refinery fuel gas system to remove sulfur from the fuel gas. The installation of the wet scrubber system on the Fluid Catalytic Cracking Unit (FCCU) Catalyst Regenerator/Carbon Monoxide (CO) Boiler system reduced particulate emissions from this system to the rate required by the MACT, and $SO_2$ emissions by 90% (to a 25 ppm annual average).

The $SO_2$ reduction at this unit reduced plant wide emissions by at least 30%. A new refinery gas hydrogen sulfide ($H_2S$) content limitation reduced the allowable $H_2S$ content to 1,000 ppm (365-day rolling average) from the previous 10,000 ppm (hourly average) level, and required installation of a continuous refinery gas hydrogen sulfide emission monitoring system. The refinery gas system modifications reduced the typical actual daily average $H_2S$ content of the refinery gas to 70 – 100 ppm from over 2,000 ppm previously. The emission reductions resulting from the wet gas scrubber were included the baseline emissions modeled by the facility. Since during the baseline period, Tesoro could legally emit $SO_2$ from refinery gas containing 10,000 ppm $H_2S$, all modeling was performed at this maximum day level.

**Table 11-13 Tesoro Emission Rates Pre - and Post - Best Available Retrofit Technology**

| | | | COMMENTS | |
|---|---|---|---|---|
| | **Pre-BART, tpy** | **Post-BART, tpy** | **Basis of comparison** | **Sources included in comparison** |
| $NO_X$ | 1360 | 1303 | 2005 vs. post-BART projects (F-103 ULNB) | BART sources only |
| $SO_2$ | 5540 | 474 | 2005 vs. 2008 (FGS; RFG treatment*) | All refinery sources |
| PM/PM10 | 588 | 140 | 2005 vs. post BART projects (FGS); no oil burning at F-103) | BART sources plus F-302 |

*** Refinery Fuel Gas (RFG) treatment improvements affected all combustion sources**

## 11.5.3 Lafarge North America

Lafarge North America (Lafarge) operates a wet process cement kiln in the Duwamish industrial area of Seattle. The primary polluting equipment at the plant is the cement kiln and its associated clinker cooler baghouses. There are numerous material handling baghouses at the plant that are part of the BART-eligible facility.

The existing particulate controls installed at the plant are determined to be BART. These controls meet the regulatory requirements for dry materials handling issued by the local air agency which is more stringent than state rule. Most units are limited to 0.05 grain/dscf, while a few are limited to 0.10 grain/dscf. The wet process cement kiln is fired by a number of materials including petroleum coke, coal, natural gas, tire derived fuel, waste oil, and tank bottom oil.

Sulfur dioxide comes from the burning of sulfur containing fuels such as coal and heavy fuel oil. The alkaline cement clinker tends to remove $SO_2$ from the combustion gases and has been a primary method of control for a number of years. As BART for $SO_2$, Lafarge proposed, and Ecology accepted, to install a dry sorbent injection system using lime to reduce $SO_2$ emissions. This system will produce calcium sulfate as a byproduct. Calcium sulfate is currently purchased for use in producing the final cement product.

Nitrogen oxides come from the burning of fuel. A number of methods for reducing $NO_x$ from this plant were investigated. Lafarge proposed, and Ecology agreed, that the installation of selective noncatalytic reduction using urea or ammonia injected at approximately the midpoint of the kiln constitutes BART. Ecology also determined that based on the available information, that if the company chose and were able to meet other emission limitation requirements, that mid-kiln firing of whole tires could also meet the $NO_x$ emission limitation.

In Spring 2010 the EPA issued a consent decree in federal court to Lafarge North America. The consent decree required emissions reductions for the Lafarge North America facilities across the nation. The requirements of the consent decree that are applicable to the Seattle facility are reflected in the emission controls and BART requirements for the facility.

**Table 11-14 Lafarge Best Available Retrofit Technology Emission Limits and Reductions Due to Best Available Retrofit Technology**

| | Pre-BART, tpy | Post-BART, maximum day rate, tpy |
|---|---|---|
| NOx | 2172.5 | 1303.5 |
| $SO_2$ | 570 | 427.5 |
| PM/PM10 | 253 | 253 |

## 11.5.4 TransAlta Centralia Generation, LLC

TransAlta Centralia Generation, LLC (TransAlta-Centralia) operates a two unit, pulverized coal fired power plant near Centralia, Washington. Each unit of the plant is rated at 702.5 MW net output. Operation of a coal fired power plant results in the visibility impairing emissions of PM, $SO_2$ and $NO_x$.

As part of the approval of the Washington State Visibility SIP in 2002, EPA Region 10 determined that particulate and $SO_2$ controls installed as part of a 1997 Reasonably Available Control Technology (RACT) determination issued by the state's local air agency met the requirements for BART and constituted BART for those pollutants. EPA specifically did not adopt the $NO_x$ controls in the RACT order as BART.

Ecology determined that BART for $NO_x$ emissions is the current combustion controls combined with the completion of the Flex Fuels project and the use of a sub-bituminous coal from the Powder River Basin (PRB) or other coal that will achieve similar emission rates. This change results in a 20% reduction of $NO_x$ emissions from the baseline period emission rate to a new emission limitation of 0.24 lb/MMBtu on a 30 day average. The use of low sulfur PRB or similar coal also reduces $SO_2$ emission by about 60% from the same period. The controls have been installed and have met the emission limitation since October 1, 2009. The $SO_2$ reduction that comes from the requirement to use PRB or similar coal goes beyond EPA's 2002 $SO_2$ BART determination. This reduction provides reasonable progress.

**Table 11-15 TransAlta-Centralia Best Available Retrofit Technology Emission Limits and Reductions Due to Best Available Retrofit Technology**

| | Pre-BART, 0.30 lb/MMBtu, tpy* | Post-BART, 0.24 lb/MMBtu, tpy* |
|---|---|---|
| NOx | 18555 | 14844 |

*Tons per year emissions based on an 85% capacity factor

## 11.6 Visibility Improvement Due to Best Available Retrofit Technology Implementation

Since visibility improvement resulting from BART occurs in different Class I Areas, or parts of Class I Areas, on difference days it is not possible to "add up" the modeled improvement expected by each facility. Consistent with the BART modeling protocol, Ecology evaluated the visibility improvement on the 22$^{nd}$ highest day over the three year period that was modeled and the reduction in the number of days above the 0.5 dv threshold over the 3 year period modeled. Table 11-16 shows the reduction in deciview impact on the 22$^{nd}$ highest day over the three year period at all mandatory Class I areas within 300 km of each plant. Table 11-17 then shows the reduction in number of days in the 3 year period above 0.5 dv at each of the mandatory Class I Areas.

Modeling does show that there will be visibility improvement at all Class I Areas within 300 km of each source because of the required BART emission controls. Modeling also shows that BART will improve visibility in all mandatory Class I Areas in Washington and many in Oregon that are more than 300 km away. The projected visibility improvements are shown in Table 11-17.

**Table 11-16 Projected Visibility Improvement on the 22nd Highest Day over the 3 Year Modeling Period Due to Implementing Best Available Retrofit Technology**

| Mandatory Class I Area | Intalco | BP Cherry Point Refinery | Tesoro Refining and Marketing | Lafarge North America | Port Townsend Paper Co | TransAlta Centralia | Weyerhaeuser Longview |
|---|---|---|---|---|---|---|---|
| North Cascades NP | 0 | 0 | 0.173 | 0.468 | 0 | 0.726 | 0 |
| Pasayten Wilderness | 0 | 0 | 0.112 | 0.261 | 0 | 0.483 | - |
| Glacier Peak Wilderness | 0 | 0 | 0.172 | 0.527 | 0 | 0.717 | 0 |
| Olympic National Park | 0 | 0 | 0.374 | 1.022 | 0 | 1.033 | 0 |
| Alpine Lakes Wilderness | 0 | 0 | 0.170 | 0.745 | 0 | 1.352 | 0 |
| Mt. Rainier NP | 0 | 0 | 0.101 | 0.645 | 0 | 1.264 | 0 |
| Goat Rocks Wilderness | 0 | 0 | 0.047 | 0.318 | 0 | 1.106 | 0 |
| Mt Adams Wilderness | 0 | 0 | 0.043 | 0.282 | 0 | 1.037 | 0 |
| Mt Hood Wilderness | - | 0 | - | 0.236 | - | 0.833 | 0 |
| Mt Jefferson Wilderness | - | - | - | - | - | 0.621 | 0 |
| Mt Washington Wilderness | - | - | - | - | - | 0.542 | 0 |
| Three Sisters Wilderness | - | - | - | - | - | 0.545 | 0 |
| Diamond Peak Wilderness | - | - | - | - | - | - | 0 |

" - " means that the area was more than 300 km from the source

**Table 11-17 Reduction in Number of Days above 0.5 dv over 3 year Modeling Period Due to Implementing Best Available Retrofit Technology**

| Mandatory Class I Area | Intalco Aluminum | BP Cherry Point Refinery | Tesoro Refining and Marketing | Lafarge North America | Port Townsend Paper | TransAlta Centralia | Weyerhaeuser Longview |
|---|---|---|---|---|---|---|---|
| North Cascades NP | 0 | 0 | 42 | 97 | 0 | 69 | 0 |
| Pasayten Wilderness | 0 | 0 | 12 | 46 | 0 | 59 | - |
| Glacier Peak Wilderness | 0 | 0 | 34 | 112 | 0 | 73 | 0 |
| Olympic National Park | 0 | 0 | 30 | 81 | 0 | 38 | 0 |
| Alpine Lakes Wilderness | 0 | 0 | 35 | 73 | 0 | 71 | 0 |
| Mt. Rainier NP | 0 | 0 | 13 | 69 | 0 | 43 | 0 |
| Goat Rocks Wilderness | 0 | 0 | 2 | 38 | 0 | 60 | 0 |
| Mt Adams Wilderness | 0 | 0 | 2 | 37 | 0 | 58 | 0 |
| Mt Hood Wilderness | - | 0 | - | 22 | - | 48 | 0 |
| Mt Jefferson Wilderness | - | - | - | - | - | 41 | 0 |
| Mt Washington Wilderness | - | - | - | - | - | 38 | 0 |
| Three Sisters Wilderness | - | - | - | - | - | 37 | 0 |
| Diamond Peak Wilderness | - | - | - | - | - | - | 0 |

"-" means that the area was more than 300 km from the source

# Chapter 12 Continuing Planning Process for Regional Haze

The Regional Haze Rule (RHR) requires each state to prepare a long-term monitoring strategy and commit to the periodic collection, reporting, and analysis of monitoring and emissions inventory data. The RHR also includes other requirements regarding periodic progress reports, State Implementation Plan (SIP) revisions, and continuing consultation. This chapter addresses these future planning requirements:

- Submitting with the SIP a monitoring strategy
- Including a commitment to update the statewide emissions inventory of visibility impairing pollutants
- Submitting periodic reports evaluating progress towards the Reasonable Progress Goals (RPG)
- Determining the adequacy of the existing SIP
- Revising the SIP in 2018 and every ten years thereafter
- Continuing interstate coordination and consultation
- Continuing consultation with the Federal Land Managers (FLMs)

## 12.1 Monitoring Strategy

Washington State will rely upon the continued existence of Western Regional Air Partnership (WRAP) and upon WRAP's provision of adequate technical support to meet its commitment to conduct the analyses necessary to meet the requirements of[1].

Washington State will depend on the Inter-Agency Monitoring of Protected Visual Environments (IMPROVE) monitoring program to collect and report aerosol monitoring data for long-term reasonable progress tracking as specified in the RHR. Because the RHR is a long-term tracking program with an implementation period nominally set for 60 years, the state expects that the IMPROVE program will provide data based on the following goals:

1) Maintain a stable configuration of the individual monitors and sampling sites, and stability in network
2) operations for the purpose of continuity in tracking reasonable progress trends
3) Assure sufficient data capture at each site of all visibility-impairing species
4) Comply with Environmental Protection Agency's (EPA) quality control and assurance requirements
5) Prepare and disseminate periodic reports on IMPROVE program operations

Washington State is relying on the IMPROVE program to meet these monitoring operation and data collection goals, with the fundamental assumption that network data collection operations will not change, or if changed, will remain directly comparable to those operated by the IMPROVE program during the 2000-04 RHR baseline period. Technical analyses and RPG in

[1] 40 CFR 51.308(d)(4)

this implementation plan for Regional Haze (RH) are based on data from these sites. As such, the state asks that the IMPROVE program identify potential issues affecting RHR implementation trends and/or notify the state before changes in the IMPROVE program affecting a RHR tracking site are made.

Further, Washington State notes that the human resources to operate these monitors are provided by FLM agencies. Beyond that in-kind contribution, resources for operation and sample analysis of a complete and representative monitoring network of these long-term reasonable progress tracking sites by the IMPROVE program in the WRAP region are a collaborative responsibility of members of the WRAP (EPA, states, tribes, and FLMs) and the IMPROVE program steering committee. Washington State will collaborate with the EPA, FLMs, other states, tribes, and the IMPROVE committee to assure adequate and representative data collection and reporting by the IMPROVE program.

Washington State depends on the following IMPROVE program-operated monitors at the following sites for tracking RHR reasonable progress:

| | |
|---|---|
| IMPROVE Monitoring Sites | OLYM1, NOCA1, SNPA1, MORA1, WHPA1, PASA1 |
| Mandatory Class I Areas | Class I Area - Olympic NP, WA; Class I Areas – North Cascades NP, WA: Glacier Peak W, WA; Class I Area – Alpine Lakes W, WA; Class I Area – Mount Rainier NP, WA; Class I Areas – Goat Rocks W, WA: Mount Adams W, WA; Class I Area – Pasayten W, WA |

Washington State will use data reported by the IMPROVE program as part of the regional technical support analysis tools found at the Visibility Information Exchange Web System (VIEWS) and the Technical Support System (TSS), as well as other analysis tools and efforts sponsored by the WRAP. Washington State will participate in the ongoing regional analysis activities of the WRAP to collectively assess and verify the progress toward RPG, also supporting interstate consultation as the RHR is implemented, and collaborate with WRAP members (EPA, states, tribes, and FLMs) to ensure the continued operation of these technical support analysis tools and systems.

Washington State may conduct additional analyses as needed.

Washington State will depend on the routine timely reporting of haze monitoring data by the IMPROVE program for the reasonable progress tracking sites to the EPA air quality data system, VIEWS, and TSS. Washington State will collaborate with WRAP members (EPA, states, tribes, and FLMs) to ensure the continued operation of these technical support analysis tools and systems.

Washington State will track data related to RHR haze plan implementation for sources for which the state has regulatory authority, and will depend on the IMPROVE program and WRAP sponsored collection and analysis efforts and data support systems for monitoring and emissions inventory data, respectively. To ensure the availability of data and analyses to report on visibility conditions and progress toward Class I Area visibility goals, Washington State will collaborate with WRAP members (EPA, states, tribes, and FLMs) to ensure the continued operation of the IMPROVE program and the WRAP sponsored technical support analysis tools and systems.

## 12.2 Statewide Emissions Inventory Updates

Washington State has prepared a statewide inventory of emissions that can reasonably be expected to cause or contribute to visibility impairment in Class I Areas. Chapter 5 of this plan summarizes the emissions by pollutant and source category.

Washington State commits to updating statewide emissions periodically. The updates will be used for states tracking of emission changes, trends, and input into WRAP's evaluation of whether reasonable progress goals are being achieved and other regional analyses. The inventories will be updated every three years on the same schedule as the every three-year reporting required by EPA's Consolidated Emissions Reporting Rule.

As a member of the WRAP, the state will continue to use the WRAP sponsored Emissions Data Management System and Fire Emissions Tracking System to store and access emission inventory data for the region. Washington State will also depend upon and participate in additional periodic collective emissions inventory efforts by the WRAP. Further, Washington State will continue to depend on and use the capabilities of the WRAP's regional modeling to simulate the air quality impacts of emissions for haze and other related air quality planning purposes. Washington State will collaborate with WRAP members (EPA, states, tribes, and FLMs) to ensure the continued operation of these technical support analysis tools and systems.

## 12.3 Periodic Reports

The RHR requires states to submit a progress report to EPA every five years evaluating progress towards the reasonable progress goals. The first progress report is due five years from the submittal of the initial implementation plan and must be in the form of an implementation plan revision that complies with EPA's public hearing and plan submittal requirements[2]. At a minimum, the progress reports must contain the elements in paragraphs[3] for each mandatory Class I Area, as summarized below:

1. Implementation status of the current SIP measures for achieving RPGs
2. Summary of emissions reductions achieved
3. Assessment of visibility conditions and changes for the most and least impaired days
4. Analysis of emission reductions of pollutants contributing to visibility impairment from all sources within the state based on the most recent updated emissions inventory, with estimates projected forward to account for emission changes during the applicable five year period

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[2] 40 CFR 51.102-103
[3] 40 CFR 51.308(g)(1-7)

5. Assessment of significant changes in anthropogenic emissions that have occurred during the five year period that have limited or impeded progress in reducing pollutant emissions and improving visibility
6. Assessment of the current SIP sufficiency to meet RPGs
7. Review of the State's visibility monitoring strategy and any modifications to the strategy as necessary.

In accordance with the requirements listed in section[4] of the RHR, Washington commits to submitting a report on reasonable progress to EPA every five years following the initial submittal of the SIP. The reasonable progress report will evaluate progress made towards the RPGs for each mandatory Class I Area located in Washington State and located outside Washington which may be significantly affected by emissions from Washington. Washington State's review will address each of the required elements listed above. The state will also evaluate the monitoring strategy adequacy in assessing RPGs.

## 12.4 Determination of State Implementation Plan Adequacy

The RHR[5] requires a state to make a determination of the adequacy of the current implementation plan as part of its five year progress report. Based on the findings of the five year progress report, the state must take one or more of the actions summarized below at the same time the state submits its five year progress report:

1. If the state finds that no substantive SIP revisions are required to meet established visibility goals, the state shall provide a negative declaration that no implementation plan revision is needed.
2. If the state finds that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another state that participated in a regional planning process, the state shall notify EPA and the other contributing state(s). The plan deficiency shall be addressed through the regional planning process to develop additional strategies through the planning efforts described in the progress report(s).
3. If the state finds that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from another country, the state shall notify EPA and provide the available supporting information.
4. If the state finds that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from within the state, the state shall revise its implementation plan to address the plan's deficiencies within one year.

Washington commits, in accordance with[6], to make an adequacy determination of the current SIP at the same time its five year progress report is due and to comply with the requirements of[7]. If Washington determines that the current implementation plan is or may be inadequate due to emissions from within the state itself, Washington will develop additional strategies to address the plan deficiencies and revise the SIP within one year from the date that the progress report is

[4] 40 CFR 51.308(g)
[5] 40 CFR 51.308(h)
[6] 40 CFR 51.308(h)
[7] 40 CFR 51.308(g)

due. If Washington determines that the plan is or may be inadequate due to emissions from other state(s), Washington will collaborate with the other state(s) through the regional planning process for the purpose of developing additional strategies to address the plan's deficiencies. If Washington determines that the current implementation plan is or may be inadequate due to emissions from sources in another country, Washington shall notify EPA and provide the available information.

## 12.5 State Implementation Plan Revisions in 2018 and Later

In addition to a SIP revision made for plan inadequacy[8], requires a state to revise and submit a comprehensive RH implementation plan revision to EPA by July 31, 2018 and every ten years thereafter. Future SIP revisions must evaluate and reassess all of the elements required under[9] and specifically address the items listed in[10]. The plan revision must take into account improvements in monitoring data collection and analysis, control technologies and other relevant factors. Washington's commitments to comply with RHR requirements for future plans follow.

By July 31, 2018 and every 10 years thereafter, Washington commits to completing and submitting a comprehensive RH SIP revision to EPA, evaluating and reassessing all of the elements required under[11]. In evaluating and reassessing these elements, Washington commits to:

1. Determining current visibility (most recent five year period preceding the required date of the SIP submittal for which data is available) conditions for the most impaired and least impaired days and determine the actual progress made towards natural conditions.
2. Determining the effectiveness of the long-term strategy for achieving the RPG for the prior SIP period as well as include enforceable emission limitations and compliance schedules.
3. Affirming or revising the current RPGs based on assessment of new or updated information, improved technologies and on-going legislation. If the RPG is found to be insufficient to attain natural conditions by 2064, Washington will look at additional or new control measures that could be adopted to achieve the degree of visibility improvement projected by the analysis contained in the first SIP.

## 12.6 Continuing Interstate Coordination and Consultation

In accordance with[12], Washington commits to continue consultation with other states which may reasonably be anticipated to cause or contribute to visibility impairment in Washington's mandatory Class I Areas. Washington will also continue consultation with any state for which Washington's emissions may reasonably be anticipated to cause or contribute to visibility impairment in those states' mandatory Class I Areas.

[8] 40 CFR 51.308(f)
[9] 40 CFR 51.308(d)
[10] 40 CFR 51.308(f)(1-3)
[11] 40 CFR 51.308(d)
[12] 40 CFR 51.308(d)(3)(i)

With regard to the established or updated goal for reasonable progress, should disagreement arise between another state or group of states and Washington, Washington will describe the actions taken to resolve the disagreement in its RH SIP submittal for EPA's consideration. With regard to assessing or updating long-term strategies, Washington commits to coordinate its emission management strategies with affected states and will continue to include in its future RH SIP revisions all measures necessary to obtain its share of emissions reductions for meeting other states' RPGs.

Washington commits to continued participation in the WRAP, to the extent appropriate, and to coordinating future plan revisions with other WRAP member states in addressing RH. This involvement in the WRAP will contribute significantly to Washington's inter-state and FLM coordination for future SIP revisions and progress reports.

## 12.7 Continuing Consultation with the Federal Land Managers

Section 51.308(i)(2) of the RHR requires that the state provide FLMs the opportunity for consultation in person and at least 60 days prior to holding any public hearing on plan revisions.

Washington commits to continuing to provide FLMs the opportunity for consultation in person and at least 60 days prior to holding any public hearing on plan revisions in accordance with[13].

Section 51.308(i)(4) requires procedures for continuing consultation between the State and FLMs on the implementation of the visibility protection program including development and review of implementation plan revisions and five year progress reports and on the implementation of other programs having the potential to contribute to impairment of visibility in mandatory Class I Areas. Washington will consult with the FLMs as required by Section[14]. At a minimum, Washington will meet with the FLMs on an annual basis through the WRAP, as long as the WRAP continues to provide this forum. All SIP revisions will include a description of how the state consulted with and addressed any comments provided by the FLMs.

The consultation will be coordinated with the designated visibility protection program coordinators for the National Park Service and the U.S. Forest Service.

## 12.8 Tribal Consultation

Washington will continue to remain in contact, via the WRAP, with the National Tribal Environmental Council to keep track of possible impacts from tribes and to provide the opportunity for consultation regarding any tribal Class I Areas that Washington's emissions may impact.

[13] 40 CFR 51.308(i)(2)
[14] 40 CFR 51.308(i)(4)

# Chapter 13 Summary

## 13.1 National Visibility Goal

In 1977, Congress amended the Clean Air Act (CAA) and declared a national visibility goal:

> *"The prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution."* (CAA § 169A).

Since then, EPA promulgated regulations to address both Reasonably Attributable Visibility Impairment (RAVI) and Regional Haze (RH). RAVI is visibility impairment directly attributable to emissions from a large stationary source. Visibility impairment due to RH is caused by emissions from numerous sources that are often mixed and transported long distances.

The objectives of the Regional Haze Rule (RHR) are to improve existing visibility in all 156 mandatory Class I Areas, prevent future impairment of visibility by human-caused sources, and meet the national goal of natural visibility conditions by 2064.

## 13.2 Washington's Foundational State Implementation Plan

The RHR breaks the RH Program into several planning phases extending from 2005 to 2064. This first RH State Implementation Plan (SIP) covers the initial (or foundational) planning period that extends from 2005 to 2018. The foundational SIP provides the basis for future RH SIPs to continue reducing visibility impairing emissions and meet the national visibility goal over several planning periods.

This foundational RH SIP sets Reasonable Progress Goals (RPGs) for each of the eight mandatory Class I Areas in Washington. The RPGs reflect already adopted controls and Best Available Retrofit Technology (BART) controls for older industrial facilities that cause or contribute to visibility impairment. These industrial facilities that began operation before federal Prevention of Significant Deterioration (PSD) rules were adopted to protect visibility in Class I Areas. The RPGs reflect CAA requirements and methodology developed by the Western Regional Air Partnership (WRAP).

Washington developed a Long-Term Strategy (LTS) that addresses RAVI and RH. The LTS applies to mandatory Class I Areas both within the state and outside the state where emissions from the state are reasonably anticipated to contribute to visibility impairment. The coordinated strategy is designed to achieve the RPGs established by this foundational RH SIP for mandatory Class I Areas inside Washington and the RPGs established by other states for mandatory Class I Areas outside of Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment. The first planning period, 2005-2018, focuses on implementing BART controls and developing controls for one or more point source categories of visibility-impairing pollutants.

## 13.3 Long-Term Challenges and Issues

Under the RHR, the state of Washington is responsible for doing its share of reducing visibility–impairing pollutants to achieve the national goal for mandatory Class I Areas within Washington and mandatory Class I Areas outside Washington. While technical development of this foundational RH SIP through the WRAP has provided a framework for understanding and dealing with the source regions and sources of visibility impairment, it has also revealed significant challenges to long-term reasonable progress and raised technical and regulatory issues.

Significant challenges to meeting the national visibility goal in Washington's mandatory Class I Areas:

- Visibility is significantly impacted by emissions from outside the modeling domain, Pacific offshore, and Canada, all of which are beyond the state's control.
- It does not appear possible for Pasayten Wilderness, North Cascades National Park, and Glacier Peak Wilderness to achieve natural conditions unless the contribution of organic mass carbon from natural fire to visibility impairment can be greatly reduced.

Meeting the national goal also requires addressing technical and regulatory issues including:

- Better understanding of the role of biogenic organic aerosols in visibility impairment and analytical technical tools
- Better ammonia emission inventories and better understanding of the chemistry of the formation of ammonium sulfate and ammonium nitrate
- Reconsideration of natural conditions especially in light of the expectation that fire will be more widespread in the future
- Continued development of federal rules reducing visibility-impairing pollutants
- Continued development of controls for on-road and off-road mobile sources

Meeting the challenges and dealing with the issues will ultimately enable Washington to achieve natural conditions within the state and contribute toward meeting natural conditions in Class I Areas outside the state.

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