State Implementation Plan Revision:

Second Regional Haze Plan (2018 – 2028)

By

Air Quality Program

Washington State Department of Ecology
Olympia, Washington

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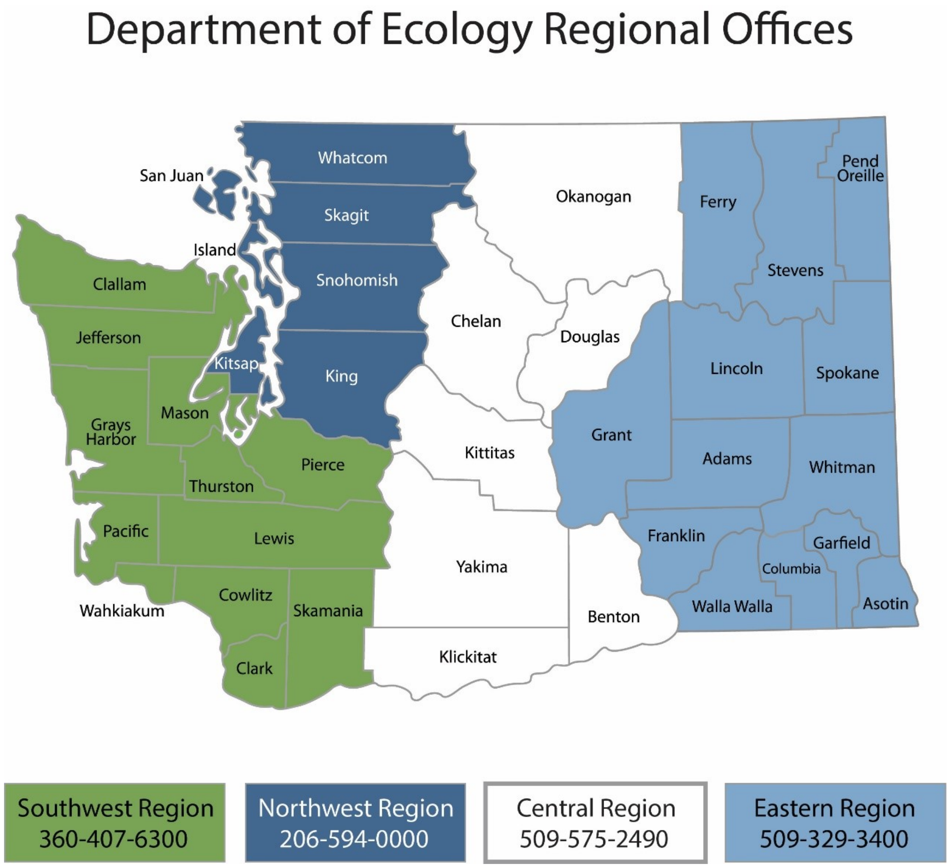

Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	P.O. Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	15700 Dayton Avenue N. Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 West Alder Street Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 North Monroe Spokane, WA 99205	509-329-3400
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DEPARTMENT OF
ECOLOGY
State of Washington

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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
Btu	British thermal unit
CAA	Clean Air Act
CAMx	Comprehensive Air Quality Model with Extensions
CD	Clearest days
CFR	Code of Federal Regulations
CIRA	Cooperative Institute for Research in the Atmosphere
CISWI	Commercial and Industrial Solid Waste Incineration Units
CM	Coarse Matter
CMAQ	Community Multi-Scale Air Quality Model
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DNR	Washington Department of Natural Resources
dv	Deciview; a measure of light extinction
EC	Elemental Carbon
Ecology	Washington State Department of Ecology
EGU	Electric Generating Unit
EI	Emission Inventory
EPA	US Environmental Protection Agency
FCCU	Fluid Catalytic Cracking Unit
FIP	Federal Implementation Plan
FLM	Federal Land Manager
GCVTC	Grand Canyon Visibility Transport Commission
GHG	Greenhouse Gas
Glidepath	The rate of improvement sufficient to attain natural conditions by 2064
HI	Haze Index
IMPROVE	Interagency Monitoring of Protected Visual Environments
LTS	Long Term Strategy
MARPOL VI	Maritime Pollution Annex VI
MID	Most Impaired Days
Mm^{-1}	Inverse megameter; a measure of light extinction
MM	Million
MM5	Meteorological Mesoscale 5
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 NH4NO3
NOx	Nitrogen Oxides

NPCA	National Parks Conservation Association
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NSPS	New Source Performance Standards
NSR	New Source Review
NTEC	National Tribal Environmental Council
NWPPA	Northwest Pulp and Paper Association
O_3	Ozone
OC	Organic Carbon
ODEQ	Oregon Department of Environmental Quality
OM	Organic Mass
OMC	Organic Mass of Carbon
PM	Particulate Matter
$PM_{2.5}$	Fine Particles or Particulate Matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	Coarse Particles or Particulate Matter with an aerodynamic diameter of 10 microns or less
POA	Primary Organic Aerosol
ppm	parts per million
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
RACT	Reasonably Available Control Technology
RAVI	Reasonably Attributable Visibility Impairment
RH	Regional Haze
RHR	Regional Haze Rule
RPG	Reasonable Progress Goal
RPO	Regional Planning Organization
RRF	Relative Response Factors
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SMP	Smoke Management Plan
SOIL	Fine Soil
SO_2	Sulfur Dioxide
SO_4	Ammonium Sulfate or $(NH_4)_2SO_4$
SOx	Sulfur Oxides
TIP	Tribal Implementation Plan
TSS2	Technical Support System
URP	Uniform Rate of Progress
USDA FS	U.S. Department of Agriculture – Forest Service
USDI FWS	U.S Department of the Interior – Fish and Wildlife Service
USDI NPS	U.S. Department of the Interior – National Park Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

WEP	Weighted Emissions Potential
WESTAR	Western States Air Resources Council
WRAP	Western Regional Air Partnership

Executive Summary

This report is Washington's second Regional Haze State Implementation Plan covering 2018 through 2028 and the progress report for 2014 through 2018. The Regional Haze Rule requires Washington to meet natural visibility conditions (no human-caused haze) in our eight mandatory Class 1 federal areas by 2064.

The plan must:

- Establish goals to improve visibility in Washington's three national parks and five wilderness areas (mandatory Class 1 federal areas).
- Develop long-term strategies to reduce air pollution that causes poor visibility:
  - Improve visibility on the 20 percent most polluted days;
  - Protect current visibility on the 20 percent clearest days;
  - Identify and reduce Washington's air impacts to mandatory Class 1 federal areas outside Washington.

Ecology identified that:

- Two mandatory Class 1 federal areas (Goat Rocks Wilderness and Mount Adams Wilderness) are forecast to meet natural conditions (EPA's visibility goals) by 2028.
- Emissions from transportation are the largest source of air pollution that causes poor visibility. We have started rulemaking to reduce transportation emissions:
  - Chapter 173-423 WAC, Clean Vehicles Program, which adopts California's more protective vehicle emission standards;
  - Chapter 173-424 WAC, Clean Fuels Program Rule, which reduces pollution from vehicle fuels.
- Emissions from petroleum refineries cause poor visibility. We plan to identify emission controls, if any, to reduce emissions from refineries. After we have identified and scheduled installation of controls, we will amend this plan.

Washington's second Regional Haze State Implementation Plan:

- Establishes 2028 visibility goals for Washington's mandatory Class 1 federal areas.
- Develops a long-term strategy to improve visibility.
- Provides inventories of emissions causing a visibility problem.
- Analyzes sources of haze in Washington's mandatory Class 1 federal areas.
- Selects and evaluates the largest emitting stationary sources for potential emission controls.
  - Determines reasonable controls using a reasonability analysis.
  - Determines the emission controls that sources must install to improve visibility.

Chapter 1. Regional Haze Program Overview and Plan Development

1.1 Background

In 1977, Congress amended the Clean Air Act (CAA), 42 U.S.C. 7401 et seq., to include provisions to protect scenic vistas in certain Class 1 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 1 federal areas which impairment results from manmade air pollution." (CAA Section 169A)*

In 1979, EPA, in consultation with the Secretary of the Interior, established 156 mandatory Class 1 federal areas (Class 1 Areas) in which they determined visibility was an important factor. EPA designated eight Class 1 Areas in Washington.

EPA promulgated reasonably attributable visibility impairment (RAVI) regulations in 1980 to address the national visibility goal. RAVI regulations address distinct plumes (called "plume blight") caused by large stationary sources. RAVI regulations represented the first phase in addressing visibility impairment. Each state must develop visibility plans as part of the larger air quality State Implementation Plan (SIP). The SIP is a large body of federally-enforceable state regulations, programs, and permits that implement, maintain, and enforce federal ambient air quality standards and the Regional Haze Program.

Ecology revised the 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 reviewed and revised the Visibility SIP several times since then.

Washington's Visibility SIP addressed the distinct plumes from large stationary sources and silvicultural smoke. Although we do not consider prescribed burning from forestry activities a stationary source, prescribed burning has a significant impact on visibility. Because of this, Washington addressed this source in its Visibility SIP. Specifically, Ecology coordinated with the Washington Department of Natural Resources (DNR) to include visibility protections in the 1998 Smoke Management Plan (SMP). Ecology submitted a RAVI SIP — including the 1998 SMP — that focused on silvicultural (forest) smoke management in addition other sources that affect haze. Ecology submitted the 1999 RAVI SIP to EPA on November 5, 1999; EPA approved it June 11, 2003.[1]

EPA adopted the Regional Haze Rule (RHR) in 1999. The RHR addressed visibility impairment from widespread haze caused by emissions from multiple sources. These emissions often mix

[1] Final Federal Register Notice: 68 FR 34821, June 11, 2003. https://www.govinfo.gov/content/pkg/FR-2003-06-11/pdf/03-14573.pdf#page=1; Proposal Federal Register Notice: 67 FR 65077, October 23, 2002. https://www.govinfo.gov/content/pkg/FR-2002-10-23/pdf/02-26992.pdf

and disperse over long distances. The RHR established a comprehensive visibility protection program for the 156 Class 1 Areas.

In 2010, Ecology developed its first Regional Haze SIP (Ecology, 2010, revised 2012). It identified key sources of air pollution and defined a strategy to improve visibility in Washington's Class 1 Areas during the first planning period from 2005 through 2018. Ecology submitted the required Regional Haze Five Year Progress Report (Ecology, 2017) in 2017. This document is the second Regional Haze SIP and covers the 10-year period from 2018 through 2028. It also serves as the progress report for 2014 through 2018.

For information on Washington's Regional Haze program, visit Ecology's Regional Haze website (Ecology, 2021).[2]

1.2 Regional Haze Rule

The objectives of the RHR are:

- Improve existing visibility in all 156 Class 1 Areas;
- Prevent future impairment of visibility by anthropogenic sources; and
- Meet the national goal of natural visibility conditions by 2064.

The RHR requires each state to adopt a RH SIP that focuses on improving visibility in the 20 percent most impaired days (MID), and protecting visibility in the 20 percent clearest days. A state's RH SIP must provide a comprehensive analysis of natural and anthropogenic sources of haze in each Class 1 Area within the state, and contain strategies to control and reduce emissions that contribute to haze. For each Class 1 Area, the state must establish reasonable progress goals (RPGs) for each implementation period toward achieving natural visibility conditions. The RPGs must provide an improvement in visibility for the most impaired days over the period of the implementation plan and maintain the visibility for the clearest days over the same period. The SIP must also address Class 1 Areas outside of the state that we anticipate emissions from within the state might affect.

The RHR breaks the regional haze program into several planning periods from 2005 to 2064. The first RH SIP covered the initial planning period from 2005 - 2018. That SIP established the basis for future RH SIP revisions and initiated the process of making reasonable progress toward the 2064 goal. This second RH SIP covers the planning periods from 2018 - 2028.

In 2017, EPA revised the RHR. EPA clarified the relationship between long-term strategies and RPGs in state plans and the long-term strategy obligations of all states. EPA reiterated that the CAA requires states to consider four statutory factors in each implementation period to determine the rate of progress toward natural visibility conditions that is reasonable for each Class 1 Area. Those four factors are:

- Costs of compliance;
- Time necessary for compliance;

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[2] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Regional-haze

- Energy and non-air quality environmental impacts; and
- Remaining useful life of the facility.

The 2017 RHR revisions also addressed other issues, including:

- Described the way in which we select a set of days during each year for purposes of tracking progress toward natural visibility conditions;
- Revised some requirements for the content of progress reports;
- Updated, simplified, and extended to all states the provisions for reasonably attributable visibility impairment;
- Revoked federal implementation plans adopted in the 1980s that require EPA to assess and address any existing RAVI situations in some states;
- Revised the requirement for states to consult with the federal land managers (FLMs);
- Adjusted the due date for the next SIP from 2018 to 2021;
- Revised the due dates for progress reports; and
- Changed the requirement that states submit progress reports as formal SIP revisions to documents that need not comply with the procedural requirements of 40 CFR 51.102, 40 CFR 51.103, and Appendix V to Part 51.

Changes to FLM consultation requirements will bring the expertise and perspective of these officials into the state plan development process early enough that they can meaningfully contribute to Washington's deliberations.

1.3 Progress report requirements

This RH SIP revision also serves as a progress report that demonstrates Washington's progress toward the 2018 Reasonable Progress Goals (RPGs) during the period since the previous progress report. To serve as a progress report, the 2021 Regional Haze Plan revision must address the *Requirements for periodic comprehensive revisions of implementation plans for regional haze in* 40 CFR 51.308(f) and (g). Each state must analyze the following elements in evaluating progress toward intermediate visibility goals. These elements include:

- A status update of all controls that were implemented and relied on to achieve the RPGs;
- A summary of the emissions reductions;
- A current conditions analysis including the clearest and most impaired days;
- Any changes to the speciated analysis at each Class 1 Area to identify if there are changes to which pollutants impact visibility in each Class 1 Area;
- Updated emissions inventory and any changes in emissions and sources;

EPA also specifies that the evaluation period should only cover the period since the last progress report, and include the most recent five years of available data.

In October 2017, Ecology submitted to EPA the progress report (Ecology, 2017). The report was originally due to EPA in 2015, using the data from 2009 – 2013. However, due to the delay in submitting the report, we reviewed intermediate progress based on the data collected during the 2009 - 2013 period as well as 2010 – 2014. The 2017 Progress Report addressed the following:

- Status of RH Plan state strategy
- Emissions reductions from RH Plan control strategies
- Visibility progress and emission inventory trends
- Assessment of changes impeding visibility progress
- Review of visibility monitoring strategy
- RH Plan adequacy determination
- FLM comments

We concluded in our 2017 Progress Report that visibility in Washington's Class 1 Areas improved since the 2000 – 2004 baseline period, and the visibility measured in the 2010–2014 period met or exceeded the 2018 visibility goals.

In the current 2021 RH SIP revision, however, EPA recalculated visibility metrics. At the time of the preparation of this RH SIP revision, the most recent data available for the analysis was for the 2014 – 2018 five-year period.

Preliminary raw Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data for 2019 was presented via the FLMs Environmental Database website to the public in February 2021.[3] However, we did not use this raw data for this progress report because it could be incomplete and any missing data substitutions would influence progress report analysis.

Table 1-1 describes each of the progress report elements required by EPA and references relevant chapters in this RH SIP revision where it addresses each element.

Table 1-1: EPA required elements of the Progress Report and the corresponding references in relevant chapters.

Progress Report Element	Chapter where Addressed
40 CFR 51.308(g)(1) A description of the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals for mandatory Class 1 federal areas both within and outside the state	Chapter 9. Reasonable Progress Goals
40 CFR 51.308(g)(2) A summary of the emissions reductions achieved throughout the state through implementation of the measures described in paragraph (g)(1) of this section	Chapter 4. Emissions Inventory

[3] http://vista.cira.colostate.edu/Improve/aqrv-summaries/

Progress Report Element	Chapter where Addressed
40 CFR 51.308(g)(3) For each mandatory Class 1 federal area within the state, the state must assess the following visibility conditions and changes, with values for most impaired, least impaired, and/or clearest days as applicable expressed in terms of 5-year averages of these annual values. The period for calculating current visibility conditions is the most recent 5-year period preceding the required date of the progress report for which data are available as of a date 6 months preceding the required date of the progress report.	Chapter 3. Current Visibility Conditions in Washington's Class 1 Areas
40 CFR 51.308(g)(4) An analysis tracking the change over the period since the period addressed in the most recent plan required under paragraph (f) of this section in emissions of pollutants contributing to visibility impairment from all sources and activities within the state. Emissions changes should be identified by type of source or activity. With respect to all sources and activities, the analysis must extend at least through the most recent year for which the state has submitted emission inventory information to the administrator in compliance with the triennial reporting requirements of subpart A of this part as of a date 6 months preceding the required date of the progress report. With respect to sources that report directly to a centralized emissions data system operated by the administrator, the analysis must extend through the most recent year for which the administrator has provided a state-level summary of such reported data or an internet-based tool by which the state may obtain such a summary as of a date 6 months preceding the required date of the progress report. The state is not required to backcast previously reported emissions to be consistent with more recent emissions estimation procedures, and may draw attention to actual or possible inconsistencies created by changes in estimation procedures.	Chapter 3. Current Visibility Conditions in Washington's Class 1 Areas Chapter 4. Emissions Inventory Chapter 5. Western Regional Air Partnership Modeling Chapter 7. Source Apportionment and Impacted Class 1 Areas Chapter 9. Reasonable Progress Goals
40 CFR 51.308(g)(5) An assessment of any significant changes in anthropogenic emissions within or outside the state that have occurred since the period addressed in the most recent plan required under paragraph (f) of this section, including whether or not these changes in anthropogenic emissions were anticipated in that most recent plan, and whether they have limited or impeded progress in reducing pollutant emissions and improving visibility.	Chapter 4. Emissions Inventory

The current implementation plan elements and strategies are sufficient to enable Washington or other states with Class 1 Areas affected by emissions from Washington, to meet all established RPGs for the period covered by the first implementation plan. All Washington Class 1 Area 2018 RPGs were below the uniform rate of progress and Washington remains on track to meet the long-term goal of natural conditions by 2064.

1.4 Regional haze state implementation plan development

Regional haze planning requires a regional approach to visibility impairment. This section provides background on:

- Regional planning to address regional haze.
- The role of the Western Regional Air Partnership (WRAP) in the development of this second regional haze State Implementation Plan (RH SIP).

Regional planning

Haze-causing pollutants originate from numerous sources located in different geographic areas and can transport over long distances. In recognition of this, EPA encouraged states to create regional planning organizations (RPOs) to coordinate regional activities related to the Regional Haze Rule (RHR). States formed—and EPA funded—five RPOs, which collectively cover the 48 contiguous states, Alaska, and Hawaii (Figure 1–1).

Figure 1–1: Regional Planning Organizations

Western Regional Air Partnership

The Western Regional Air Partnership (WRAP) is a voluntary organization of western states, tribes, and federal agencies that work collaboratively to address visibility impairment in Class 1 Areas. WRAP formed in 1997 as the successor to the Grand Canyon Visibility Transport Commission (GCVTC). The 1990 Amendments to the CAA authorized the formation of visibility transport commissions and required EPA to establish the GCVTC.

WRAP promoted, supported, and monitored 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 represented a significant milestone in the study of regional haze. The GCVTC's technical analysis found the customary focus on mitigating visibility impairment from stack plumes associated with stationary point sources 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 the long-range transport (more than 100 miles) of emissions from numerous and widespread sources contributed to regional haze.

The RHR expanded the focus of regional visibility planning processes in the West from the Colorado Plateau to all western Class 1 Areas. WRAP embraced this geographic expansion by expanding its role to address regional haze in all 13 contiguous western states, Alaska, and Hawaii.

The focus of WRAP for this second RH SIP is technical analysis. 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 regional haze in the west. WRAP also provides a forum for coordination and consultation between states, tribes, and FLMs.

WRAP staff work through committees, and workgroups composed of states, tribes, FLMs, and EPA. Various state and federal agencies provide additional staff time. WRAP also contracts with environmental consulting firms for analysis of air pollution data, compilation and preparation of emissions inventory data, photochemical modeling, and analyses of natural and/or uncontrollable air pollution sources.

Washington's consultation with other states, tribes, and FLMs

Addressing regional haze requires communication between states, tribes, EPA, and FLMs. Communications can be both informal and formal. The RHR has requirements for a state to consult with the FLMs administering Class 1 Areas within a state. This section discusses the role of consultation between Washington and other states, tribes, and FLMs in the development of the second RH SIP.

Consultation with other states

The RHR requires consultation between states on the development of coordinated emission management strategies. This requirement applies both to Class 1 Areas within Washington, and to Class 1 Areas outside Washington, where we anticipate emissions from Washington contribute to visibility impairment.

Coordination facilitates completion of technical tasks and policy decisions in areas such as:

- Monitoring
- Emissions
- Source attribution
- Modeling
- Control measures

This extensive coordination results in an RH SIP that reflects Washington's implementation of a regionally consistent approach to addressing visibility impairment in the west.

Washington held several conference calls with neighboring states (Alaska, Idaho and Oregon) from 2019 through 2021 to discuss the progress of regional haze plan development, including discussions on the RACT/four factor analysis and control strategies (Appendix R). Our participation in WRAP also fostered a regionally consistent approach to regional haze planning in the western states and provided a sound mechanism for consultation (Appendix K). Consultation among the fifteen western states within WRAP continues through conference calls and WRAP sponsored working group updates and results meetings.

Tribal notification

Although the RHR does not have a requirement for formal consultation with the tribes, Washington notified tribes in Washington, and federally-recognized tribes in Oregon, and Idaho closest to Washington, of the development of the RH SIP. This was an informative letter to the chairpersons of the tribes in Washington. We followed up with invitations to chairpersons, natural resource managers, and tribal historic preservation officers to public meetings held in December of 2020 and January 2021 and several participated in those meetings.

Consultation with federal land managers

The RHR requires consultation between Washington and FLMs on development and implementation of the RH SIP. The RHR specifies that the consultation must provide an opportunity for affected FLMs to comment on Washington's assessment of visibility impairment in each Class 1 Area and provide recommendations on the reasonable progress goals and the development and implementation of visibility control strategies to address visibility impairment. Ecology provided FLMs with an opportunity to comment on the long-term strategy, reasonable progress goals, source selection, and four-factor analysis to identify reasonable controls of haze causing emissions more than 120 days prior to the start of a public hearing or other public comment opportunity.

Formal consultation requirements do not preclude informal consultation. Ecology had informal consultation opportunities and other public comment opportunities during SIP development. These were conference calls with representatives of the U.S. Forest Service, the National Park Service, and the U.S. Fish and Wildlife Service. The major focus of these meetings was Ecology's source selection. Ecology used the EPA recommended Q/d (emissions over distance to the nearest Class 1 Area) method to determine the sources we analyzed, the four-factor analyses, and suggested control strategies. These discussions were helpful for both Ecology and the

FLMs. Ecology used the discussions and informal written comments from FLMs to review the Q/d determinations.

Appendix A contains information on Ecology's early and formal consultation with the FLMs for this RH SIP. It includes the written comments submitted to Ecology along with a synopsis of FLM comments accompanied by Ecology's responses, as well as a summary of our meetings.

1.5 Environmental justice considerations

Introduction

Ecology incorporates environmental justice (EJ) into its planning process. EJ captures the need for change and defines actions agencies may take to remove disparities. In general, EJ includes two main components:

- Fair treatment means that no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies.
- Meaningful involvement means that the public has a fair opportunity to participate in decisions about activities that may affect their environment and/or health; can influence the regulatory agency's decision; and the decision-makers seek out and facilitate the involvement of those potentially-affected early and throughout the process.

Ecology EJ actions

Ecology consulted with our EJ coordinator to determine how best to address EJ concerns within the constraints of the Regional Haze Rule and guidance. Based upon her guidance and the use of EJSCREEN, we took the following actions:

- Identified the population characteristics of the people affected by the action (such as minority populations, low-income populations, non-English speaking populations, and tribes)
- Assessed and addressed disproportionately high and adverse human health or environmental effects on minority populations and low-income populations
- Planned for and facilitated the meaningful involvement of affected communities in the processes
- Ensured that potentially affected populations have appropriate opportunity to learn about, participate in, and influence Ecology's decisions and actions

To ensure that all people, regardless of their social, racial, geographical, or able-bodied status could participate in the review and decision making about the second Regional Haze SIP, we:

- Provided public notices that meet online accessibility requirements and notified interested public via emails and newspaper publications.
- Translated the notices into the priority minority languages in Washington:
    - Spanish
    - Korean

    - Vietnamese
    - Chinese
- Notified the leaders of the tribal communities in Washington and offered Government-to-Government consultation in addition to inviting the tribal members to attend public meetings.
- Held accessible online webinars to discuss various aspects of the program.
- Provided 45 days for the public to submit comments.
- Held a virtual public hearing.
- Simplified and formatted the Public Review Draft (text and graphics) to ensure it is compatible with available text-to-speech readers.

The long-term strategy in this regional haze SIP revision includes emission reductions from permits and state rules. The visibility benefits of these controls provide co-benefits to the communities that are in the vicinity where emission reductions occur. An example of such controls would be federal fuel and engine rules that have resulted in large reductions in mobile source air pollution and improvements in visibility.

Grant programs to reduce mobile source emissions and diesel pollution in disproportionately-impacted communities

There are several emission control grant programs in Washington that take into account EJ concerns in awarding grants or have co-benefits for nearby disadvantaged communities. These include the wood stove buy-back and exchange program (Chapter 173-433 WAC), the low emission vehicles 2021 rulemaking to reduce emissions around ports, distribution centers, and freight corridors (which tend to be located within disadvantaged communities), and the Volkswagen enforcement action grants that prioritizes projects in or near communities disproportionately-impacted by diesel fumes.

1.6 Meaningful public participation (reserved)

Summary of changes to the public review draft (reserved)

Ecology's response to comments on the public review draft (reserved)

1.7 Organization of the second regional haze plan (2018 - 2028)

The RH SIP is organized as follows:

Chapter 1

- Overview of the RHR and the development of the RH SIP.
- This includes the role of regional planning, the Western Regional Air Partnership (WRAP), and consultation with FLMs, tribes, and other states.
- It also includes a description of where the progress report elements are found in the document.

Chapter 2

- Primer on visibility
- Describes Washington's eight Class 1 Areas
- Describes visibility monitoring for these area at the Interagency Monitoring of Protected Visual Environments (IMPROVE) sites.

Chapter 3

- Describes current conditions in the Class 1 Areas.
- Describes the uniform rate of progress (URP) in visibility improvement needed to achieve the 2064 natural conditions.

Chapter 4

- Discusses the visibility baseline and 2018 statewide emissions inventories that Ecology developed and used to prepare this plan.

Chapter 5

- Describes the modeling used by the WRAP that Washington relied upon for this plan.

Chapter 6

- Discusses the significant in-state and regional sources of haze that affect Washington's Class 1 Areas and will likely affect visibility conditions in 2028.
- Discusses the Class 1 Areas in adjacent states that Washington emissions significantly affect.

Chapter 7

- Describes the source selection process and the four-factor analysis to determine the reasonableness of additional emission controls for inclusion in the long-term strategy.

Chapter 8

- Describes the long-term strategy to address regional haze visibility impairment in Washington's Class 1 Areas.
- Identify and reduce Washington's air impacts to mandatory Class 1 federal areas outside of Washington.

Chapter 9

- Defines the reasonable progress goal for each of the eight Class 1 Areas in Washington.

Chapter 10

- Describes future planning.
- Summarizes the Washington RH SIP.

Chapter 2. Visibility and Visibility Monitoring in Washington's Class 1 Areas

2.1 Natural sources of visibility impairment

Natural sources of visibility impairment are emissions not attributed to anthropogenic (human-caused) emissions, and they can be major contributors to visibility impairment. Natural sources include:

- Volcanos
- Wildfire
- Windblown dust
- Certain wildland prescribed fire

Even when there is an absence of emissions, the scattering of light by air molecules can degrade visibility. We refer to this as "Rayleigh scattering". The air molecules' temperature and density can cause this effect.

We cannot control these sources. We focus control strategies for visibility improvement on what we can control, anthropogenic sources. Current analysis methods for monitoring data do not provide a clear distinction between natural and anthropogenic emissions, but certain pollutant species, such as sulfur dioxide (SO_2) and nitrogen oxides (NOx) are more representative of anthropogenic sources, while organic mass (OM) and coarse particulate matter (PM_{10}) are usually more representative of natural sources such as wildfire and dust, respectively.

2.2 Anthropogenic sources of visibility impairment

Anthropogenic sources of visibility impairment include everything attributable to human activities that produces emissions of visibility impairing pollutants. Some examples include:

- Industrial activities
- Transportation
- Agricultural activities
- Residential heating
- Managed outdoor burning

Anthropogenic sources can be of local, regional, or international nature. Only anthropogenic sources and emissions within the boundaries of the United States can be controlled. Some anthropogenic sources of emission are beyond the scope of Washington's SIP. Emissions from Mexico, Canada, other international emissions, and offshore marine shipping emissions in the Pacific Ocean are examples of anthropogenic sources that contribute to visibility impairment in Washington, but are beyond the scope of this planning document.

2.3 Emissions

Natural sources and anthropogenic sources emit visibility-impairing pollutants. Particle and gas emissions may go through chemical changes before an air monitor captures them. For this reason, the chemical species causing visibility impairment may not be the same species emitted by a pollution source.

2.4 The IMPROVE program for visibility monitoring

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program is a multi-agency cooperative effort with the primary purposes of protecting visibility in Class 1 Areas and characterizing regional haze. The objectives of IMPROVE program are to:

- Establish current visibility and aerosol conditions in Class 1 Areas.
- Identify chemical species and emission sources responsible for visibility impairment.
- Document long-term trends for assessing progress toward the national visibility goal.
- Provide regional haze monitoring representing visibility in Class 1 Areas, where practical, in support of the Regional Haze Rule (RHR).

A formal cooperative relationship operates and maintains the IMPROVE monitoring sites. This cooperative includes:

- EPA
- National Parks Service (NPS)
- Fish and Wildlife Service (USFWS)
- Bureau of Land Management (BLM)
- Forest Service (USFS)

IMPROVE monitors 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 every three days to determine the standard chemical components causing visibility impairment at that site.

To facilitate the data analysis, we group together some elemental particles and compounds (based on scientific principles) into seven standard components that cause light extinction.

Table 2-1 lists the seven standard aerosol components of light extinction along with the default color used in graphics throughout this document.

Table 2-1: Monitor Aerosol Composition

Aerosol Component	Abbreviation (color)
Ammonium sulfate	$(NH_4)_2SO_4$ (yellow)
Ammonium nitrate	NH_4NO_3 (orange)
Organic mass	OM (green)
Elemental carbon	EC (black)

Aerosol Component	Abbreviation (color)
Fine soil	Soil (maroon)
Coarse mass	CM (gray)
Sea salt	Sea salt (light blue)

The IMPROVE website (IMPROVE) has detailed information regarding the IMPROVE program, including history, sampling protocols, standard operating procedures, and data availability.

Data collected at the IMPROVE monitoring sites is used by:

- Land managers
- Industry planners
- Scientists
- Public interest groups
- Air quality regulators

2.5 The revised IMPROVE 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. Light extinction is the technical term for visibility impairment between the viewer and the light source.

Each of the key components of particulate aerosols affect light extinction in different ways. The first IMPROVE equation underestimated the highest extinction values and overestimated the lowest extinction values. The revised algorithm was developed by Pitchford et al., 2007 (Marc Pitchford, 2007). The revised algorithm is relatively simple, it produces consistent estimates of light extinction for all IMPROVE aerosol monitoring sites, and it permits the individual particle component contributions to light extinction to be separately estimated (see Figure 2–1). The revised IMPROVE equation also accounts for site-specific Rayleigh scattering values based on altitude. Rayleigh scattering is the scattering of light by molecules of air.

$$
\begin{aligned}
b_{ext} \approx\ & 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}] \\
& + 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}] \\
& + 2.8 \times [\text{Small Organic Mass}] + 6.1 \times f_L(RH) \times [\text{Large Organic Mass}] \\
& + 10 \times [\text{Elemental Carbon}] \\
& + 1 \times [\text{Fine Soil}] \\
& + 1.7 \times f_S(RH) \times [\text{Sea Salt}] \\
& + 0.6 \times [\text{Coarse Mass}] \\
& + \text{Rayleigh Scattering (site specific)} \\
& + 0.33 \times [NO_2\ (\text{ppb})]
\end{aligned}
$$

Figure 2–1: 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.

We express reconstructed light extinction in units of inverse megameters (Mm^{-1}). The RHR requires the tracking of visibility conditions in terms of the haze index metric expressed in the deciview (dv) unit (40 CFR 51.308(f)(1)(i)). Generally, we consider a one-dv change in the haze index a humanly perceptible change under ideal conditions, regardless of background visibility conditions. Figure 2–2 shows the relationship between extinction, Mm^{-1}, dv, and visual range (km).

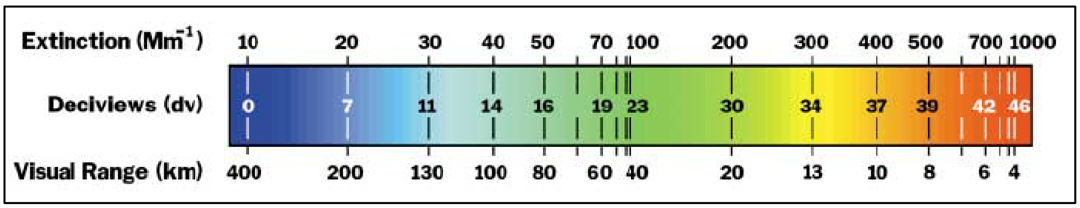

Figure 2–2: Comparison of extinction, deciview, and visual range
Source: (Malm, 2018).

2.6 Baseline conditions

The RHR requires the calculation of baseline conditions for each Class 1 Area. EPA has defined baseline conditions as the five-year average (annual values for 2000 - 2004) of IMPROVE monitoring data (expressed in dv) for the most impaired days (MID) and the clearest days. In the first regional haze plan, we defined the baseline conditions as reference points against which we tracked visibility improvement.

2.7 Natural conditions

The visibility under natural conditions (absent any anthropogenic impairment) could vary daily, based on the contribution of natural sources and meteorological conditions. Therefore, natural conditions consist of a level of visibility (in dv) for both the most impaired and clearest days. Since no visibility monitoring data exists from the before anthropogenic impairment period, we base these estimates of natural conditions on EPA guidance (EPA, 2003) on how to estimate natural conditions.

2.8 Uniform rate of progress

The uniform rate of progress (URP) is the calculation of the uniform slope, or glidepath, of the line between baseline visibility conditions and natural visibility conditions over the 60-year period. For the first regional haze plan, the benchmark was the dv level that we planned to meet in 2018 (Figure 2-3). This was the 2018 milestone, and it applied to both the most impaired and clearest days. For the second regional haze planning period, the benchmark is the dv level achieved by 2028 (Figure 2-3).

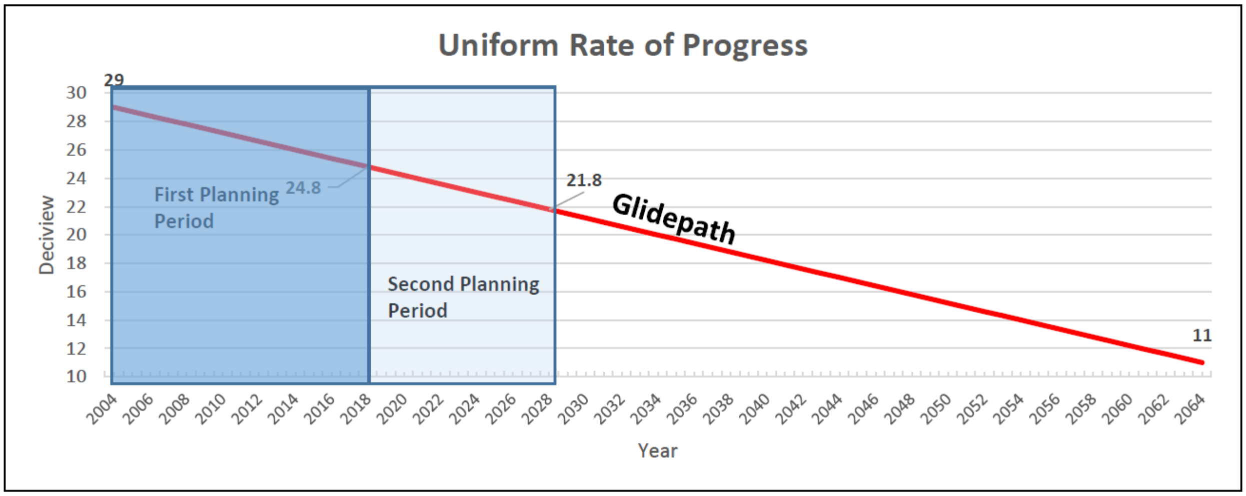

Figure 2-3: Example of How Uniform Rate of Progress is Determined Source: EPA Guidance for Setting Reasonable Progress Goals under the Regional Haze Program

The difference between baseline conditions and natural conditions represents the amount of progress needed to reach natural visibility conditions. In this example (not actual data), Washington has determined that the baseline for the most impaired days for the Class 1 Area is 29 dv and estimated that natural background is 11 dv, a difference of 18 dv.

The annual average visibility improvement needed to reach natural conditions by 2064 is the total amount of improvement needed divided by 60 years (the period between 2005 and 2064). The visibility improvement per year is the uniform rate of progress (URP) expressed in dv per year. In this example, the average improvement needed is 0.3 dv/yr.

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

Multiply the annual average visibility improvement needed by the number of years in the first planning period (14 years from 2005 until 2018). In this example, this value is 4.2 dv. This is the visibility improvement that we would need during the first planning period to attain natural visibility conditions by 2064.

Calculate the visibility improvement needed to maintain a uniform rate of progress to 2028 (i.e. the amount of reduction in dv necessary for the second planning period) by multiplying the URP value by the number of years between the baseline period and the end of the second planning period (24 years). In this example, the value is 7.2 dv.

Visibility improvement from the baseline to 2018 = [uniform rate of progress] x [14 years]

Visibility improvement from the baseline to 2028 = [uniform rate of progress] x [24 years]

2.9 Washington's Class 1 Areas and visibility monitoring

Washington's Class 1 Areas

Washington has eight Class 1 Areas: three national parks and five wilderness areas. Visibility in the Class 1 Areas is monitored at the interagency monitoring of protected visual environments

(IMPROVE) sites. Figure 2–4 shows Washington's eight Class 1 Areas along with the locations of the IMPROVE monitors for the Class 1 Areas.

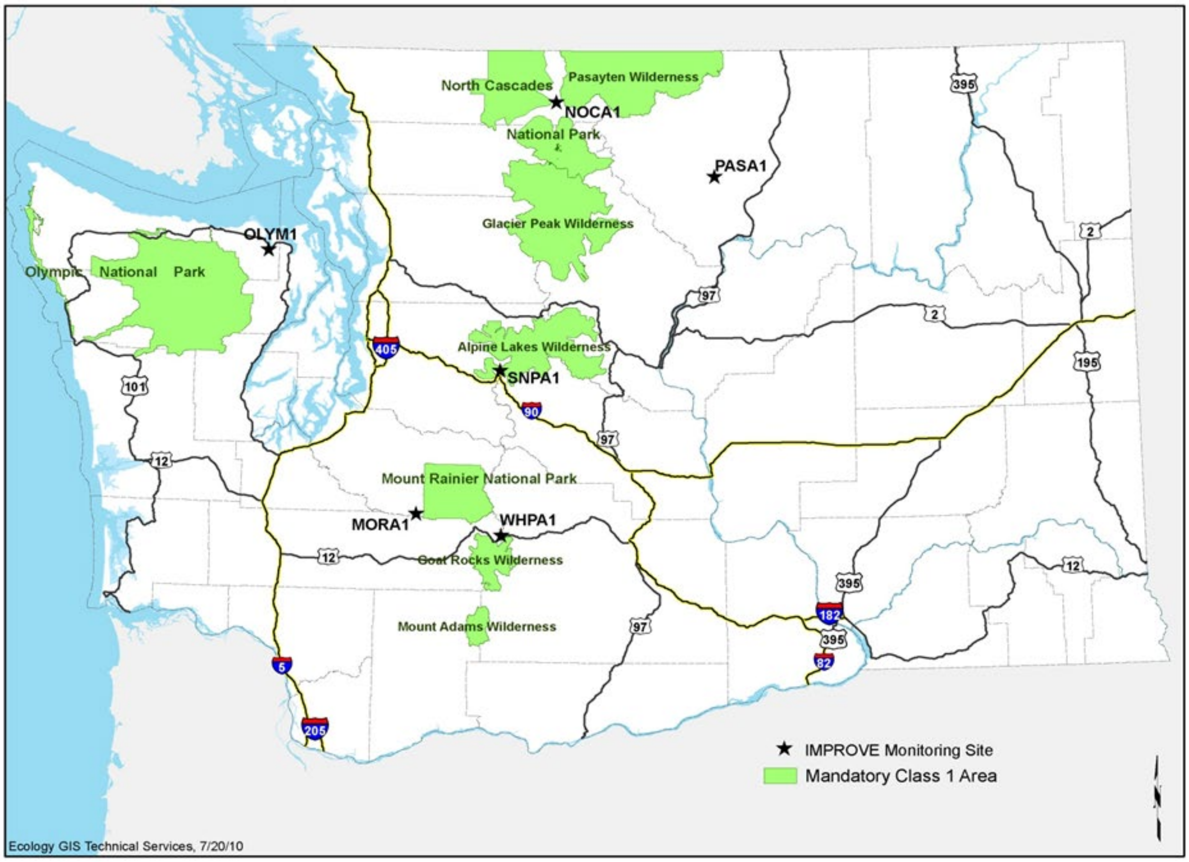

Figure 2–4: Washington's Class 1 Areas and visibility monitoring sites

Table 2-2 provides information on the size of and the federal agency that manages each Class 1 Area, as well as the name of the IMPROVE monitor for each area. The acreages are from 40 CFR 81.434. They 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 2-2: Washington's Class 1 Areas

Class 1 Area	Acreage	Federal Land Manager	IMPROVE monitor
Olympic National Park	892,578	USDI-NPS	OLYM1
North Cascades National Park	503,277	USDI-NPS	NOCA1
Glacier Peak Wilderness	464,258	USDA-FS	NOCA1
Alpine Lakes Wilderness	303,508	USDA-FS	SNPA1

Class 1 Area	Acreage	Federal Land Manager	IMPROVE monitor
Mt. Rainier National Park	235,239	USDI-NPS	MORA1
Goat Rocks Wilderness	82,680	USDA-FS	WHPA1
Mt. Adams Wilderness	32,356	USDA-FS	WHPA1
Pasayten Wilderness	505,524	USDA-FS	PASA1
Total Acres	3,019,420		

The sections below briefly describe Washington's Class 1 Areas. Maps of these areas are included later in this chapter.

Olympic National Park

Olympic National Park includes a significant portion of the Olympic Peninsula in northwestern Washington. It consists of two segments: the Olympic Mountains, which form the mountainous core of the park, and a coastal strip, stretching for 90 km (56 mi) along the Pacific coast. Thirteen major rivers are flowing from the Olympic Mountains in all directions. Ninety-five percent of the park is designated wilderness.

Elevations range from sea level to 2,428 m (7,965 ft.) 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 in) in the western valleys and 500 cm (200 in) at the summit of Mt Olympus but as little as 41 cm (16 in) on the northeast shore of the peninsula in the rain shadow of the Olympic Mountains.

North Cascades National Park

North Cascades National Park is set in the rugged mountains and the beautiful scenery of the Cascade Mountain Range in northcentral Washington, about 80 km (50 mi) 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 ft.) above the valley floor. Approximately 93 percent of the park is designated wilderness.

North Cascades National Park lies less than 150 km (95 mi) from major metropolitan areas, most notably, Seattle, Washington and Vancouver, British Columbia.

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.

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

Glacier Peak Wilderness drains on the west side of the Cascade crest to 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 ft.). The lowest elevations east of the Cascade crest are 350 to 400 m (1,200 to 1,300 ft.), close to the 335 m (1,099 ft.) elevation of Lake Chelan.

Alpine Lakes Wilderness

When Congress passed the 1976 Alpine Lakes Wilderness Act to protect the area in its unique natural state they created the Alpine Lakes Wilderness. 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 Mt. Baker-Snoqualmie National Forest and the Okanogan-Wenatchee National Forest jointly administer the wilderness.

Alpine Lakes Wilderness is located in the rugged central Cascade Range. It is accessible by 47 trailheads and 990 km (615 mi) 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.

Mount Rainier National Park

Mount Rainier National Park became 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 mi) southeast of Seattle, Mount Rainier is the highest of the chain of volcanoes comprising the Cascade Range. At 4,392 m (14,410 ft.), 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 of Alaska.

Mount Rainier National Park lies within 64 km (40 mi) of Puget Sound. The lowlands along the eastern shore of Puget Sound are the most populated and industrialized area of Washington.

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 earned the title “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 ft.) to 2,450 m (8,201 ft.) 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.

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 ft.) 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.

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 Pasayten is a series of high ridges that flatten out in the eastern portion to high plateaus. Almost 150 peaks in the Pasayten have elevations above 2,300 m (7,500 ft.). The part west of the Cascade crest is in the upper Skagit River basin and drains into Ross Lake and the Skagit River and then 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 elevations are around 1,000 m (3,000 ft.) at the western boundary near Ross Lake and the southern boundary near Lost River Gorge.

Visibility monitoring of Washington's Class 1 Areas

Washington has six IMPROVE sites that monitor the visibility of Washington's eight Class 1 Areas. Four have been combined into two clusters and one monitor is used to represent each cluster. We discuss each site briefly below. You can find additional information on nearby populations, industrial centers, and wind patterns for the sites in Appendix B.

Olympic IMPROVE site: OLYM1

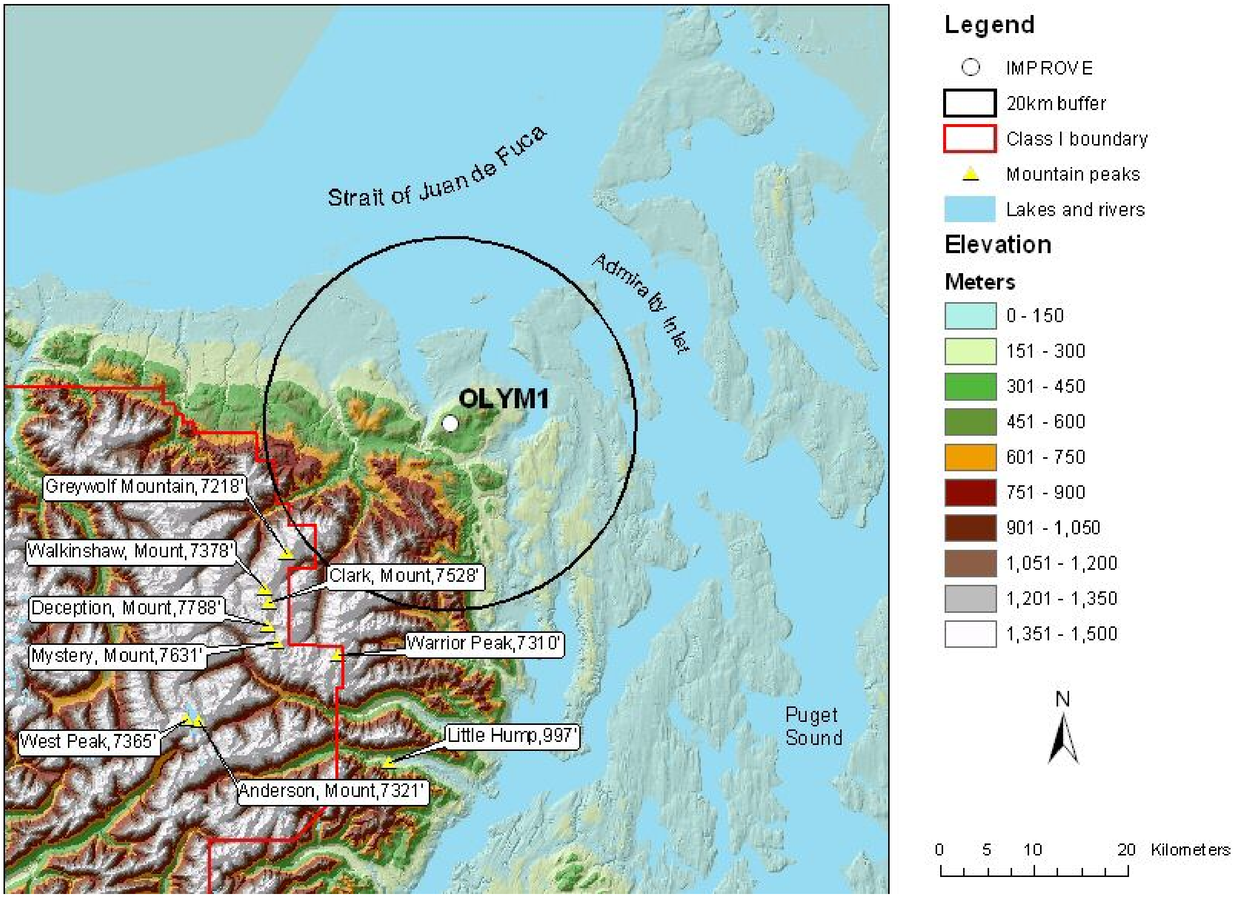

Figure 2–5: Location of the OLYM1 site
Source: Causes of Haze Assessment Descriptive Maps

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 ft.) (Figure 2–5).

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 Olympic 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 sources may affect different areas. For the northeastern portion of the 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 park, including the coastal section, there are no additional large source areas, although there may be timber and shipping related industries.

North Cascades IMPROVE Site: NOCA1

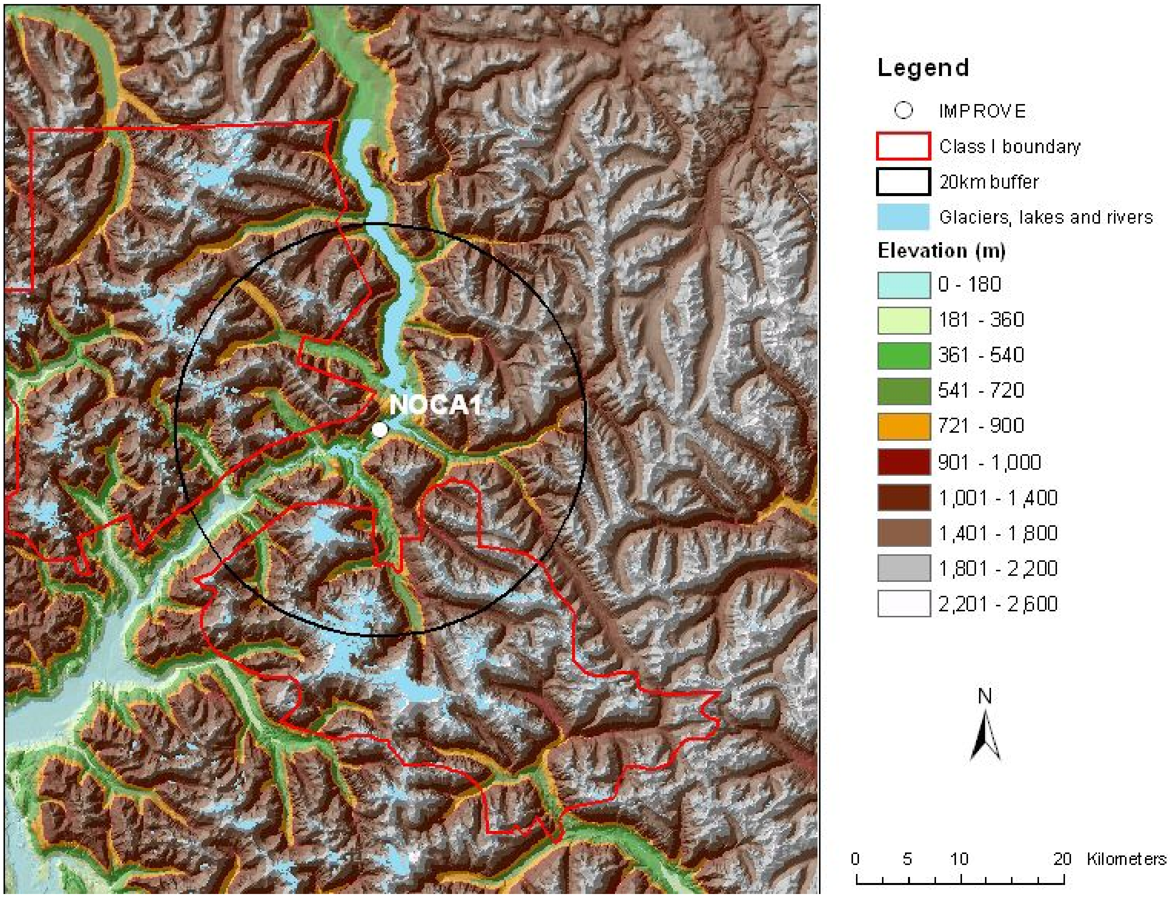

Figure 2–6: Location of the NOCA1 Site
Source: Causes of Haze Assessment Descriptive Maps

The NOCA1 IMPROVE site is the monitoring site for two Class 1 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 (Figure 2–6). The monitor is situated at an elevation of 576 m (1,889 ft.) and is 87 m (285 ft.) above the level of Ross Lake and about 200 m (650 ft.) below the surrounding ridge tops.

Representativeness

The NOCA1 IMPROVE site is within the Skagit River Valley near Ross Lake and is in the lower slopes of a valley. It may at times be within surface-based valley inversions. The monitor is representative of the lower elevation air shed.

Snoqualmie Pass IMPROVE site: SNPA1

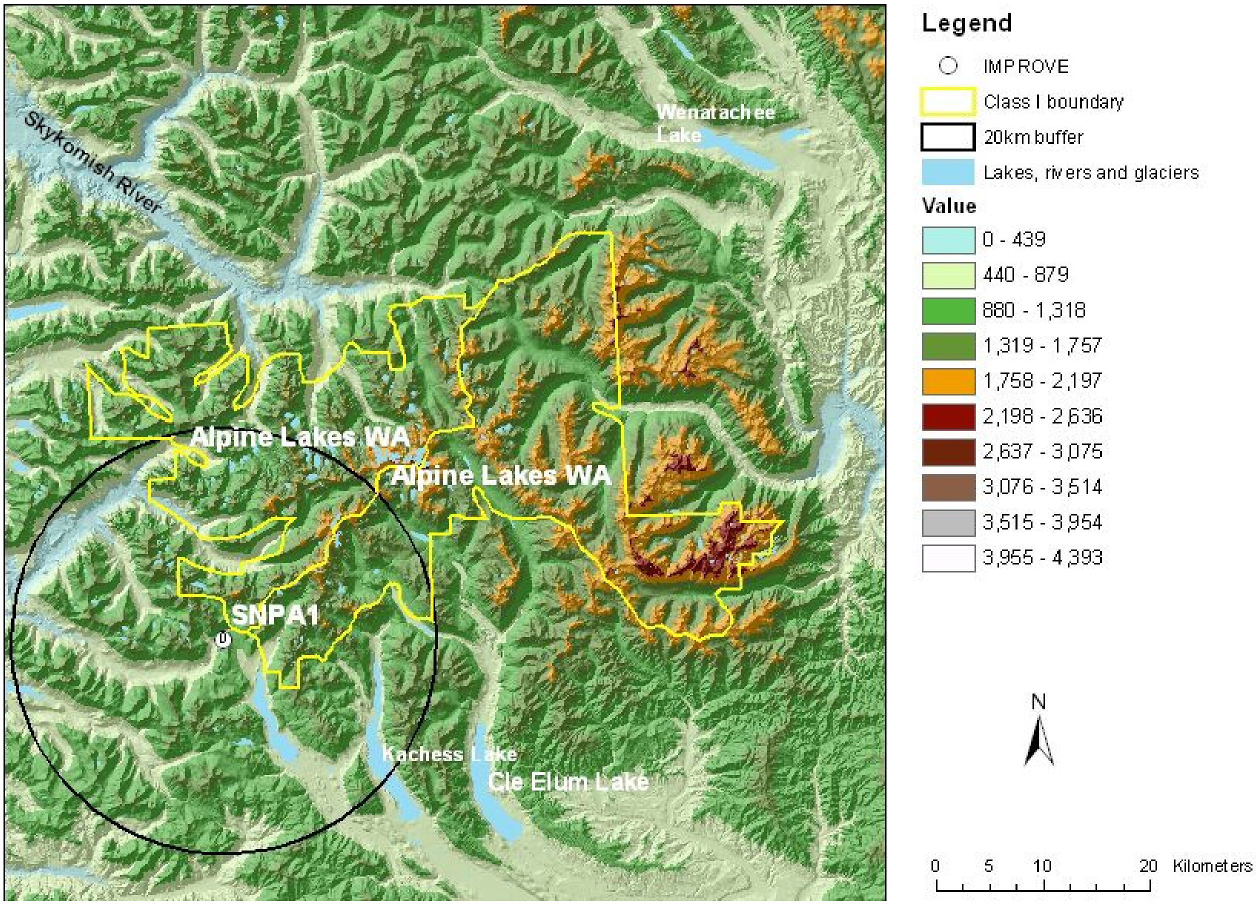

Figure 2–7: Location of the SNPA1 site
Source: Causes of Haze Assessment Descriptive Maps

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 (Figure 2–7). The monitoring site elevation of 1,160 m (3,805 ft.) is 239 m (784 ft.) above the Snoqualmie Pass elevation of 921 m (3,022 ft.). SNPA1 is located near a ski area on Snoqualmie Pass.

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.

Mount Rainier IMPROVE site: MORA1

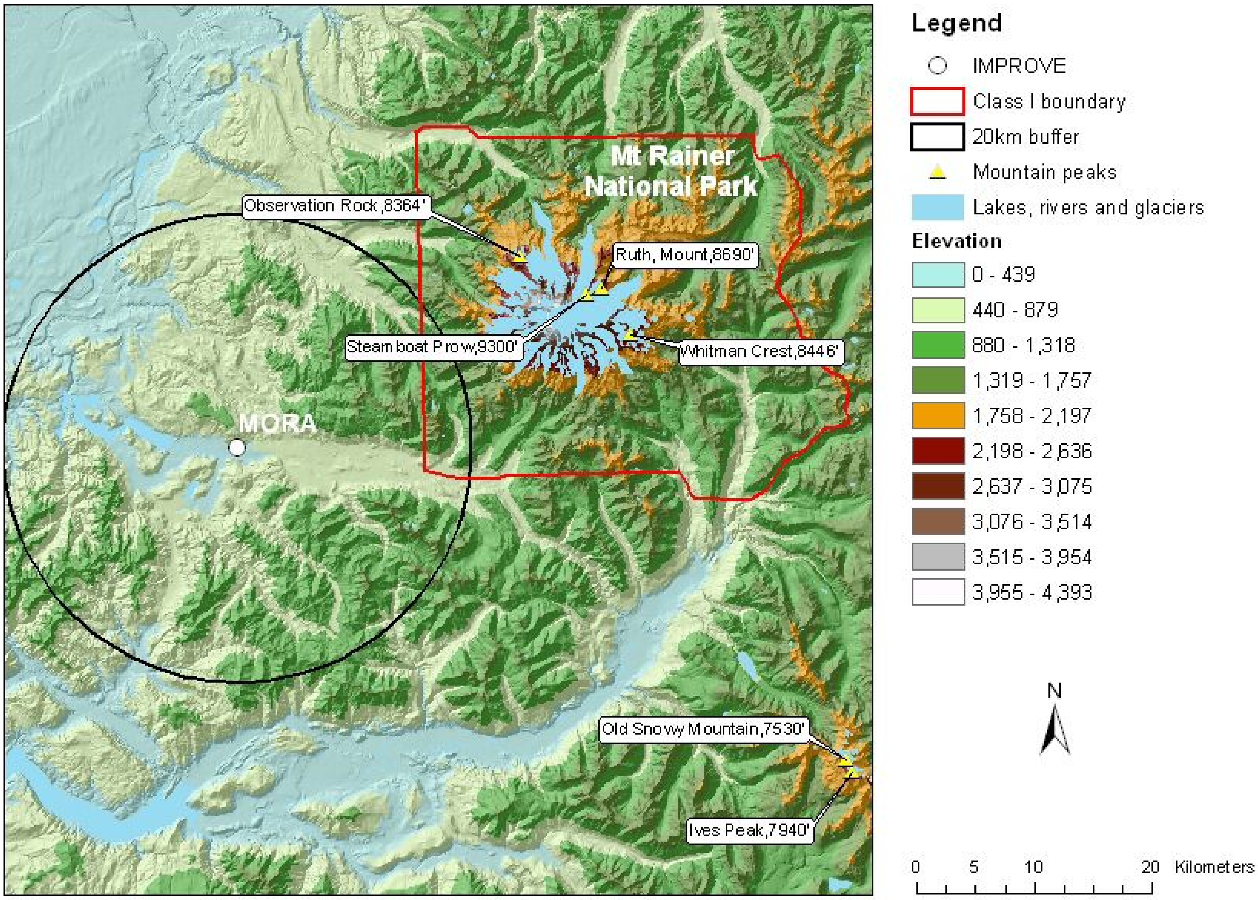

Figure 2–8: Location of the MORA1 site
Source: Causes of Haze Assessment Descriptive Maps

The IMPROVE site representing Mount Rainier National Park, MORA1, is situated southeast of the park at the Tahoma Woods park headquarters. MORA1 is located within the Nisqually River Valley at an elevation of 439 m (1,440 ft.). The monitor is some 30 km (18.5 mi) west-southwest from the summit of Mount Rainer (Figure 2–8) as shown above.

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 ft.).

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 ft.) 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.

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 trapped stable layer would contain the monitoring site. In those instances, the monitor would only be representative of the lower portions of the park.

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

White Pass IMPROVE site: WHPA1

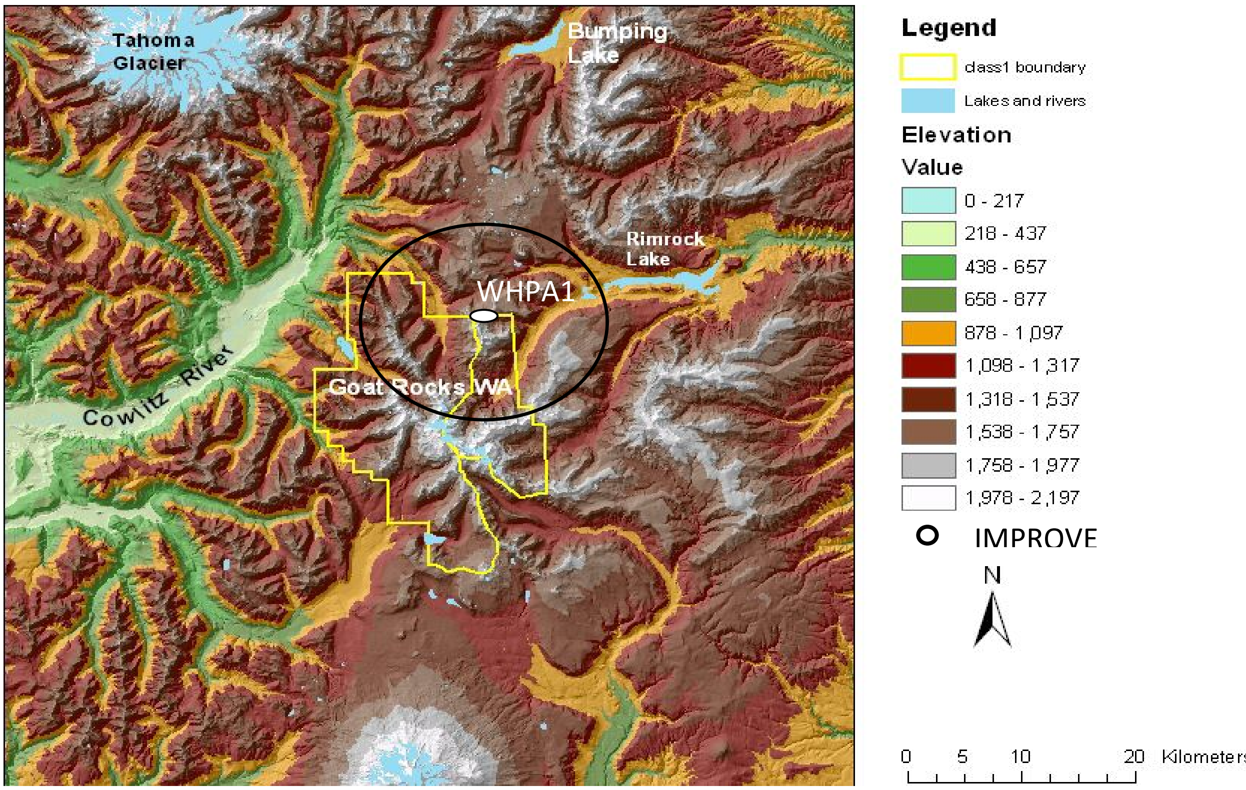

Figure 2–9: Location of the WHPA1 site
Source: Causes of Haze Assessment Descriptive Maps

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 (Figure 2–9). The monitoring site elevation is 1,830 m (6,002 ft.).

Representativeness

WHPA1 is at a ridge crest location well exposed to upper airflows and to aerosols transported aloft from upwind sources. WHPA1 should be 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.

Pasayten IMPROVE site: PASA1

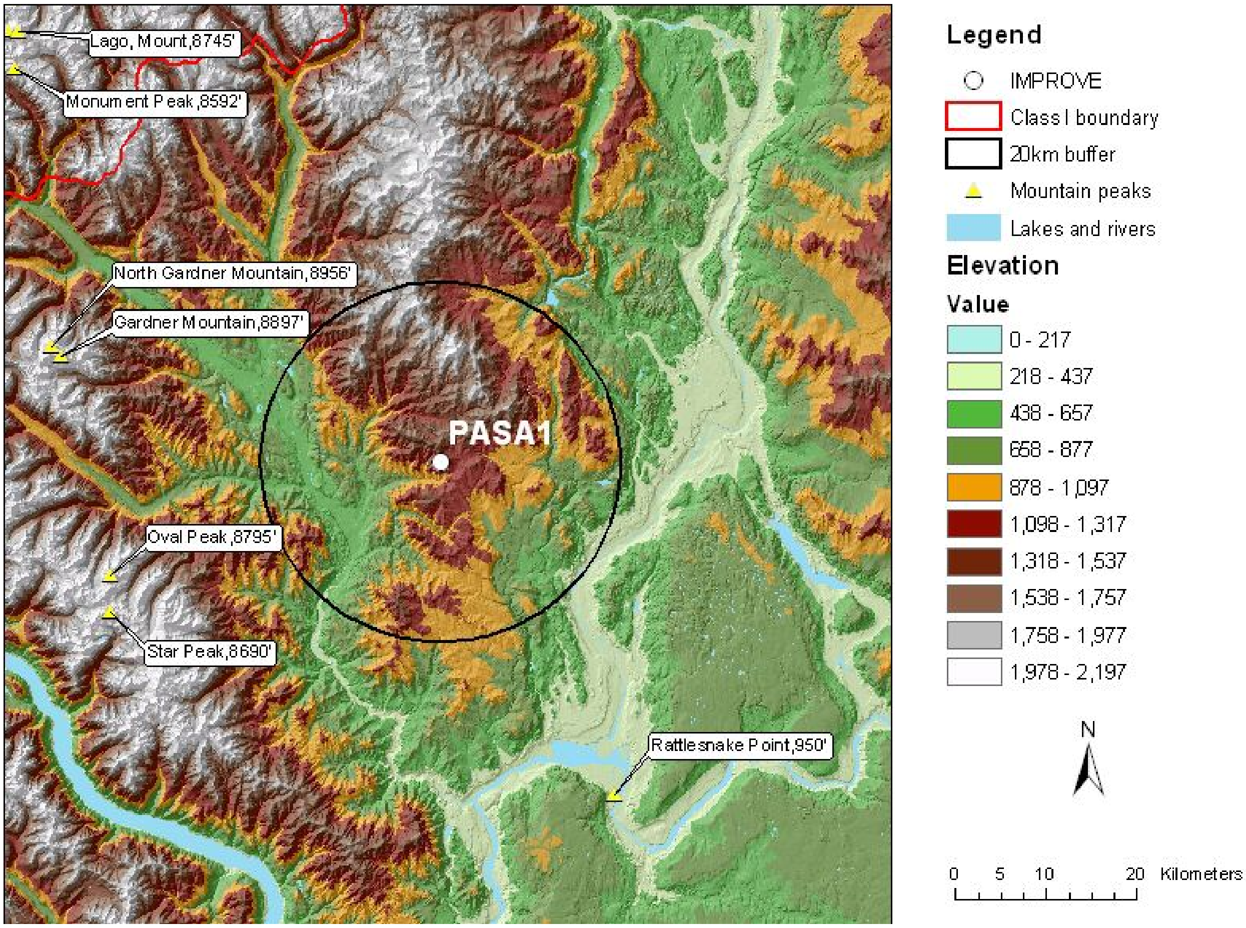

Figure 2–10: Location of the PASA1 site
Source: Causes of Haze Assessment Descriptive Maps

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 (Figure 2–10). PASA1 is located at an exposed elevation of 1,634 m (5,360 ft.).

Representativeness

The PASA1 IMPROVE site is at a well-exposed ridge top location and is somewhat representative of regional conditions including high elevation locations in the Pasayten Wilderness. It is more representative of upper level (850 mb) aerosol characteristics of the central Columbia Plateau and Basin. This monitor is further away from the Class 1 Area it represents than any others in Washington. The PASA1 monitor is in an area that has frequent prescribed burning that may not actually affect the Pasayten Wilderness. Prescribed burning near the PASA1 monitor does not typically affect visibility in the Pasayten Wilderness because prevailing westerly winds and terrain limit the transport of smoke from the Columbia Plateau to the Cascade Mountains.

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

Chapter 3. Current Visibility Conditions in Washington’s Class 1 Areas

3.1 Overview of visibility conditions in Washington

3.1.1 Introduction

Ecology analyzed current visibility conditions in Washington’s eight mandatory Class 1 Federal Areas (Class 1 Areas) as required by the Regional Haze Program (40 CFR 51.308(f)(1)). We compared current visibility conditions to both the historical baseline and natural conditions. The five-year period (2014 - 2018) is the most recent monitoring dataset available for regulatory use and is the period we refer to as “current conditions” throughout this document. The first Regional Haze State Implementation Plan (RH SIP) defined “baseline visibility conditions’’ as the five-year period from 2000 - 2004. The Regional Haze Rule (RHR) sets the statutory deadline of 2064 to reach natural visibility conditions at all Class 1 Areas. Natural visibility represents the visibility conditions in the absence of human-caused impairment.

3.1.2 Methodology

Ecology used the monitoring data for the current conditions from the interagency monitoring of protected visual environments (IMPROVE) sites that track pollutants affecting visibility in Class 1 Areas. For more information on the pollutants, see Chapter 4 Emission Inventories. Washington has six IMPROVE sites and eight Class 1 Areas. Two of the sites cover four Class 1 Areas. Table 3-1 provides general information on the six sites[4]. For more information about the IMPROVE program see Chapter 2, Section 2.2: Visibility monitoring of Washington’s Class 1 Areas.

Table 3-1: IMPROVE monitoring sites.

Site name	Site abbreviation	Site sponsor	Monitored Class 1 Area
Olympic	OLYM1	USDI-NPS	Olympic National Park
North Cascades	NOCA1	USDI-NPS	North Cascades National Park and 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 and Mount Adams Wilderness
Pasayten	PASA1	USDA-FS	Pasayten Wilderness

[4] See the map of the Class 1 Areas and the monitoring sites at: https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Regional-haze.

The Western Regional Air Partnership (WRAP) analyzed and compiled the IMPROVE monitoring data for consistency in planning among Western states. We used WRAP's technical data and analysis to determine current conditions. We also used the WRAP Technical Support System (TSS) online tool at https://views.cira.colostate.edu/tssv2/ to generate graphs and tables illustrating the results of the data analysis. Those interested in reviewing the data may access the observation-specific tools at https://views.cira.colostate.edu/tssv2/Express/VisTools.aspx.

During the first planning period, we used the worst (haziest) days from the IMPROVE monitoring data to determine the baseline visibility for the worst visibility days for the 2000 - 2004 period. However, the RHR revision in 2017 changed the metric on how to select a set of the worst visibility days during each year to track progress toward natural visibility conditions. The revised metric reflects the finding that natural events such as wildfires and dust storms overwhelmingly influence the haziest days. The rule revision removed five percent of the haziest days recorded at the IMPROVE sites from the calculations to create "the most impaired days" (MID) metric. The MID are the 20 percent of the worst visibility days in a calendar year, after removing the five percent haziest days. Thus, the design of the MID metric identifies the days with the largest amounts of anthropogenic visibility impairment. Because of the rule revision, EPA and WRAP recalculated the baseline conditions for all Class 1 Areas for the second implementation period.

The RHR requires that states track progress in visibility with a metric of haze known as the deciview (dv). We use the dv because under many circumstances, a person will perceive a change in one dv to be the same on both clear and hazy days. However, the dv does not easily relate to pollutant concentrations. Therefore, species contribution analysis uses a metric directly related to pollutant concentrations, known as "light extinction," with units of inverse megameters (Mm^{-1}). Light extinction does not linearly relate to a person's perception of changes in haze, but does linearly relate to pollutant concentrations in the atmosphere.

The glidepath from the baseline visibility conditions for the MID to the natural conditions over a 60-year period depicts the uniform rate of progress (URP). The uniform rate of visibility improvement for the MID is measured in deciviews of improvement per year. We need to maintain this average rate to attain natural visibility conditions by the end of 2064 in each Class 1 Area. Thus, the URP glidepath is a planning tool to help track ongoing improvements in visibility and to gauge whether there are sufficient controls over the emission sources to meet our progress goals during this planning period and stay on track to achieve the natural condition goals by 2064.

In the first planning period, natural conditions and the URP glidepath endpoint were the same by default. However, not all human-caused impairment comes from emission sources that Washington can control. In accordance with the RHR (40 CFR 51.308(f)(1)(vi)(B)), the states can propose an adjustment to the endpoint of the glidepath to account for emissions they do not control such as international emissions. In this planning period, WRAP calculated the impacts of international anthropogenic sources on Washington's visibility in each Class 1 Area.

Washington is focusing on impairments that come from the sources within the states' control and is proposing an adjustment to the endpoint of the glidepath in Chapter 9 to account for international contributions.

In this chapter, the current visibility conditions are compared to the unadjusted glidepath for each of the eight Class 1 Areas in Washington (40 CFR 51.308(f)(1)(vi)). In Chapter 9, we adjusted the endpoint of the glidepath to account for the international contributions and use the international adjusted glidepath when we project reasonable progress goals.

For each Class 1 Area, we calculated the uniform rate of progress, and reviewed the visibility during MID and clearest days during 2014 - 2018. We compared the clearest days to the baseline, and the MID to the unadjusted URP glidepath. We provided an analysis of the annual and seasonal species' contributions to the visibility impairment during the current period. We also provided a visibility trend synopsis of annual species contributions to light extinction from 2002 - 2018.

3.1.3 Summary results

Table 3-2 and Table 3-3 show a summary of the 2000 - 2004 baseline, IMPROVE 2008 - 2012, IMPROVE 2014 - 2018, and estimated natural conditions for the clearest days and MID. This is required by the RHR (40 CFR 51.308(f)(1)(i – v)).

Table 3-2: Baseline, current, and estimated natural visibility conditions for the clearest days (in dv).

Class 1 Area	IMPROVE monitor	Baseline 2000-2004	Average 2008-2012	Current conditions 2014-2018	Estimated natural conditions 2064	Difference between current and natural conditions
Olympic National Park	OLYM1	6.0	3.9	3.6	2.7	0.9
Glacier Peak Wilderness Area	NOCA1	3.4	2.9	2.5	1.9	0.6
North Cascades National Park	NOCA1	3.4	2.9	2.5	1.9	0.6
Alpine Lakes Wilderness Area	SNPA1	5.5	4.0	3.3	2.3	1.0
Mount Rainier National Park	MORA1	5.5	4.2	3.9	2.6	1.3
Goat Rocks Wilderness Area	WHPA1	1.7	1.3	1.0	0.8	0.2
Mount Adams Wilderness Area	WHPA1	1.7	1.3	1.0	0.8	0.2
Pasayten Wilderness Area	PASA1	2.7	2.1	1.6	1.2	0.4

Table 3-3: Baseline, current, and estimated future visibility conditions for the most impaired days (in dv).

Class 1 Area	IMPROVE monitor	Baseline 2000-2004	Average 2008-2012	Current conditions 2014-2018	Estimated unadjusted natural conditions 2064	Difference between current and natural conditions
Olympic National Park	OLYM1	14.9	13.5	11.9	6.9	5.0
Glacier Peak Wilderness Area	NOCA1	12.6	11.1	10.0	6.9	3.1
North Cascades National Park	NOCA1	12.6	11.1	10.0	6.9	3.1
Alpine Lakes Wilderness Area	SNPA1	15.4	13.7	12.7	7.3	5.4
Mount Rainier National Park	MORA1	16.5	14.1	12.7	7.7	5.0
Goat Rocks Wilderness Area	WHPA1	10.5	9.1	8.0	6.1	1.9
Mount Adams Wilderness Area	WHPA1	10.5	9.1	8.0	6.1	1.9
Pasayten Wilderness Area	PASA1	10.4	9.6	9.5	6.0	3.5

3.2 Olympic National Park

The baseline visibility for the Olympic National Park is 6.0 dv for the clearest days and 14.9 dv for the MID. The unadjusted URP glidepath goes from 14.9 to 6.9 dv at a rate of 0.13 dv per year (8 dv divided by 60 years), which is the rate that would need to be maintained to reach natural visibility conditions in the park by 2064.

The current conditions (2014 - 2018) calculated from OLYM1 monitoring data are 3.6 dv for the clearest days and 11.9 dv for the MID. The clearest days' visibility improved by 2.4 dv from the baseline. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 1.8 dv. The MID visibility improved by 3 dv and is under the unadjusted URP glidepath.

Figure 3–1 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at OLYM1 for the five-year averages 2000 - 2008, 2008 - 2012, and

2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are below the glidepath, which indicates a rate of visibility improvement that will accomplish the 2064 natural conditions goal.

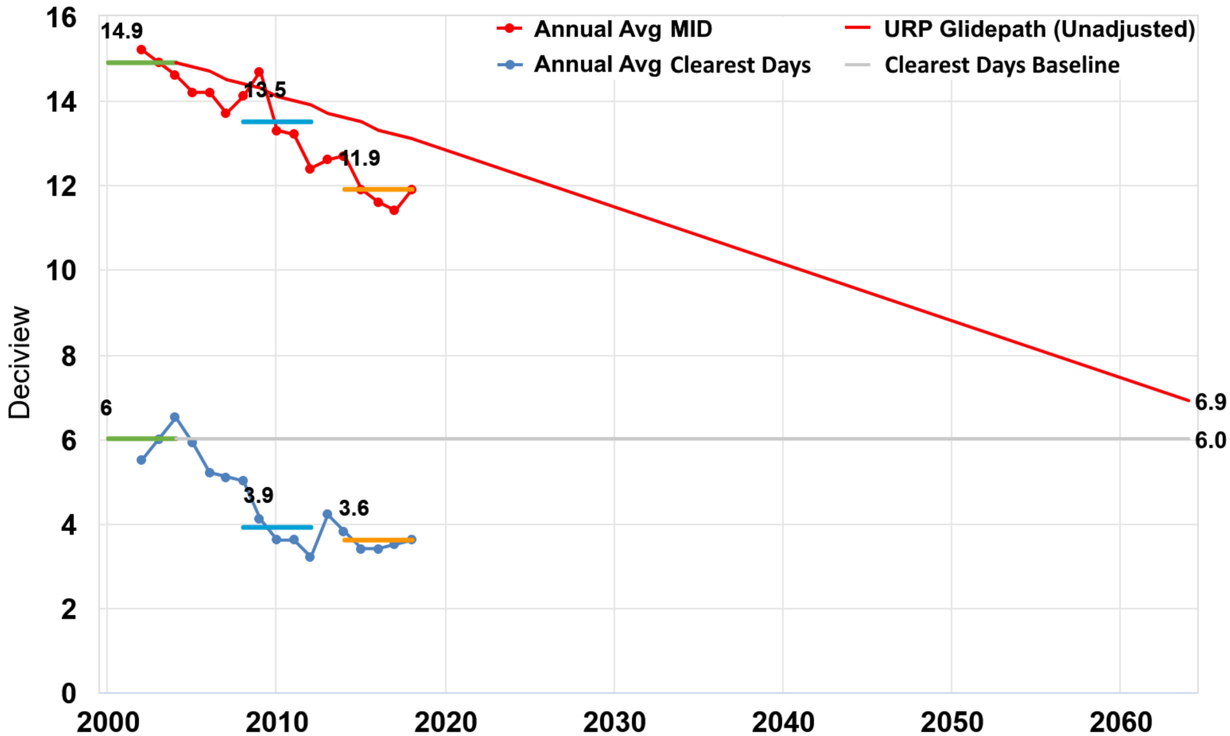

Figure 3–1: Current visibility conditions compared to the unadjusted URP glidepath and baseline (clearest days) at OLYM1.

Figure 3–2 shows the annual species contributions to light extinction from 2014 - 2018 for both MID and clearest days. Sulfates decreased in 2015 for both MID and clearest days and the decrease sustained through the rest of the five-year period. Nitrates showed very little change and organic mass showed some year-to-year variability.

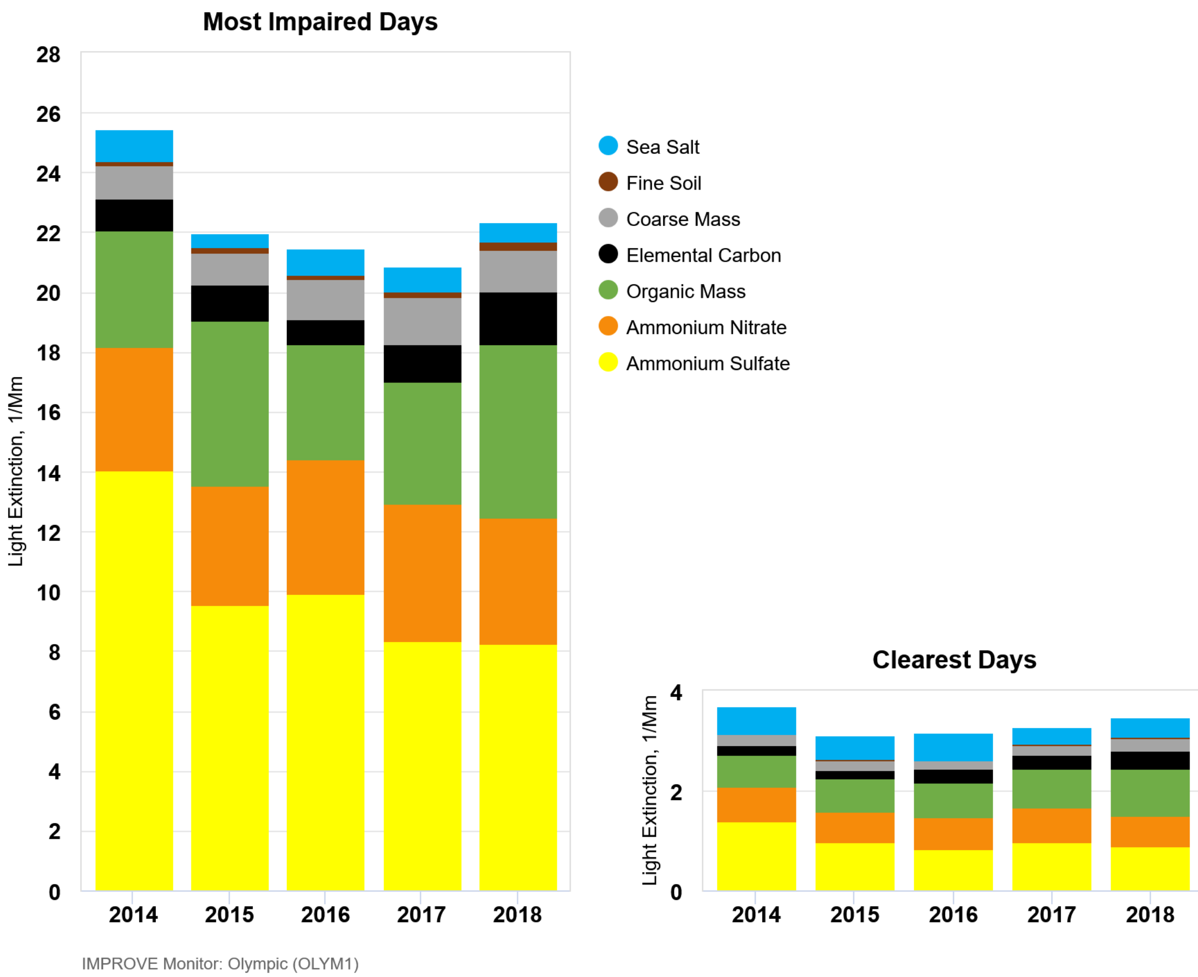

Figure 3–2: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at OLYM1.

Table 3-4 shows the annual species' contribution during the five-year period from 2014 - 2018 for the MID. Sulfates contributed nearly half of the light extinction to MID from 2014 - 2018. The percentage of organic mass increased in 2015 and 2018. During the five-year period, sulfates (44%) were the largest contributor to light extinction, followed by organic mass (21%) and nitrates (19%). Elemental carbon, coarse mass, fine soil, and sea salt had minimal contributions to light extinction.

Table 3-4: Annual species contributions to light extinction for MID from 2014 - 2018 at OLYM1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	4%	2%	4%	4%	3%	3%
Fine Soil	1%	1%	1%	1%	1%	1%
Coarse Mass	4%	5%	6%	8%	6%	6%
Elemental Carbon	4%	5%	4%	6%	8%	5%
Organic Mass	15%	25%	18%	20%	26%	21%
Ammonium Nitrate	16%	18%	21%	22%	19%	19%
Ammonium Sulfate	55%	44%	46%	40%	37%	44%

Table 3-5 shows the annual species contributions during the five-year period for the clearest days. Sulfates (30%) contributed the most to light extinction followed by organic mass (22%), nitrates (20%), and sea salt (14%).

Table 3-5: Annual species contributions to light extinction for clearest days from 2014 - 2018 at OLYM1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	15%	15%	17%	11%	11%	14%
Fine Soil	0%	1%	0%	0%	1%	0%
Coarse Mass	6%	7%	6%	6%	8%	7%
Elemental Carbon	5%	5%	8%	9%	10%	7%
Organic Mass	17%	22%	22%	23%	27%	22%
Ammonium Nitrate	19%	19%	21%	22%	17%	20%
Ammonium Sulfate	38%	31%	26%	29%	26%	30%

Table 3-6 and Table 3-7 show the seasonality of MID from 2014 - 2018. Sulfates contributed nearly half of the visibility impacts in spring, summer, and fall. Nitrates contributed a third of visibility impacts in the winter, but less for other seasons. The majority of MID occurred during the spring and summer, which is also when sulfate impacts were largest.

Table 3-6: Number of MID at OLYM1, by season, from 2014 - 2018.

Year	Winter	Spring	Summer	Fall
2014	1	7	10	6
2015	2	12	3	7
2016	1	5	14	4
2017	3	4	13	4
2018	3	8	8	5
5-yr Total	10	36	48	26

Table 3-7: Seasonal species contributions to light extinction for MID from 2014 - 2018 at OLYM1.

Species	Winter	Spring	Summer	Fall
Sea Salt	3%	3%	4%	3%
Fine Soil	1%	2%	1%	1%
Coarse Mass	4%	6%	7%	4%
Elemental Carbon	7%	6%	4%	7%
Organic Mass	22%	19%	19%	25%
Ammonium Nitrate	32%	17%	17%	21%
Ammonium Sulfate	31%	46%	49%	40%

Figure 3–3 shows the long-term trends for OLYM1. Nitrates and sulfates decreased since the baseline period for both MID and clearest days. Organic mass decreased for the clearest days over the past 17 years of observations.

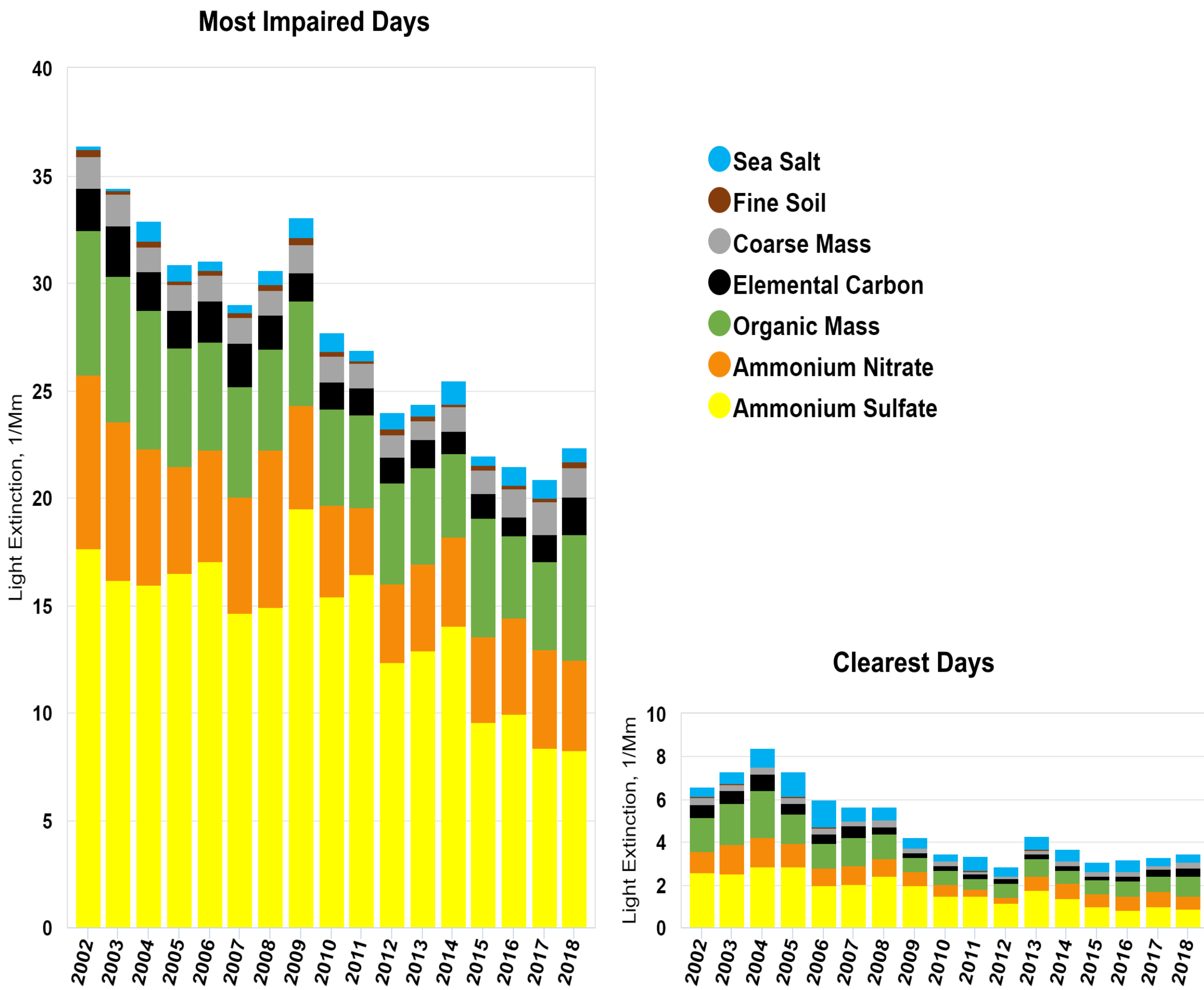

Figure 3–3: Annual species contributions to light extinction for MID and clearest days from 2002 - 2018 at OLYM1.

3.3 North Cascades National Park and Glacier Peak Wilderness

The NOCA1 monitoring site measures visibility in the North Cascades National Park and Glacier Peak Wilderness. Data for 2017 did not meet the data completeness requirements per the EPA document “Guidance for Tracking Progress under the RHR” (EPA, 2003). Twenty-three days (19% of the total) were missing for all species. WRAP performed data substitutions for 2017 using the OLYM1 IMPROVE site to address data completeness problems, due to the reasonable sulfate, elemental carbon, and organic mass correlation. See Appendix C for additional information on the WRAP data completeness memo.

The baseline visibility for the North Cascades National Park and Glacier Peak Wilderness is 3.4 dv for the clearest days and 12.6 dv for the MID. The unadjusted URP glidepath goes from 12.6 to 6.9 dv at a rate of 0.01 dv per year (5.7 dv divided by 60 years), which is the rate that needs to be maintained to reach natural visibility conditions in the park by 2064.

Based on the IMPROVE monitoring data, the 2014 – 2018 period visibility for the MID is 10.0 dv, and 2.5 dv for the clearest days. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 1.3 dv. The MID visibility improved by 2.6 dv from the baseline and is under the unadjusted URP glidepath. On the clearest days, the visibility improved by 0.9 dv.

Figure 3–4 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at NOCA1 for the five-year averages 2000 - 2008, 2008 - 2012, and 2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are below the glidepath, which indicates a rate of visibility improvement that will accomplish the 2064 natural conditions goal.

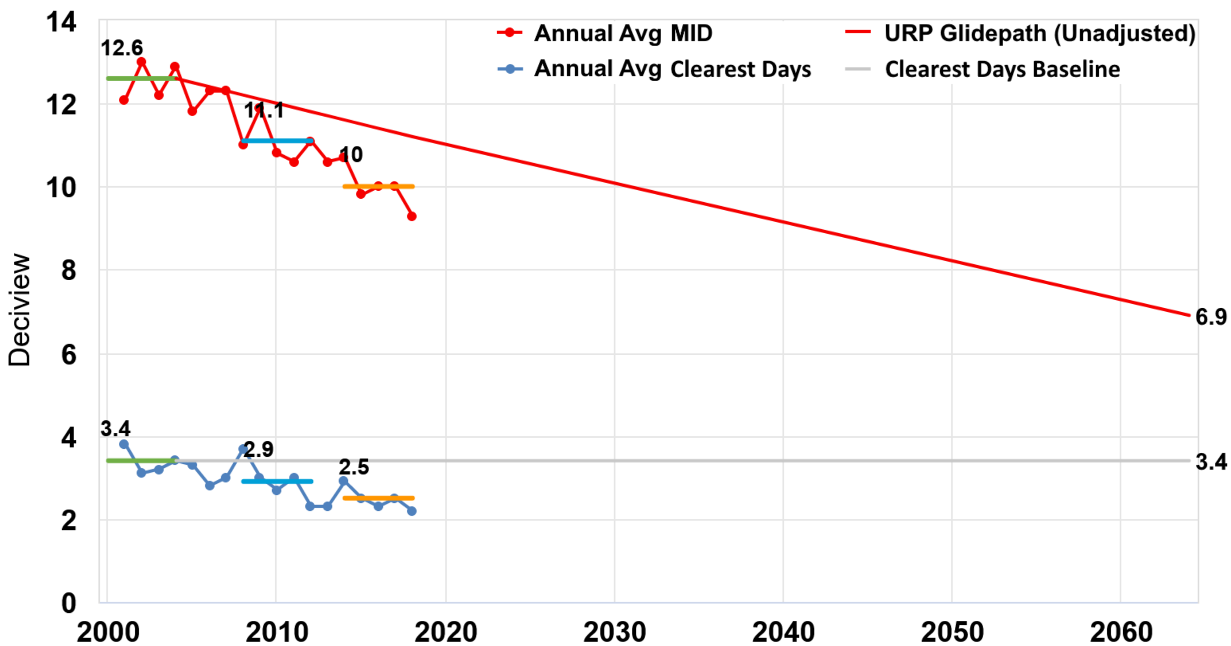

Figure 3–4: Current visibility conditions compared to the unadjusted glidepath (MID) and baseline (clearest days) at NOCA1.

Figure 3–5 shows the annual species contributions to light extinction from 2014 to 2018 for both MID and clearest days. Sulfates decreased for both MID and clearest days during the five-year period. Nitrates and organic mass showed some year-to-year variability.

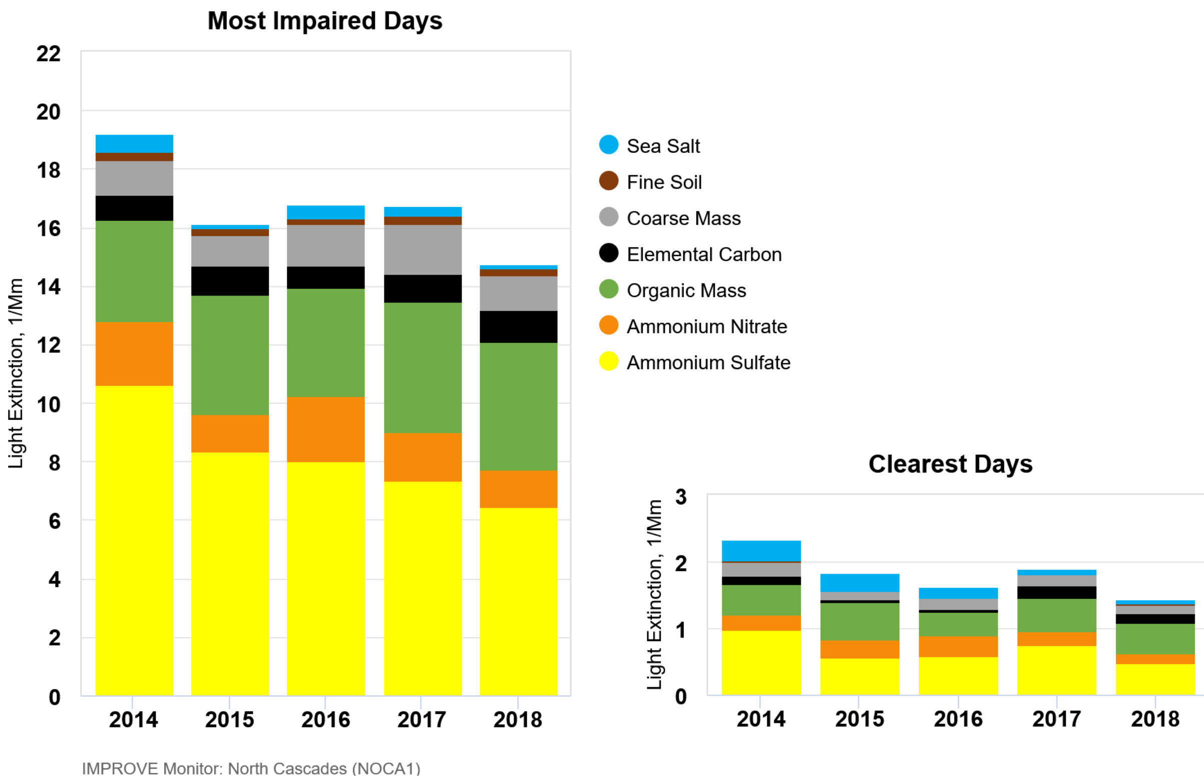

Figure 3–5: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at NOCA1.

Table 3-8 shows the annual species contributions during the five-year period for the MID. Sulfates contributed half of the light extinction to MID from 2014 - 2018. The percentage of organic mass increased in 2015, 2017, and 2018. During the five-year period, sulfates (49%) were the largest contributor to light extinction, followed by organic mass (24%), nitrates (10%), and coarse mass (8%). Elemental carbon, fine soil, and sea salt had minimal contributions to light extinction.

Table 3-8: Annual species contributions to light extinction for MID from 2014 - 2018 at NOCA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	3%	1%	3%	2%	1%	2%
Fine Soil	2%	2%	1%	2%	2%	2%
Coarse Mass	6%	7%	9%	10%	8%	8%
Elemental Carbon	4%	6%	4%	6%	7%	5%
Organic Mass	18%	25%	22%	27%	30%	24%
Ammonium Nitrate	11%	8%	13%	10%	9%	10%
Ammonium Sulfate	55%	52%	48%	44%	44%	49%

Table 3-9 shows the annual species contributions during the five-year period for the clearest days. Sulfates (36%) contributed the most to light extinction, followed by organic mass (26%). Note the relatively low contribution of nitrates for both MID and clearest days at NOCA1.

Table 3-9: Annual species contributions to light extinction for clearest days from 2014 - 2018 at NOCA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	14%	14%	10%	4%	5%	9%
Fine Soil	1%	1%	1%	1%	1%	1%
Coarse Mass	9%	7%	9%	8%	9%	8%
Elemental Carbon	5%	2%	3%	10%	9%	6%
Organic Mass	19%	30%	23%	27%	31%	26%
Ammonium Nitrate	10%	15%	19%	11%	11%	13%
Ammonium Sulfate	41%	31%	36%	39%	33%	36%

Table 3-10 and Table 3-11 show the seasonality of MID from 2014 - 2018. Sulfates contributed to the majority of light extinction for all seasons. Organic mass contributed to nearly a third of light extinction in the fall. Coarse mass contributed to 10% of the light extinction in the summer, but less for other seasons. The majority of MID occurred during the spring and summer, when nitrate and coarse mass contributions were largest.

Table 3-10: Number of MID at NOCA1, by season, from 2014 - 2018.

Year	Winter	Spring	Summer	Fall
2014	1	11	7	4
2015	2	14	4	3
2016	0	8	13	3
2017	2	7	13	2
2018	1	13	5	5
5-yr Total	6	53	42	17

Table 3-11: Seasonal species contributions to light extinction for MID from 2014 - 2018 at NOCA1.

Species	Winter	Spring	Summer	Fall
Sea Salt	0%	1%	2%	3%
Fine Soil	1%	2%	1%	1%
Coarse Mass	4%	7%	10%	6%
Elemental Carbon	6%	6%	5%	7%
Organic Mass	18%	23%	24%	29%
Ammonium Nitrate	5%	10%	12%	8%
Ammonium Sulfate	67%	50%	46%	46%

Figure 3–6 shows the long-term trends for NOCA1. Sulfates decreased since the baseline period for both MID and clearest days. Organic mass showed some year-to-year variability over the past 17 years of observations.

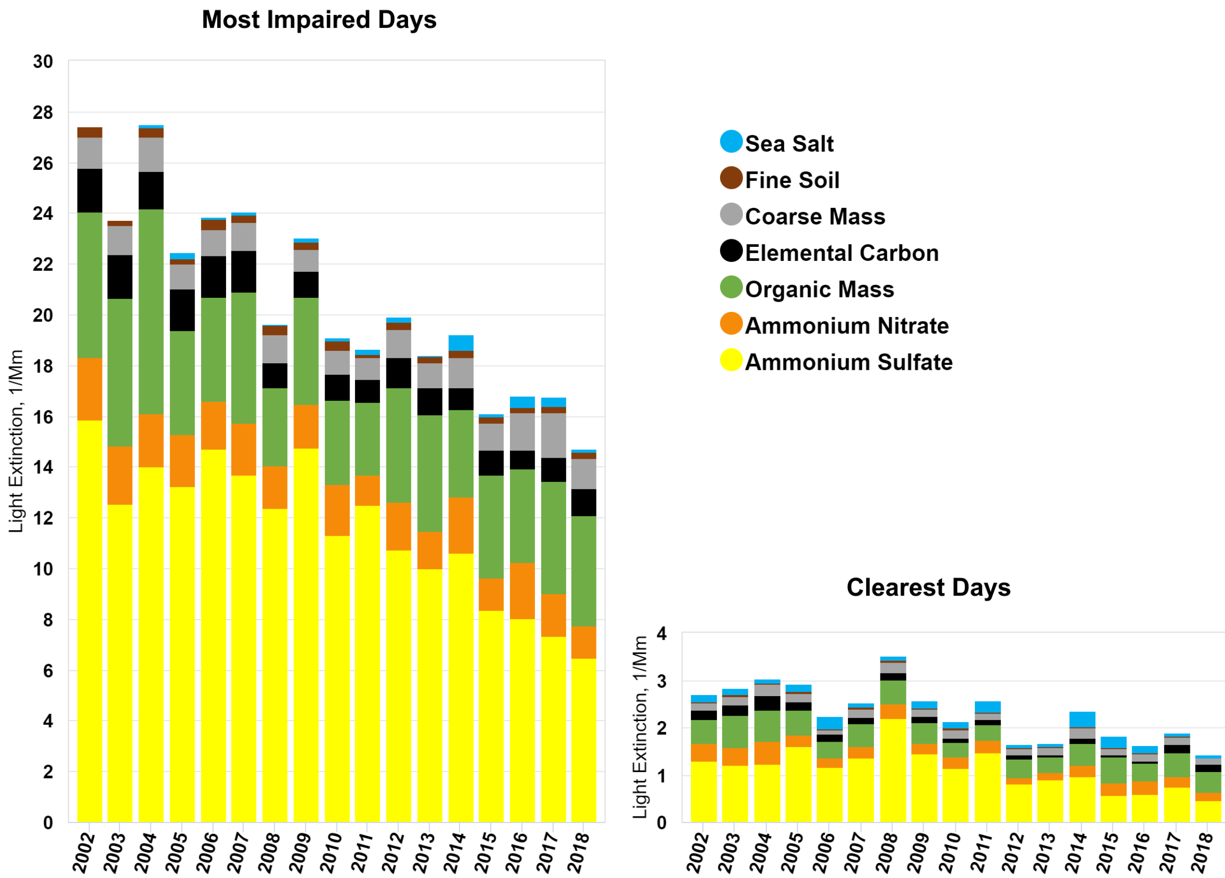

Figure 3–6: Annual species contributions to light extinction for MID and clearest days from 2002 to 2018 at NOCA1.

3.4 Alpine Lakes Wilderness

The SNPA1 monitoring site measures baseline visibility in the Alpine Lakes Wilderness for the MID and clearest days for the years 2001 - 2004. Data for 2013 did not meet the data completeness requirements per the EPA document "Guidance for Tracking Progress under the RHR." Fourteen days (12% of the total) were missing for all species. WRAP performed data substitutions for 2013 to using the MORA1 IMPROVE site to address data completeness problems, due to the strong sulfate and soil correlation, and reasonable elemental carbon, organic mass, and coarse matter correlation. See Appendix C for additional information on the WRAP data completeness memo.

The baseline visibility for the Alpine Lakes Wilderness is 5.5 dv for the clearest days and 15.4 dv for the MID. The unadjusted URP glidepath goes from 15.4 to 7.3 dv at a rate of 0.14 dv per year (8.1 dv divided by 60 years), which is the rate that would need to be maintained to reach natural visibility conditions in the park by 2064.

The current conditions (2014 – 2018) calculated from the SNPA1 monitoring data are 3.3 dv for the clearest day and 12.7 dv for the MID. The clearest days' visibility improved by 2.2 dv from the baseline. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 2.0 dv. The MID visibility improved by 2.7 dv and is below the unadjusted URP glidepath.

Figure 3–7 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at SNPA1 for the five-year averages 2000 - 2008, 2008 - 2012, and 2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are below the glidepath, which indicates a rate of visibility improvement that will accomplish the 2064 natural conditions goal.

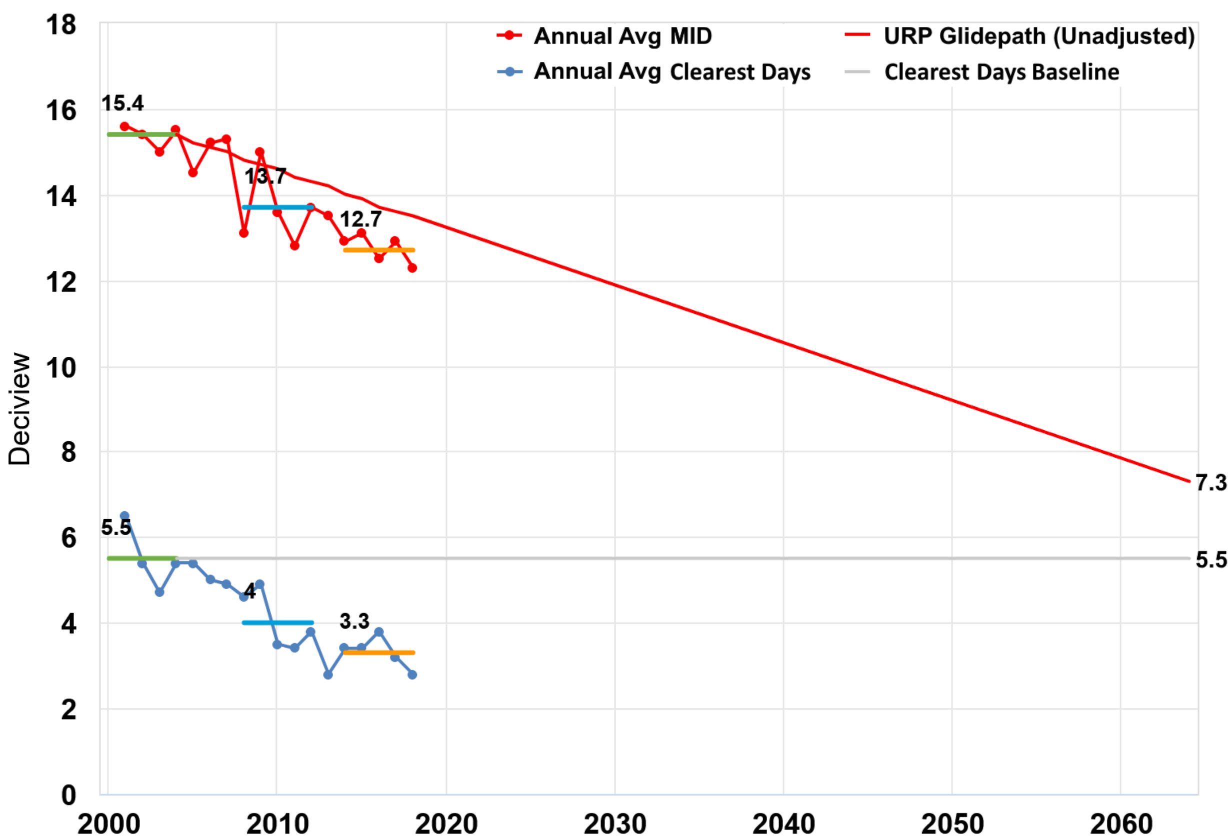

Figure 3–7: Current visibility conditions compared to the unadjusted URP glidepath and baseline (clearest days) at SNPA1.

Figure 3–8 shows the annual species contributions to light extinction from 2014 - 2018 for both MID and clearest days. Sulfates decreased for MID during the five-year period. Nitrates and organic mass showed some year-to-year variability.

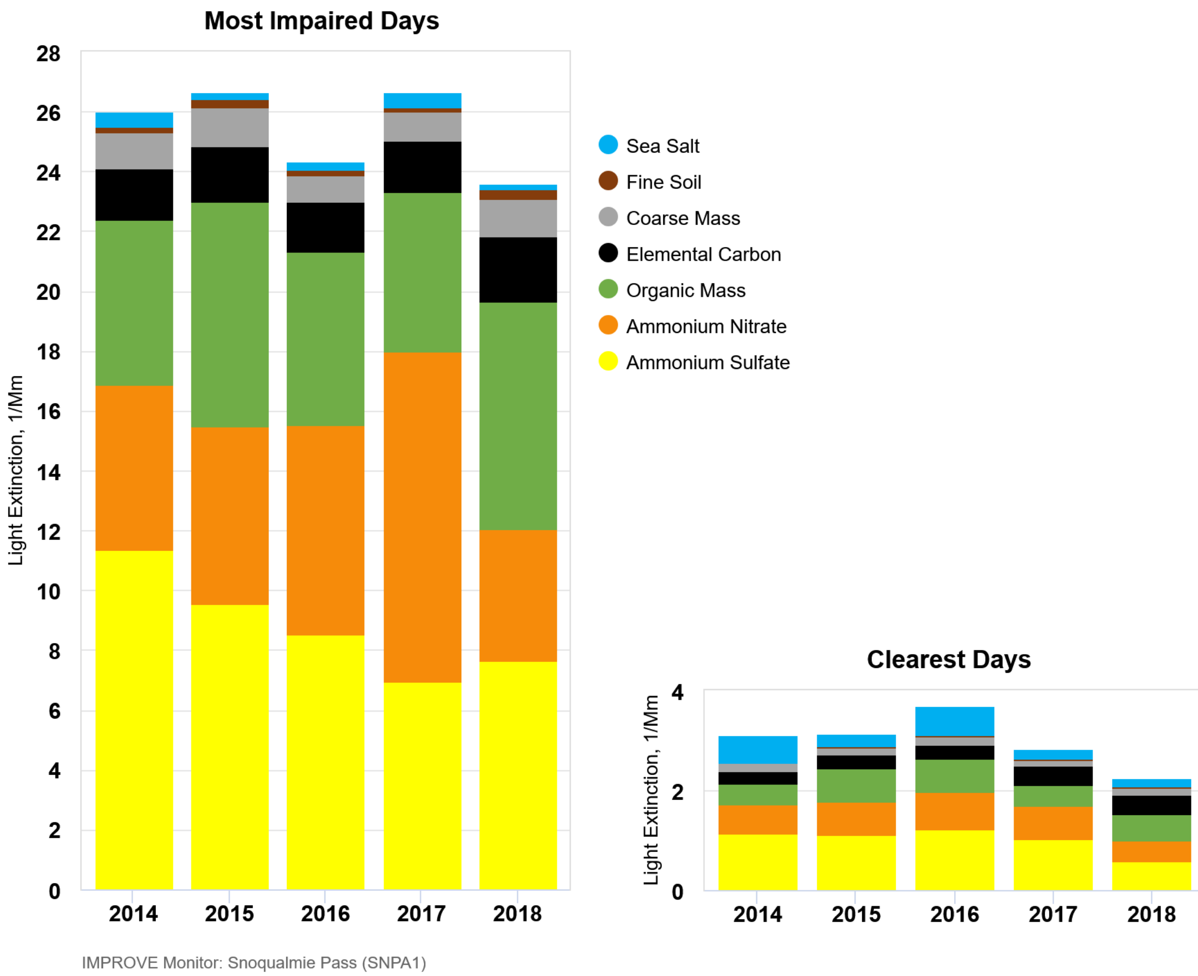

Figure 3–8: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at SNPA1.

Table 3-12 shows the annual species contribution during the five-year period for the MID. Sulfates contributed more than a third of the light extinction on MID from 2014 to 2018. The percentage of nitrates increased in 2017 while the percentage of organic mass increase in 2015 and 2018. During the five-year period, sulfates (35%) were the largest contributor to light extinction, followed by nitrates (26%) and organic mass (25%). Elemental carbon, coarse mass, fine soil, and sea salt had minimal contributions to light extinction.

Table 3-12: Annual species contributions to light extinction for MID from 2014 - 2018 at SNPA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	2%	1%	1%	2%	2%	2%
Fine Soil	1%	1%	1%	1%	1%	1%
Coarse Mass	5%	5%	4%	4%	5%	5%
Elemental Carbon	7%	7%	7%	6%	9%	7%
Organic Mass	21%	28%	24%	20%	32%	25%
Ammonium Nitrate	21%	22%	29%	41%	19%	26%
Ammonium Sulfate	44%	36%	35%	26%	32%	35%

Table 3-13 shows the annual species contributions during the five-year period for the clearest days. Sulfates (33%) contributed the most to light extinction, followed by nitrates (20%), sea salt (19%), organic mass (18%), and elemental carbon (12%).

Table 3-13: Annual species contributions to light extinction for clearest days from 2014 - 2018 at SNPA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	18%	21%	18%	14%	23%	19%
Fine Soil	1%	1%	0%	1%	1%	1%
Coarse Mass	5%	4%	5%	4%	6%	5%
Elemental Carbon	9%	9%	8%	14%	18%	12%
Organic Mass	13%	21%	18%	14%	23%	18%
Ammonium Nitrate	19%	21%	20%	23%	19%	20%
Ammonium Sulfate	36%	35%	33%	37%	26%	33%

Table 3-14 and Table 3-15 show the seasonality of MID from 2014 - 2018. Sulfates contributed nearly half of the light extinction in spring and summer. Nitrates contributed two thirds of the light extinction in winter, but much less for other seasons. Organic mass contributed to nearly a third of light extinction in the summer and fall. The majority of MID occurred in spring, summer, and fall.

Table 3-14: Number of MID at SNPA1, by season, from 2014 - 2018.

Year	Winter	Spring	Summer	Fall
2014	2	8	9	5
2015	0	10	7	6
2016	2	4	10	6
2017	5	3	10	5
2018	1	7	6	9
5-yr Total	10	32	42	31

Table 3-15: Seasonal species contributions to light extinction for MID from 2014 - 2018 at SNPA1.

Species	Winter	Spring	Summer	Fall
Sea Salt	2%	2%	1%	1%
Fine Soil	0%	2%	1%	0%
Coarse Mass	2%	6%	6%	3%
Elemental Carbon	5%	7%	7%	8%
Organic Mass	10%	22%	29%	29%
Ammonium Nitrate	66%	19%	16%	32%
Ammonium Sulfate	16%	44%	40%	27%

Figure 3–9 shows the long-term trends for SNPA1. Sulfates have decreased since the baseline period for MID. Every species decreased since the baseline period for clearest days.

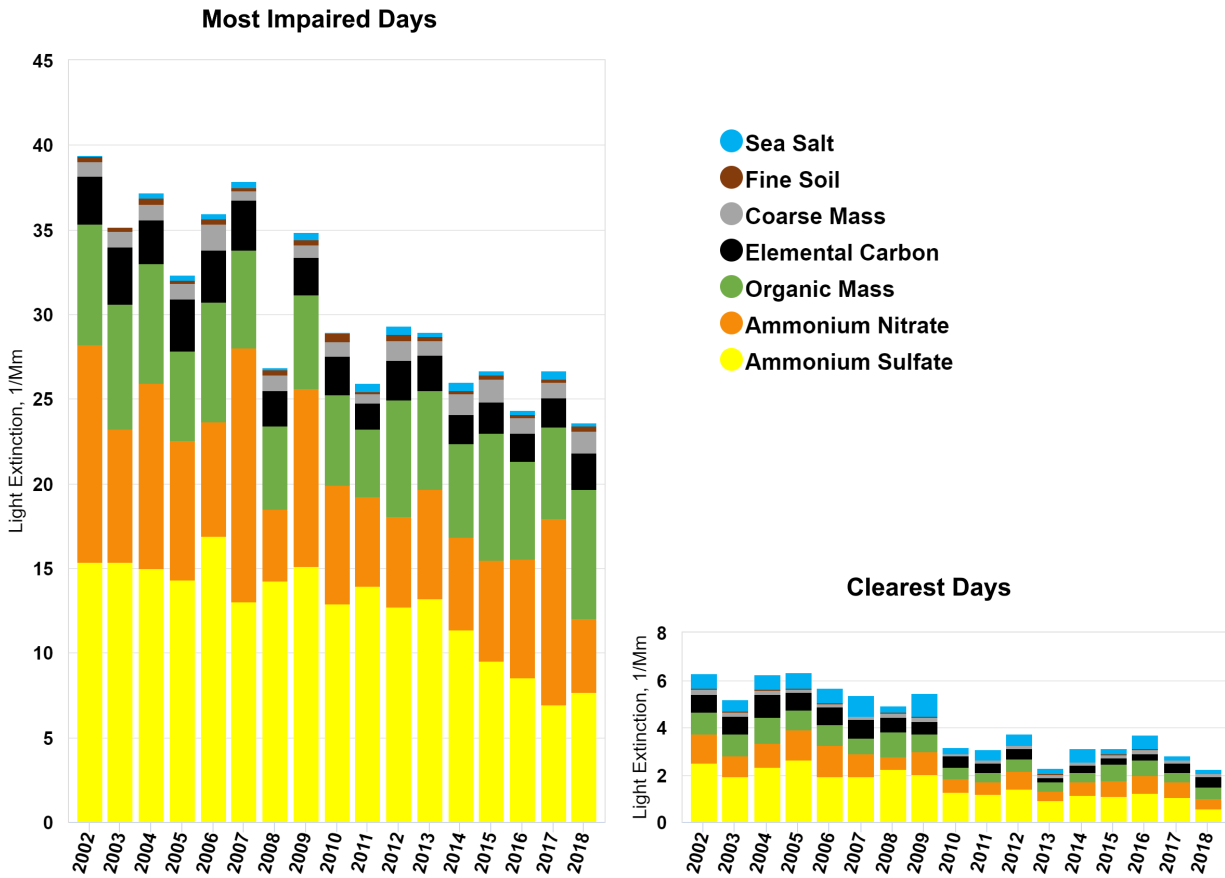

Figure 3–9: Annual species contributions to light extinction for MID and clearest days from 2002 - 2018 at SNPA1.

3.5 Mount Rainier National Park

The baseline visibility for the Mount Rainier National Park is 5.5 dv for the clearest days and 16.5 dv for the MID. The unadjusted URP glidepath goes from 16.5 to 7.7 dv at a rate of 0.15 dv per year (9.8 dv divided by 60 years), which is the rate that would need to be maintained to reach natural visibility conditions in the park by 2064.

The current conditions (2014 - 2018) calculated from the MORA1 monitoring data are 3.9 dv for the clearest days and 12.7 for the MID. The clearest days' visibility improved by 1.6 dv from the baseline. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 2.1 dv. The MID visibility improved by 3.8 dv and is under the unadjusted URP glidepath.

Figure 3–10 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at MORA1 for the five-year averages 2000 - 2008, 2008 - 2012, and 2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are below the glidepath, which indicates a rate of visibility improvement that will accomplish the 2064 natural conditions goal.

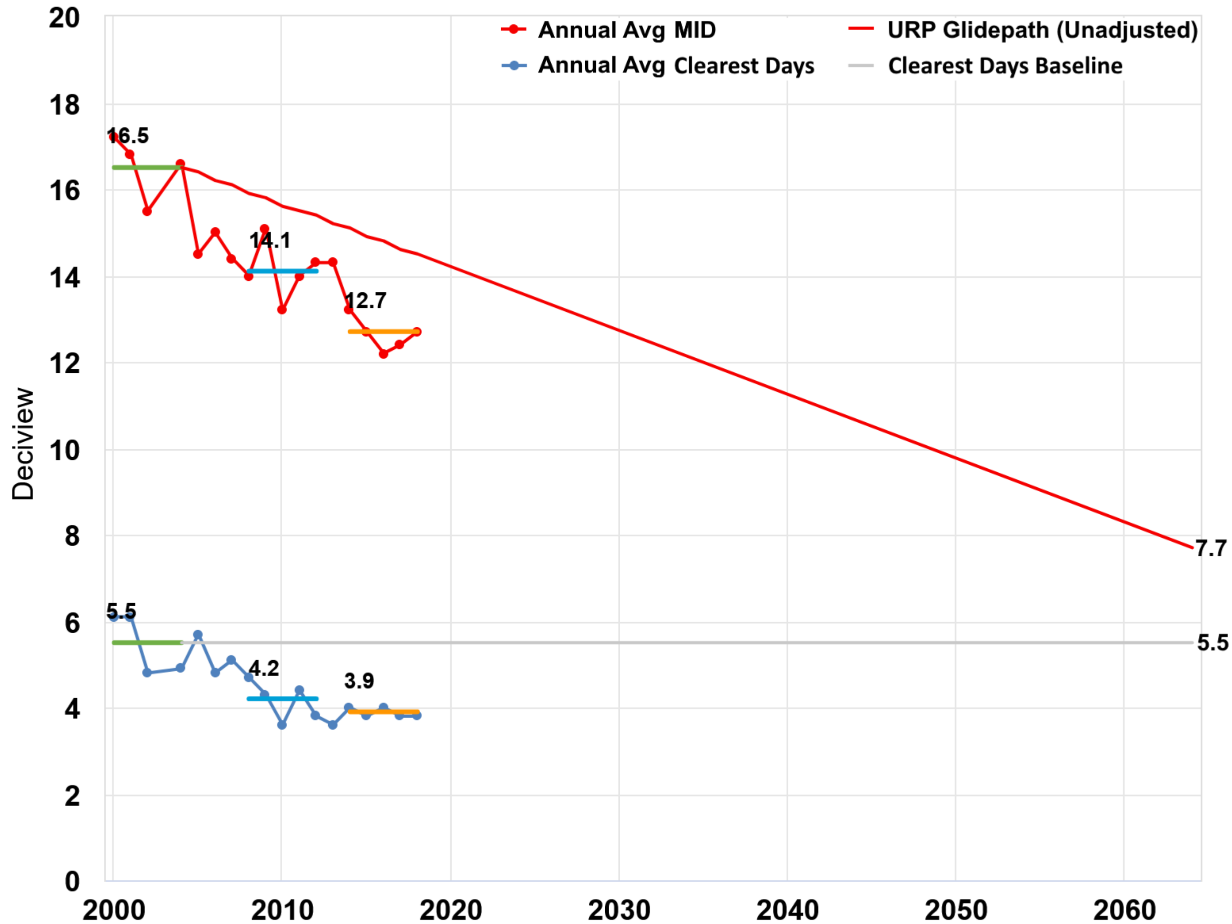

Figure 3–10: Current visibility conditions compared to the unadjusted URP glidepath and baseline (clearest days) at MORA1.

Figure 3–11 shows the annual species contributions to light extinction from 2014 - 2018 for both MID and clearest days. Sulfates decreased each year for MID. Organic mass increased in 2018 for MID. The clearest days showed very little change for all species.

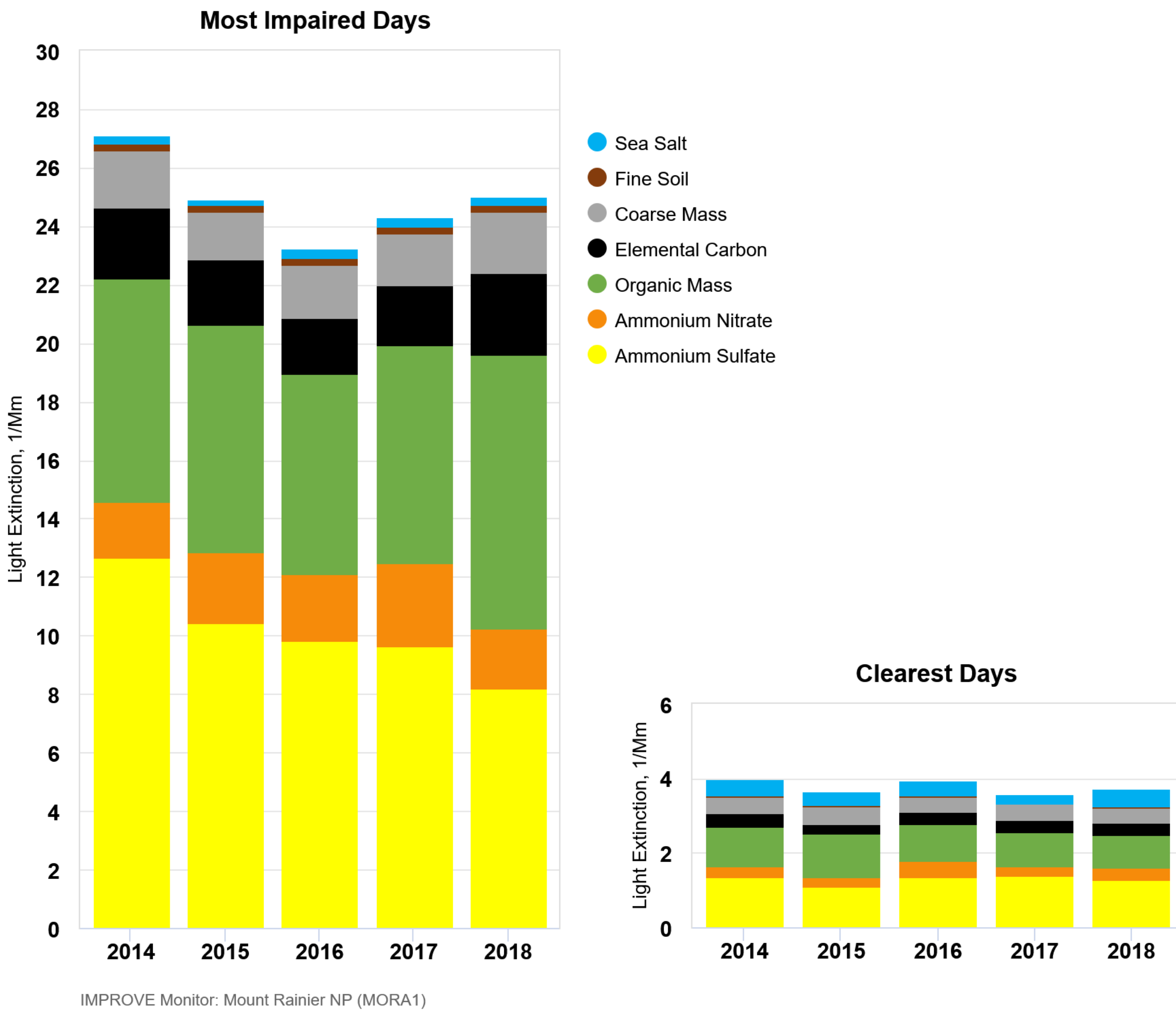

Figure 3–11: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at MORA1.

Table 3-16 shows the annual species contributions during the five-year period for the MID. Sulfates contributed more than a third of the light extinction to MID from 2014 - 2018. Organic mass contributed to nearly a third of the light extinction, but increased in 2018. During the five-year period, sulfates (41%) were the largest contributor to light extinction, followed by organic mass (31%), nitrates (9%), and elemental carbon (9%).

Table 3-16: Annual species contributions to light extinction for MID from 2014 - 2018 at MORA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	1%	0%	1%	1%	1%	1%
Fine Soil	1%	1%	1%	1%	1%	1%
Coarse Mass	7%	7%	8%	7%	8%	7%
Elemental Carbon	9%	9%	8%	8%	11%	9%
Organic Mass	28%	31%	29%	31%	38%	31%
Ammonium Nitrate	7%	10%	10%	12%	8%	9%
Ammonium Sulfate	47%	42%	42%	40%	33%	41%

Table 3-17 shows the annual species contributions during the five-year period for the clearest days. Sulfates (35%) contributed the most to light extinction, following by organic mass (26%), coarse mass (12%), and sea salt (10%).

Table 3-17: Annual species contributions to light extinction for clearest days from 2014 - 2018 at MORA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	11%	10%	11%	7%	13%	10%
Fine Soil	0%	1%	0%	1%	1%	1%
Coarse Mass	11%	13%	11%	12%	11%	12%
Elemental Carbon	10%	7%	8%	9%	9%	9%
Organic Mass	26%	32%	25%	25%	24%	26%
Ammonium Nitrate	8%	7%	11%	7%	9%	8%
Ammonium Sulfate	34%	31%	35%	39%	34%	35%

Table 3-18 and Table 3-19 show the seasonality of MID from 2014 - 2018. Sulfates contributed nearly half of the light extinction in spring and summer. Organic mass contributed more than a third of the light extinction in fall and winter. The majority of MID occurred during the spring and summer, which is also when sulfate and nitrate impacts are highest.

Table 3-18: Number of MID at MORA1, by season, from 2014 - 2018.

Year	Winter	Spring	Summer	Fall
2014	3	3	14	3
2015	3	12	5	3
2016	1	6	12	5
2017	1	3	15	4
2018	1	8	8	7
5-yr Total	9	32	54	22

Table 3-19: Seasonal species contributions to light extinction for MID from 2014 - 2018 at MORA1.

Species	Winter	Spring	Summer	Fall
Sea Salt	1%	1%	1%	1%
Fine Soil	1%	1%	1%	0%
Coarse Mass	3%	7%	8%	8%
Elemental Carbon	19%	8%	8%	12%
Organic Mass	41%	29%	31%	36%
Ammonium Nitrate	6%	10%	9%	7%
Ammonium Sulfate	29%	43%	42%	36%

Figure 3–12 shows the long-term trends for MORA1. Sulfates decreased since the baseline period for both MID and clearest days.

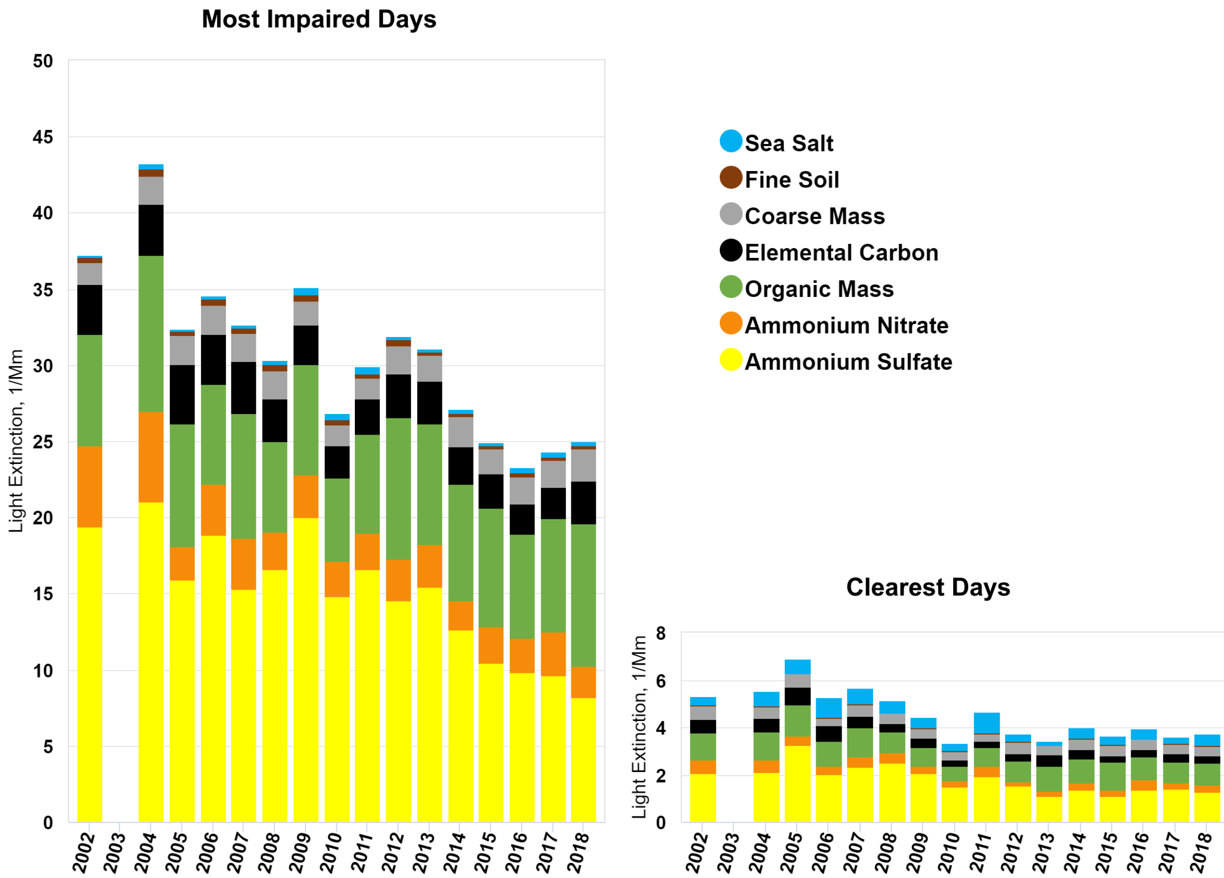

Figure 3–12: Annual species contributions to light extinction for MID and clearest days from 2002 - 2018 at MORA1.

3.6 Goat Rocks Wilderness and Mount Adams Wilderness

The baseline visibility for the Goat Rocks Wilderness and Mount Adams Wilderness is 1.7 dv for the clearest days and 10.5 dv for the MID. The unadjusted URP glidepath goes from 10.5 to 6.1 dv at a rate of 0.07 dv per year (4.4 dv divided by 60 years), which is the rate that would need to be maintained to reach natural visibility conditions in the park by 2064.

The current conditions (2014 - 2018) calculated from WHPA1 monitoring data are 1.0 dv for the clearest days and 8.0 dv for the MID. The clearest days' visibility improved by 0.7 dv from the baseline. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 1.0 dv. The MID visibility improved by 2.5 dv and is under the unadjusted URP glidepath.

Figure 3–13 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at WHPA1 for the five-year averages 2000 - 2008, 2008 - 2012, and 2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are below the glidepath, which indicates a rate of visibility improvement that will accomplish the 2064 natural conditions goal.

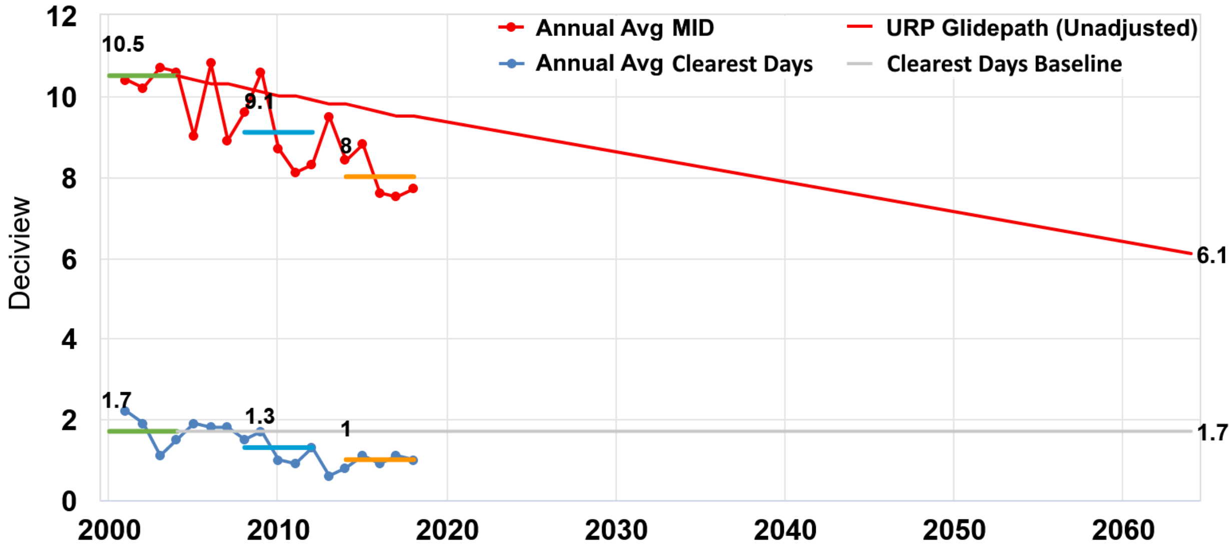

Figure 3–13: Current visibility conditions compared to the unadjusted URP glidepath and baseline (clearest days) at WHPA1.

Figure 3–14 shows the annual species contributions to light extinction from 2014 - 2018 for both MID and clearest days. Sulfates decreased in 2016 for MID, with the decrease sustained through the rest of the five-year period. Organic mass increased in 2015 and 2018 for MID. All species showed very little change for clearest days.

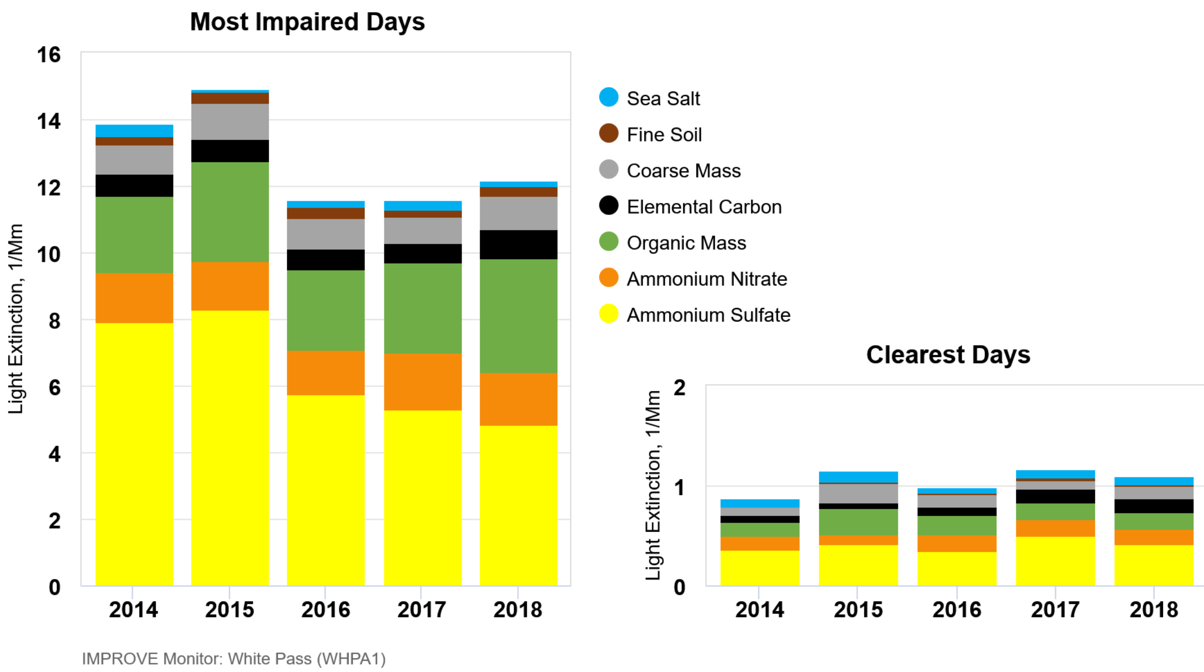

Figure 3–14: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at WHPA1.

Table 3-20 shows the annual species contribution during the five-year period for the MID. Sulfates contributed half of the light extinction to MID from 2014 - 2018. During the five-year period, sulfates (50%) were the largest contributor to light extinction, followed by organic mass (22%) and nitrates (12%). Elemental carbon, coarse mass, fine soil, and sea salt had minimal contributions to light extinction.

Table 3-20: Annual species contributions to light extinction for MID from 2014 - 2018 at WHPA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	3%	1%	2%	2%	2%	2%
Fine Soil	2%	2%	3%	2%	2%	2%
Coarse Mass	6%	7%	8%	7%	8%	7%
Elemental Carbon	5%	4%	5%	5%	7%	5%
Organic Mass	16%	20%	21%	23%	28%	22%
Ammonium Nitrate	11%	10%	11%	15%	13%	12%
Ammonium Sulfate	57%	56%	50%	46%	40%	50%

Table 3-21 shows the annual species contributions during the five-year period for the clearest days. Sulfates (39%) contributed the most to light extinction followed by organic mass (18%), nitrates (14%), and coarse mass (12%).

Table 3-21: Annual species contributions to light extinction for clearest days from 2014 - 2018 at WHPA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	9%	10%	6%	8%	7%	8%
Fine Soil	1%	1%	1%	1%	2%	1%
Coarse Mass	9%	17%	13%	8%	12%	12%
Elemental Carbon	8%	5%	8%	11%	12%	9%
Organic Mass	17%	23%	20%	15%	15%	18%
Ammonium Nitrate	15%	9%	18%	14%	14%	14%
Ammonium Sulfate	42%	36%	35%	43%	38%	39%

Table 3-22 and Table 3-23 show the seasonality of MID from 2014 - 2018. Sulfates contributed most of the visibility impacts in all seasons. Organic mass contributed nearly a third of visibility impacts in the summer, but less for other seasons. The majority of MID occurred during the spring, when nitrate and coarse mass contributions were largest.

Table 3-22: Number of MID at WHPA1, by season, from 2014 - 2018.

Year	Winter	Spring	Summer	Fall
2014	3	11	3	5
2015	3	10	5	3
2016	0	8	8	7
2017	2	8	11	2
2018	3	9	3	8
5-yr Total	11	46	30	25

Table 3-23: Seasonal species contributions to light extinction for MID from 2014 - 2018 at WHPA1.

Species	Winter	Spring	Summer	Fall
Sea Salt	1%	1%	2%	3%
Fine Soil	2%	3%	1%	1%
Coarse Mass	6%	8%	8%	6%
Elemental Carbon	7%	5%	5%	6%
Organic Mass	14%	19%	29%	22%
Ammonium Nitrate	11%	14%	11%	9%
Ammonium Sulfate	60%	49%	45%	54%

Figure 3–15 shows the long-term trends for WHPA1. Sulfates, nitrates, and organic mass decreased since the baseline period for both MID and clearest days.

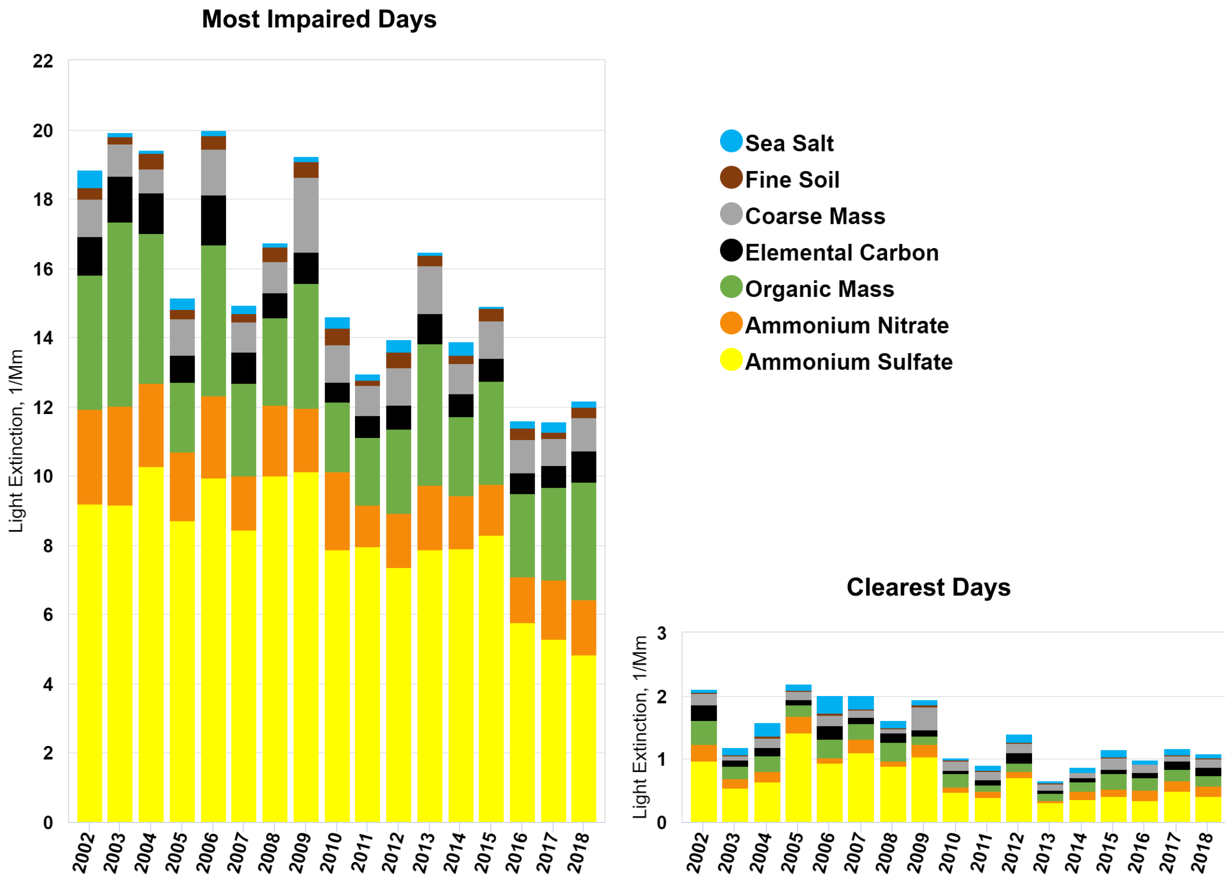

Figure 3–15: Annual species contributions to light extinction for MID and clearest days from 2002 - 2018 at WHPA1.

3.7 Pasayten Wilderness

The baseline visibility for the Pasayten Wilderness is 2.7 dv for the clearest days and 10.4 dv for the MID. Pasayten had the best baseline visibility conditions for the MID of all Washington's Class 1 Areas, and is the second best for the visibility on the clearest days. The unadjusted URP glidepath goes from 10.4 to 6.0 dv at a rate of 0.07 dv per year (4.4 dv divided by 60 years), which is the rate that would need to be maintained to reach natural visibility conditions in the park by 2064.

The current conditions (2014 – 2018) calculated from the PASA1 monitoring data are 1.6 dv for the clearest days and 9.5 dv for the MID. The clearest days' visibility improved by 1.1 dv from the baseline. The amount of visibility improvement from the baseline to 2018 required to stay below the 2018 URP unadjusted glidepath for MID is 1.0 dv. The MID visibility improved by 0.9 dv so the Pasayten's five-year average for MID is slightly above the unadjusted URP glidepath.

Figure 3–16 shows the MID compared to the unadjusted URP glidepath, and the clearest days compared to the baseline at PASA1 for the five-year averages 2000 - 2008, 2008 - 2012, and 2014 - 2018; and the annual averages for the MID and clearest days since 2002. The most recent annual average MID are above the glidepath. Note that some days included in the MID were influenced wildfire smoke. Ecology estimated that in Pasayten from 2014-2018, seven percent of the haziest days were influenced by wildfire, with considerable year-to-year variability. Thus, the removal of five percent of the haziest days as allowed by the RHR was insufficient to remove natural events such as wildfire from the MID. After the proposed endpoint adjustment for international emissions in **Chapter 9**, as allowed by the RHR, the most recent MID are below the adjusted glidepath, which indicates a rate of visibility improvement that will accomplish the adjusted 2064 natural conditions goal.

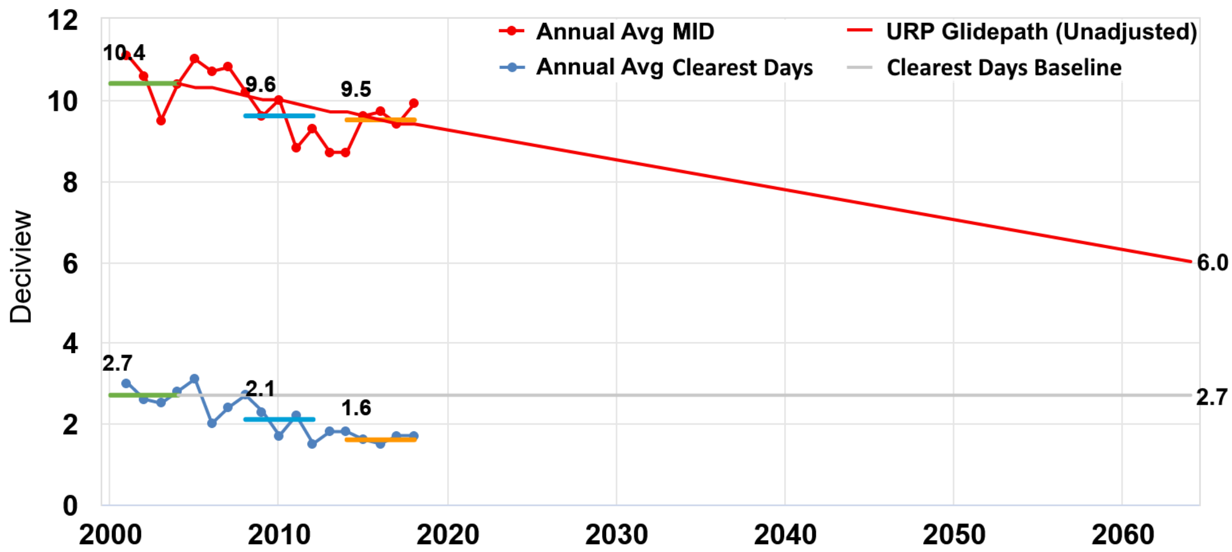

Figure 3–16: Current visibility conditions compared to the unadjusted URP glidepath and baseline (clearest days) at PASA1.

Figure 3–17 shows the annual species contributions to light extinction from 2014 - 2018 for both MID and clearest days. Sulfates decreased over the five-year period for MID and clearest days. Organic mass increased and nitrate showed year-to-year variability for MID. All species showed very little change for clearest days.

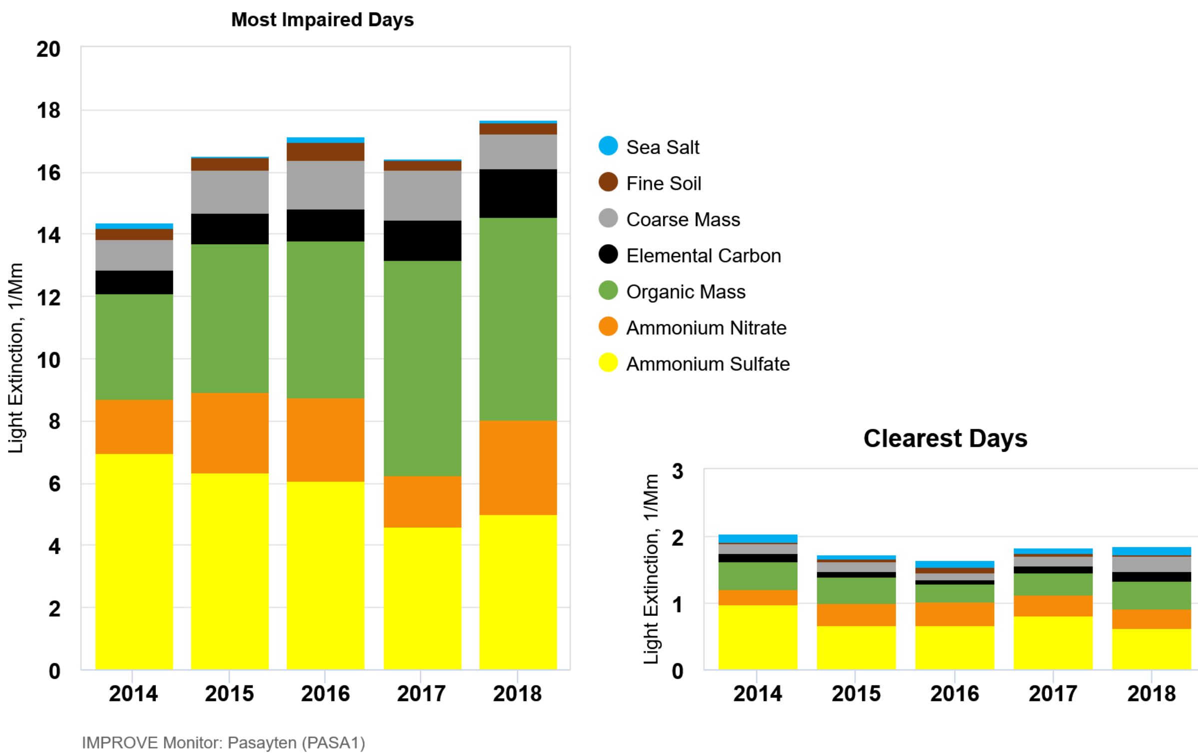

Figure 3–17: Annual species contributions to light extinction for MID and clearest days from 2014 - 2018 at PASA1.

Table 3-24 shows the annual species contributions during the five-year period for the MID. Sulfates and organic mass each contributed one third of the light extinction to MID from 2014 - 2018. Organic mass increased in 2017 and 2018. During the five-year period, contributions to light extinction were largest from sulfates (35%), organic mass (32%), and nitrates (14%). Elemental carbon, coarse mass, fine soil, and sea salt had minimal contributions to light extinction.

Table 3-24: Annual species contributions to light extinction for MID from 2014 - 2018 at PASA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	1%	1%	1%	0%	0%	1%
Fine Soil	2%	2%	3%	2%	2%	2%
Coarse Mass	7%	8%	9%	10%	6%	8%
Elemental Carbon	5%	6%	6%	8%	9%	7%
Organic Mass	24%	29%	30%	42%	37%	32%
Ammonium Nitrate	12%	16%	16%	10%	17%	14%
Ammonium Sulfate	48%	38%	35%	28%	28%	35%

Table 3-25 shows the annual species contributions during the five-year period for the clearest days. Sulfates (41%) contributed the most to light extinction followed by organic mass (20%) and nitrates (17%).

Table 3-25: Annual species contributions to light extinction for clearest days from 2014 - 2018 at PASA1.

Species	2014	2015	2016	2017	2018	Average
Sea Salt	5%	4%	4%	4%	6%	5%
Fine Soil	1%	2%	6%	2%	2%	3%
Coarse Mass	7%	9%	7%	8%	12%	9%
Elemental Carbon	6%	5%	4%	6%	8%	6%
Organic Mass	20%	23%	16%	18%	22%	20%
Ammonium Nitrate	12%	18%	22%	17%	15%	17%
Ammonium Sulfate	48%	39%	41%	45%	34%	41%

Table 3-26 and Table 3-27 show the seasonality of MID from 2014 - 2018. Sulfates contributed nearly half the visibility impacts in winter and spring. Organic mass contributed more than a third of visibility impacts in summer and fall. The majority of MID occurred in the fall and spring, but summer MID increased in 2017 due to the large wildfire season in the Pacific Northwest. Six of the seven summer MID in 2017 were during regional wildfire events (Dates: July 12, 2017; July 15, 2017; July 24, 2017; August 14, 2017; August 17, 2017; September 19, 2017). Eleven regional wildfire days were included in the MID for PASA during the five-year period, suggesting that the standard threshold to remove wildfire impacts from MID (top 5% of large organic mass days) was insufficient.

Table 3-26: Number of MID at PASA1, by season, from 2014 to 2018.

Year	Winter	Spring	Summer	Fall
2014	4	11	0	8
2015	1	8	3	9
2016	0	9	4	11
2017	1	7	7	8
2018	2	8	2	12
5-yr Total	8	43	16	48

Table 3-27: Seasonal species contributions to light extinction for MID from 2014 to 2018 at PASA1.

Species	Winter	Spring	Summer	Fall
Sea Salt	0%	0%	1%	1%
Fine Soil	1%	4%	3%	1%
Coarse Mass	3%	11%	13%	5%
Elemental Carbon	6%	5%	6%	8%
Organic Mass	16%	25%	43%	37%
Ammonium Nitrate	24%	10%	5%	19%
Ammonium Sulfate	49%	44%	29%	28%

Figure 3–18 shows the long-term trends for PASA1. Sulfates decreased since the baseline period for both MID and clearest days. Organic mass and nitrates showed some year-to-year variability for MID.

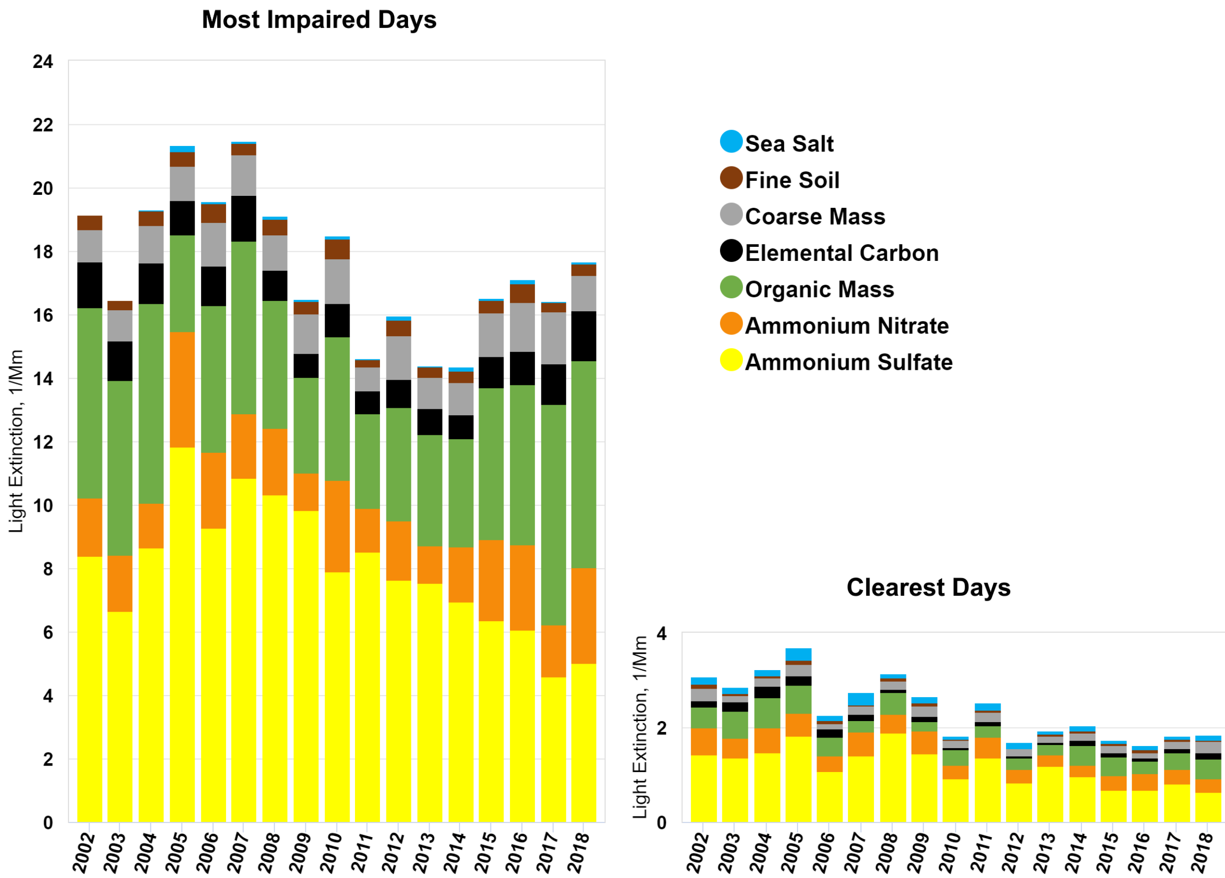

Figure 3–18: Annual species contributions to light extinction for MID and clearest days from 2002 to 2018 at PASA1.

3.8 Summary

All of Washington's Class 1 Areas have shown improvements in visibility on the MID since the baseline and since the first implementation period. The visibility also has not degraded on the clearest days. Sulfates, nitrates and organic mass are the largest contributors to regional haze, with organic mass showing variability from year-to-year. All the Class 1 Areas are also below the unadjusted glidepath for this implementation period except the current five-year MID average for the Pasayten Wilderness, although it has some of the best visibility in Washington. The Pasayten's five-year average is slightly above the unadjusted glidepath due to effects of wildfire where the removal of five percent of the haziest days was insufficient to compensate for the effects of fire. The area also borders Canada and receives the most international contributions. In subsequent chapters, we propose adjusting the endpoint of the URP glidepath to account for the impact from international emissions. The Pasayten's 5-year MID average is below the URP glidepath when adjusted for international contributions.

Chapter 4. Emissions Inventory

This chapter summarizes emissions from sources located in Washington that could be affecting visibility in mandatory class 1 federal areas (Class 1 Areas) in Washington and other states. The Regional Haze Rule (RHR) (40 CFR 51.308 (f)(6)(v)) requires a statewide emissions inventory (EI) of pollutants that we reasonably anticipate to cause or contribute to visibility impairment in any Class 1 Areas. This chapter describes the EI development process, the various EI scenarios developed for regional haze (RH) modeling, a summary of the emissions from each anthropogenic source category, and changes in emissions at facilities selected for a four-factor analysis (FFA).

4.1 Emissions inventory development

The emissions summaries presented in this chapter play an important role in the identification and evaluation of sources that we reasonably expect to influence visibility. An accurate EI helps prioritize emission reduction efforts and helps ensure that model predictions of 2028 visibility impairment are reasonable. The year 2028 represents the second milestone date for demonstrating reasonable progress toward the national visibility goal.

State, local, and tribal air pollution control programs regularly collect and report EI data to EPA. EPA publishes a national emissions inventory (NEI) every three years, which includes all sources of air pollution. Reviewing EI summaries, identifying issues, and correcting errors is an important process that provides a better understanding of emissions sources that could be contributing to visibility impairment.

Western Regional Air Partnership (WRAP) workgroups compiled EI data for use in WRAP modeling and individual state analyses. EI summaries are available from the WRAP Technical Support System (TSS) website[5]. The TSS website also provides references that describe the methods used for RH SIP EI development.

The EPA NEI is the cornerstone of regional haze state implementation plan (RH SIP) EI development. WRAP developed the EI data for RH modeling in collaboration with state, local, and tribal air pollution control programs and EPA, using the 2014 NEI as the starting point. WRAP made several improvements to the 2014 NEI using corrections submitted by the regulatory agencies and updates from the EPA 2016 modeling platform. EPA subsequently released the 2017 NEI in 2020, summarized in this chapter for reference.

4.2 Emissions inventory scenarios

The WRAP focused on EI development for three scenarios: 2014 Actual, Representative Baseline (RepBase), and 2028 On-the-Books (OTB):

- The 2014 Actual EI is a quality-controlled dataset, including state corrections to the 2014 NEI point and nonpoint sources. The purpose of the 2014 Actual EI is to represent the

[5] http://views.cira.colostate.edu/tssv2/

actual emissions of pollutants causing or contributing to visibility impairment during calendar year 2014. The WRAP considers the 2014 Actual EI to be the best available estimates of 2014 emissions for all states in the WRAP. The WRAP used the 2014 Actual EI as the basis to model visibility for the calendar year 2014 and to evaluate model performance.

- The RepBase EI is the modeling baseline used for comparison to future projections. The WRAP designed the Rep Base EI to be the best available data representative of the 2014-2018 five-year period. Ecology used the 2014 Actual EI to develop the RepBase EI with the following updates: states and WRAP workgroups submitted point source emissions, WRAP workgroups developed a representative fire EI, and used the EPA 2016 modeling platform for nonroad emissions. Industrial pulp and paper mill emissions in Washington used the 2017 values for the RepBase EI.
- The 2028 OTB EI is a projected inventory to evaluate reasonable progress toward achieving the national visibility goal. This EI uses the 2016 modeling platform projections for 2028 and emissions submitted by state, local, and tribal air pollution control programs and WRAP workgroups. It includes additional controls or plant closures, which have a planned completion prior to 2028.

The WRAP estimated emissions for the year 2028 by including “On-the-Books” (that is, adopted or soon to be adopted) controls, regulations, and major facility changes. The OTB EI also includes changes to mobile (on-road and non-road) sources as represented in the EPA 2016 modeling platform projections of 2028 emissions. EPA based 2028 mobile source emissions on known fuel standards and projections of population and mobile fleet make-up.

The documentation section of the webpage entitled “Inventory Collaborative 2016v1 Emissions Modeling Platform” [6] (WRAP) cites the methods for projecting mobile source emissions. In summary:

- EPA projected the Commercial Marine Vessel (CMV) (C1 and C2) emissions from 2016 to 2028 using factors derived from the Regulatory Impact Analysis (RIA) *Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder (73 FR 37095)*.
- EPA developed growth rates for CMV (C3) emissions from 2016 to 2028 using an EPA report on projected bunker fuel demand. The EPA used bunker fuel usage as a surrogate for marine vessel activity.
- EPA estimated locomotive fuel use for 2028 based on the 2018 Annual Energy Outlook (U.S. Energy Information Administration) freight rail energy use growth rate projections for 2016 through 2028.
- EPA used the Motor Vehicle Emissions Simulator (MOVES) model for other non-road sources and for on-road sources, run specifically for 2028.
- EPA reduced medium and heavy-duty truck energy rates for 2014 and later model-year vehicles to account for the Phase 1 of the Greenhouse Gas Emissions Standards and Fuel

[6] http://views.cira.colostate.edu/wiki/wiki/10202

Efficiency Standards for Medium-and Heavy-Duty Engines and Vehicles. (U.S. EPA and NHTSA, 2012).

- Reductions of the Light-duty energy rates for 2017 and later model years vehicles to account for the Light-duty EPA and NHTSA greenhouse gas and fuel economy standards. (U.S. EPA & NHTSA, 2011).

4.3 Emissions inventory comparison

We analyzed anthropogenic EI data for the following visibility-impairing pollutants: sulfur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter ($PM_{2.5}$ and PM_{10}), and ammonia (NH_3). The emissions tables in this section show the primary source categories for each visibility impairing pollutant. The primary emissions source categories vary by the type of pollutant. Using the following groups, we calculated the summaries for anthropogenic sources:

- Point Sources
  - Electric Generating Units (EGU)
  - Non-EGU
- On-road Mobile
- Non-road
  - Commercial Marine Vessel (CMV)
  - Rail
  - Other Non-road (vehicles and equipment)
- Non-point
  - Home heating (wood)
  - Agriculture and fugitive dust (from livestock, tilling, roads, construction)
  - Other non-point
- Fire Events
  - Prescribed fire
  - Agricultural fire

The EI data had two general issues identified:

- Prescribed fire calculations in the modeled scenarios (2014 Actual, RepBase, and 2028 OTB) used EPA methodology. This method is problematic for Washington because most accomplished prescribed burning is as pile burns, which the EPA methodology does not consider. The 2017 NEI prescribed fire emissions are based on our permitted tons burned and appropriate corresponding emission factors, which represents Ecology's best estimate of the category.
- Some non-point emissions in the modeled scenarios (2014 Actual, RepBase, and 2028 OTB) used methodology that Ecology has since revised. Non-point calculations in the 2017 NEI use updated methodology and represent Ecology's best estimate of the category.

Despite the known issues with the EI comparison, the RepBase is comparable to the 2028 OTB in a relative sense for projecting future visibility. However, when attempting to discern the best actual estimate of recent emissions, the 2017 NEI value is the best reference.

SO_2 emissions

Gaseous SO_2 emissions convert 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.

SO_2 emissions in Washington come primarily from point sources, including a coal-fired power plant, oil refineries, primary aluminum plants, pulp and paper mills, and a cement plant. Ecology expects a large reduction in SO_2 emissions by 2028 because TransAlta will cease coal-fired power production by the end of 2025, with one boiler shut down at the end of 2020. CMV was a large source of SO_2 but recent adoption of low-sulfur fuels and port electrification efforts have reduced emissions, as represented in the 2017 NEI.

Table 4-1: Washington anthropogenic SO_2 emissions (in tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	3,229	1,588	2,134	62
Non-EGU Point	11,577	12,503	8,060	12,528
On-Road Mobile	552	552	410	241
CMV	10,232	374	478	516
Rail	10	10	11	10
Other Non-Road	52	50	47	34
Home Heating (Wood)	229	229	225	229
Agriculture and Dust				
Other Non-Point	2,042	2,042	1,097	2,042
Prescribed Fire	997	1,611	18	1,611
Agricultural Fire	111	111	152	111
Total (tons/year)	**29,031**	**19,070**	**12,632**	**17,384**

NOx emissions

The burning of any material or fuel can generate NOx ($NO + NO_2$) emissions because atmospheric oxygen and nitrogen chemically react at temperatures found in combustion. NOx 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.

NOx emissions come predominantly from on-road mobile sources. Ecology expects those vehicular emissions to continue decreasing through 2028 due to new fuel efficiency standards and the transition to cleaner-burning (and electric) vehicles. We also expect total NOx emissions from non-road mobile sources to decrease. Another sizable reduction in NOx will occur when coal-fired power production ceases at TransAlta. Overall, Ecology expects NO_X emissions in Washington to decline by more than 40 percent by 2028, primarily due to significant improvements in on-road and non-road mobile source emissions.

Table 4-2: Washington anthropogenic NOx emissions (in tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	10,023	8,482	10,196	2,250
Non-EGU Point	20,687	21,948	20,567	21,439
On-Road Mobile	130,500	130,500	89,319	34,366
CMV	16,767	19,062	23,458	17,652
Rail	15,202	15,202	14,258	11,631
Other Non-Road	28,398	24,509	23,200	13,886
Home Heating (Wood)	1,530	1,530	1,381	1,530
Agriculture and Dust				
Other Non-Point	12,050	12,050	10,455	12,050
Prescribed Fire	1,662	1,614	717	1,614
Agricultural Fire	479	479	1,063	479
Total (tons/year)	**237,298**	**235,376**	**194,614**	**116,897**

VOC emissions

VOCs emitted into the atmosphere can condense and oxidize to form secondary organic aerosols, which can degrade visibility. VOCs also play a role in the photochemical production of ozone in the troposphere. The dominant source of VOCs is biogenic emissions, which comprise more than half of the total Washington VOC emissions. Forests and other vegetation emit these natural emissions. VOCs react with NOx 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. However, since natural biogenic VOCs are a dominant source, it is difficult to get visibility improvements by controlling VOCs from anthropogenic sources.

The largest sources of anthropogenic VOC emissions include on-road mobile sources and solvent use (included in the “other non-point” category). Population growth primarily drives significant VOC increases in the “other non-point” category for 2028. However, Ecology expects VOC reductions from mobile sources in the 2028 inventory to more than offset any increases due to population growth.

Table 4-3: Washington anthropogenic VOC emissions (in tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	114	65	285	36
Non-EGU Point	11,764	11,291	10,118	11,299
On-Road Mobile	71,971	71,971	59,158	26,295
CMV	596	1,073	1,173	1,252
Rail	744	716	611	494
Other Non-Road	36,508	25,629	24,166	19,189
Home Heating (Wood)	15,448	17,371	13,803	17,370
Agriculture and Dust	2,236	2,236	1,635	2,236
Other Non-Point	86,545	86,545	97,490	86,545
Prescribed Fire	29,998	72,388	3,406	72,388
Agricultural Fire	748	747	2,369	747
Total (tons/year)	**256,672**	**290,032**	**214,214**	**237,851**

$PM_{2.5}$ emissions

$PM_{2.5}$ in the EI includes primary emissions of particulate matter less than 2.5 microns in size, and is synonymous with smoke and fine aerosols. Depending on the year, wildfires generate the majority of $PM_{2.5}$ emissions in Washington. The primary anthropogenic sources are non-point, including fugitive dust (agriculture, construction, and roads) and residential wood combustion. Ecology expects modest $PM_{2.5}$ reductions from the on-road and non-road sectors as they use technology that is more efficient. However, there are large uncertainties when projecting categories like fugitive dust, prescribed burning, and wildfires.

Table 4-4: Washington anthropogenic $PM_{2.5}$ emissions (in tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	402	537	671	315
Non-EGU Point	4,007	4,040	2,978	4,057
On-Road Mobile	3,808	3,808	2,573	1,484
CMV	651	396	464	443
Rail	389	389	356	298
Other Non-Road	2,824	2,332	2,217	1,316
Home Heating (Wood)	12,371	12,371	10,614	12,371
Agriculture and Dust	18,304	18,304	29,822	18,304
Other Non-Point	12,932	12,932	6,383	12,932
Prescribed Fire	12,337	21,860	2,420	21,860
Agricultural Fire	1,895	1,894	2,703	1,894
Total (tons/year)	**69,920**	**78,863**	**61,200**	**75,274**

PM_{10} emissions

PM_{10} in the EI includes primary emissions of particulate matter less than 10 microns in size, representing the sum of coarse and fine particles. The primary anthropogenic source is fugitive dust (agriculture, construction, and roads), but fire categories do have significant influence on state totals. Small non-point category increases, which are sensitive to population growth, match the small reductions expected from the on-road and non-road sectors.

Table 4-5: Washington anthropogenic PM_{10} emissions (tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	427	586	914	334
Non-EGU Point	4,576	4,594	3,446	4,613
On-Road Mobile	6,913	6,913	5,219	5,029
CMV	819	418	490	469
Rail	404	404	367	307
Other Non-Road	2,973	2,451	2,331	1,402
Home Heating (Wood)	12,377	12,377	10,622	12,377
Agriculture and Dust[7]	237,282	237,282	183,637	237,282
Other Non-Point	14,854	14,854	7,505	14,854
Prescribed Fire	14,557	24,800	2,778	24,800
Agricultural Fire	2,718	2,717	2,769	2,717
Total (tons/year)	**297,900**	**307,396**	**220,078**	**304,184**

[7] The TSS data from this row showed dust emissions after meteorological adjustment. We replaced those values with the unadjusted numbers so that they are directly comparable to the 2017 NEI values.

Ammonia emissions

Agricultural related activities such as livestock operations and farming fertilizer applications are the primary sources of NH_3. NH_3 emissions can react with SO_2 and NOx to form sulfate and nitrate particles, which are significant contributors to visibility impairment. Washington has a strong agricultural community that will continue operating indefinitely. We expect no changes to agricultural practices that will decrease ammonia emissions.

Table 4-6: Washington anthropogenic ammonia emissions (tons/year)

Source Category	2014 Actual	Rep Baseline	2017 NEI	2028 OTB
EGU Point	69	88	106	86
Non-EGU Point	436	449	388	449
On-Road Mobile	2,356	2,356	2,206	1,744
CMV	8	8	9	9
Rail	9	9	9	9
Other Non-Road	48	40	40	45
Home Heating (Wood)	735	735	656	735
Agriculture and Dust	27,538	27,538	34,570	27,538
Other Non-Point	1,562	1,562	1,252	1,562
Prescribed Fire	2,394	3,602	2,244	3,602
Agricultural Fire	1,952	1,950	6,164	1,950
Total	**37,107**	**38,337**	**47,644**	**37,729**

4.4 Facilities selected for Four-Factor Analysis (FFA)

This section provides emissions from major point sources identified for FFA. Ecology selected seventeen facilities for additional evaluation, spanning six categories:

- Aluminum Production
- Cement Manufacturing
- Glass Manufacturing
- Electric Power Generation
- Paper Manufacturing
- Petroleum Refineries

Table 4-7: Information for facilities selected for FFA

Category	Current Facility Name	FIPS	Site Code
Aluminum Production	Alcoa Primary Metals Intalco Works	53073	0001
Aluminum Production	Alcoa Wenatchee, LLC	53007	0001
Cement Manufacturing	Ash Grove Cement Company	53033	11339
Flat Glass Manufacturing	Cardinal FG Winlock	53041	2175
Electric Power Generation	TransAlta Centralia Generation, LLC	53041	754

Category	Current Facility Name	FIPS	Site Code
Paper Manufacturing	Boise Paper	53071	0003
Paper Manufacturing	COSMO Specialty Fibers, Inc.	53027	0001
Paper Manufacturing	Georgia-Pacific Consumer Operations, LLC	53011	0005
Paper Manufacturing	Longview Fibre Paper and Packaging, Inc.	53015	0002
Paper Manufacturing	Nippon Dynawave Packaging Co.	53015	0003
Paper Manufacturing	Port Townsend Paper	53031	0001
Paper Manufacturing	WestRock Tacoma Mill	53053	0008
Petroleum Refineries	BP Cherry Point Refinery	53073	10007
Petroleum Refineries	Phillips 66 Ferndale Refinery	53073	00005
Petroleum Refineries	Shell Puget Sound Refinery	53057	00003
Petroleum Refineries	Tesoro Northwest Company	53057	00005
Petroleum Refineries	U.S. Oil & Refining Co.	53053	12593

Aluminum production facilities

Alcoa has two aluminum smelters in Washington under Ecology's Industrial Section jurisdiction: Intalco in Ferndale (Whatcom County) and Wenatchee Works (Chelan County). Alcoa curtailed the Wenatchee facility in 2015 and the Ferndale facility in 2020. Both facilities have a very large potential to emit SO_2, and would contribute to regional haze if Alcoa re-started aluminum production operations. Ecology held facility emissions constant at 2014 Actual levels for the RepBase and 2028 OTB scenarios.

Cement manufacturing

The Ash Grove Cement Company (King County; Puget Sound Clean Air Agency jurisdiction) is one of the largest NOx point sources in Washington, emitting over 1,000 tons of NOx per year. Ecology held facility emissions constant at 2014 Actual levels for the RepBase and 2028 OTB scenarios.

Flat glass manufacturing

The Cardinal FG Winlock (Lewis County; SWCAA jurisdiction) glass manufacturing facility is one of the largest NOx point sources in Washington, emitting over 800 tons per year. Facility emissions were set to 2014 Actual levels for the RepBase and the 2028 OTB scenario assumed reductions from a selective catalytic reduction control with ammonia injection, which will be installed in 2021.

Electric power generation

The TransAlta Centralia coal-powered EGU (Lewis County; SWCAA jurisdiction) has historically been one of the largest sources of NOx and SO_2 in Washington, currently emitting over 5,000 tons of NOx and 1,500 tons of SO_2 per year. The facility will cease coal-fired energy production before 2028; one unit ceased coal-fired operation in 2020 and the other in 2025 with additional

NOx reductions until then. Ecology set facility emissions to 2014 Actual levels for the RepBase and to zero for the 2028 OTB scenario.

Paper manufacturing

Seven paper-manufacturing facilities in Washington collectively emit over 6,000 tons of NOx, 1,500 tons of SO_2, and 1,300 tons of PM_{10} per year. Facility emissions were set to 2017 NEI levels for the RepBase and 2028 OTB scenarios.

Petroleum refineries

Five petroleum refineries in Washington collectively emit over 5,500 tons of NOx and 1,000 tons of SO_2 per year. Ecology held facility emissions constant at 2014 Actual levels for the RepBase and 2028 OTB scenarios.

Table 4-8: Annual NOx emissions for FFA facilities (tons/year)

Current Facility Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	Rep Base	2028 OTB
Alcoa Primary Metals Intalco Works	152	185	220	227	213	188	192	183		227	227
Alcoa Wenatchee, LLC	63	66	67	70	63	1	0	0		70	70
Ash Grove Cement Company	918	665	997	1,144		1,343	1,368	1,159		1,144	1,144
Cardinal FG Winlock	810	657	774	791	807	808	809	809		791	250
TransAlta Centralia Generation, LLC	6,635	4,658	7,793	7,538	5,624	5,019	6,232	5,939		7,538	0
Boise Paper	861	760	629	742	676	681	637	600		637	637
COSMO Specialty Fibers, Inc.	367	364	374	465	644	606	402	384		402	402
Georgia-Pacific Consumer Operations, LLC	528	489	464	463	453	452	486	235		486	486
Longview Fibre Paper and Packaging, Inc.	1,372	1,389	1,498	1,215	952	1,044	1,041	1,092		1,041	1,041
Nippon Dynawave Packaging Co.	2,137	2,221	2,048	2,086	2,024	1,969	1,949	2,276		1,949	1,949
Port Townsend Paper	473	493	482	494	488	489	475	490		475	475
WestRock Tacoma Mill	945	985	890	940	1,032	1,084	1,121	1,035		1,121	1,121
BP Cherry Point Refinery	1,991	1,876	1,959	1,893	1,865	1,905	1,930	1,820		1,893	1,893
Phillips 66 Ferndale Refinery	788	702	784	723	726	769	674	691		723	723
Shell Puget Sound Refinery	1,101	1,319	1,409	1,230	1,076	1,109	1,054	1,146		1,230	1,230
Tesoro Northwest Company	1,882	2,051	1,731	1,918	1,826	2,020	1,971	1,878		1,918	1,918
U.S. Oil & Refining Co.	134	127	135	133		63	115	116		133	133

Table 4-9: Annual SO_2 emissions for FFA facilities (tons/year)

Current Facility Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	Rep Base	2028 OTB
Alcoa Primary Metals Intalco Works	4,538	4,723	4,672	4,794	5,022	4,374	3,987	4,103		4,794	4,794
Alcoa Wenatchee, LLC	2,906	3,127	3,712	2,935	2,741	0				2,935	2,935
Ash Grove Cement Company	51	37	42	57		68	69	67		57	57
Cardinal FG Winlock	56	47	54	57	59	59	56	55		57	71
TransAlta Centralia Generation, LLC	1,136	1,228	2,820	3,037	2,386	1,438	1,707	1,502		3,037	0
Boise Paper	793	604	534	186	68	692	885	393		885	885
COSMO Specialty Fibers, Inc.	214	206	230	237	353	369	242	255		242	242
Georgia-Pacific Consumer Operations, LLC	19	20	19	17	16	30	40	21		40	40
Longview Fibre Paper and Packaging, Inc.	202	302	133	141	220	126	198	258		198	198
Nippon Dynawave Packaging Co.	582	484	378	440	351	376	390	328		390	390
Port Townsend Paper	150	187	198	79	51	44	46	68		46	46
WestRock Tacoma Mill	349	347	263	261	244	190	190	224		190	190
BP Cherry Point Refinery	1,026	930	879	917	907	781	828	726		917	917
Phillips 66 Ferndale Refinery	108	73	46	49	44	45	38	43		49	49
Shell Puget Sound Refinery	369	445	466	349	233	246	225	228		349	349
Tesoro Northwest Company	315	284	237	191	130	125	80	80		191	191
U.S. Oil & Refining Co.	5	4	4	4		7	6	7		4	4

Table 4-10: Annual PM_{10} emissions for FFA facilities (tons/year)

Current Facility Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	Rep Base	2028 OTB
Alcoa Primary Metals Intalco Works	679	736	705	637	708	696	599	563		637	637
Alcoa Wenatchee, LLC	546	395	430	457	467	3	3	3		457	457
Ash Grove Cement Company	31	30	36	43		30	29	16		43	43
Cardinal FG Winlock	10	8	12	12	12	11	16	16		12	15
TransAlta Centralia Generation, LLC	415	209	236	187	140	299	423	347		187	0
Boise Paper	127	124	123	120	113	122	134	106		134	134
COSMO Specialty Fibers, Inc.	272	232	285	272	398	417	280	333		280	280
Georgia-Pacific Consumer Operations, LLC	167	193	178	173	181	151	163	95		163	163
Longview Fibre Paper and Packaging, Inc.	81	257	333	218	202	213	209	220		209	209
Nippon Dynawave Packaging Co.	76	75	121	129	133	129	124	144		124	124
Port Townsend Paper	314	264	291	275	247	220	193	181		193	193
WestRock Tacoma Mill	97	125	155	153	136	201	222	223		222	222
BP Cherry Point Refinery	131	128	98	83	107	118	84	130		83	83
Phillips 66 Ferndale Refinery	59	46	65	64	59	54	60	59		64	64
Shell Puget Sound Refinery	236	228	193	183	207	177	182	191		183	183
Tesoro Northwest Company	154	162	143	157	152	140	144	136		157	157
U.S. Oil & Refining Co.	12	12	12	12		11	12	12		12	12

4.5 Summary

The EI summarizes emissions from sources located in Washington that we reasonably expect to affect visibility in Class 1 Areas in Washington and other states. We used the EI to summarize the anthropogenic emissions from each source category and the changes in emissions at the facilities subjected to a four-factor analysis. We used these emission summaries to prioritize emission reduction efforts and ensure that model predictions of 2028 visibility impairment are reasonable.

Chapter 5. Regional Haze Modeling

Washington relied on the Western Regional Air Partnership (WRAP) modeling for this Regional Haze (RH) State Implementation Plan (SIP). This chapter describes the modeling effort conducted by WRAP for the western contiguous states. Also discussed are model configuration, model performance, and source apportionment options.

WRAP used the Comprehensive Air Quality model and Extensions (CAMx) to perform the representative baseline and 20218 OTB scenarios. CAMx results were used to calculate Relative Response Factors (RRFs), which were applied to the measured baseline period concentrations at the IMPROVE sites. This provided a visibility projection for 2028. Chapter 9 discusses visibility projection results in the context of Reasonable Progress Goals and the Uniform Rate of Progress Glidepath, as determined by the RRFs derived from CAMx simulations.

The WRAP provided source apportionment results using the Weighted Emissions Potential (WEP) technique and the CAMx Particulate Matter Source Apportionment Technology (PSAT) tool. The WEP is a useful method for identifying sources that impair visibility at the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors, and requires far less computational resources than CAMx PSAT. However, the CAMx PSAT analysis is more appropriate for computing projected visibility because it considers all possible sources of air pollution and atmospheric processes. Chapter 6 discusses the WEP and PSAT results.

5.1 CAMx simulations

The primary tool used by the WRAP for projecting future visibility is the CAMx v 7.0. CAMx is a state-of-the-science photochemical grid model that comprises a "one-atmosphere" treatment of tropospheric air pollution that includes source apportionment techniques[8]. The CAMx 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.

CAMx requires meteorological inputs of three-dimensional gridded variables such as wind, temperature, humidity, cloud cover, and precipitation. The CAMx simulations computed for WRAP utilized gridded meteorological data from the Weather Research and Forecasting model. The Weather Research and Forecasting model is the most common source of modeled meteorology in the U.S. used as input to photochemical grid models. Local, state, national, and international modeling efforts use the Weather Research and Forecasting model extensively.

WRAP and the Western Air Quality Study (WAQS) developed the modeling platform with two-way nesting between the continental U.S. (36 km grid-cells) and the western U.S. (12-km grid-cells) modeling domains. Ramboll Group A/S (Ramboll) conducted model simulations for the 2014 base case, the representative baseline, and the 2028 on-the-books (OTB) future U.S. anthropogenic emissions scenarios. Ramboll simulated two 2028 emission scenarios: one with

[8] http://www.camx.com/home.aspx

2014 actual fires and one with a representative fire dataset developed by the WRAP Fire and Smoke Work Group.

Ramboll compiled emissions updates submitted by local, state, and federal agencies and went through several updates as requested by states in the WRAP. Ramboll included a wind-blown dust pre-processor for better soil and coarse mass performance during dust events. They also implemented a bi-directional ammonia deposition scheme for better nitrate performance, especially in agricultural regions. The emission inventories were prepared for CAMx using the Sparse Matrix Operator Kernel Emissions (SMOKE) program. See Chapter 4 for more information about the anthropogenic emissions inventory data used in modeling.

CAMx simulations of the WRAP region required emission inventory data outside the WRAP region. Ramboll compiled emissions for Pacific offshore commercial marine vessels, non-WRAP states, Mexico, and Canada. WRAP posted results on the Technical Support System (TSS) website[9]. The CAMx model also requires input of specific concentrations of visibility-impairing pollutants at the boundaries of the modeling domain. Boundary conditions represent pollutants reaching North America from the rest of the world. Boundary conditions came from the WRAP Revised 2014 GEOS-Chem Base Case.

5.2 CAMx performance

RAMBOLL evaluated the performance of CAMx simulations by comparing CAMx model-simulated concentrations with 2014 ambient monitoring data from a large number of sites. This evaluation determined that the model's performance justified use of the model for simulating future conditions. RAMBOLL used the 2014 Actual emissions inventory for the simulation. They evaluated CAMx for both the most impaired days and the clearest days. See the CAMx 2014v2 Model Performance Evaluation section reported on the WRAP/WAQS 2014v2 Modeling Platform Description and Western Region Performance Evaluation (MPE)[10] site.

The following list summarizes model performance evaluation findings for particulate speciation monitors in the northwest part of the WRAP modeling domain at the locations of IMPROVE and Chemical Speciation Network (CSN) sites:

- Sulfate (SO_4)
    - Year-round overestimation in the northwest.
- Nitrate (NO_3)
    - Initial tests largely underestimated nitrate, but the addition of a bi-directional ammonia deposition scheme to the final 2014 modeling scenario-increased nitrate (NO_3). This may have been too much of an increase for the northwest.
    - Final result was year-round overestimation of nitrate (NO_3) in the northwest at IMPROVE sites but better nitrate (NO_3) performance in the northwest at CSN sites.
    - Better nitrate (NO_3) performance in cold months when monitored concentrations are greater.

[9] https://views.cira.colostate.edu/tssv2/

[10] http://views.cira.colostate.edu/iwdw/docs/WRAP_WAQS_2014v2_MPE.aspx

- Organic mass
    - Overestimation in many parts of the domain, including the northwest.
    - Overestimation of primary organic aerosol (POA) on days when fire impacts occur.
    - Dominated by fires and biogenic secondary organic aerosol (SOA), which are both large sources of uncertainty and generally due to uncontrollable emissions.
- Elemental carbon
    - Overestimated in the northwest during fire impacts, but otherwise concentrations are small.
- Soil and coarse mass
    - The model underestimates windblown dust emissions, causing underestimates of soil and coarse mass during windblown dust events.
    - Better soil performance than Round one RH SIPs due to new method to calculate elements from the model, which matches monitoring methods.
    - Coarse mass (CM) is underestimated in all climate regions and seasons.
        - Much of CM monitored is likely local as CM has a higher deposition rate and shorter transport distance.
        - Subgrid-scale impacts are difficult for a regional grid-model to simulate.
    - Given the uncertainties in the CM modeling results, future-year CM projections were held constant, with an RRF = 1.

Model performance was analyzed for IMPROVE monitors that represent mandatory Class 1 Areas in Washington. Light extinction derived from the 2014 IMPROVE monitor data was compared to the 2014, representative baseline, and OTB model scenarios. CAMx over-predicted light extinction at every IMPROVE monitor for the average clearest days and most impaired days (MIDs).

All model species related to anthropogenic emissions consistently over-predicted for 2014 clearest days at Washington IMPROVE monitors, across all months. Figure 5–1 shows the clearest days model performance for the 2014 model scenario. The representative baseline and 2028 OTB model scenarios were similar to the 2014 model scenario for clearest days at all sites, except for organic mass in October at NOCA1. The representative baseline and 2028 OTB modeling scenarios showed a tripling of the organic mass bias at NOCA1 for clearest days (not shown), due to change-over to the “representative” fire emissions dataset.

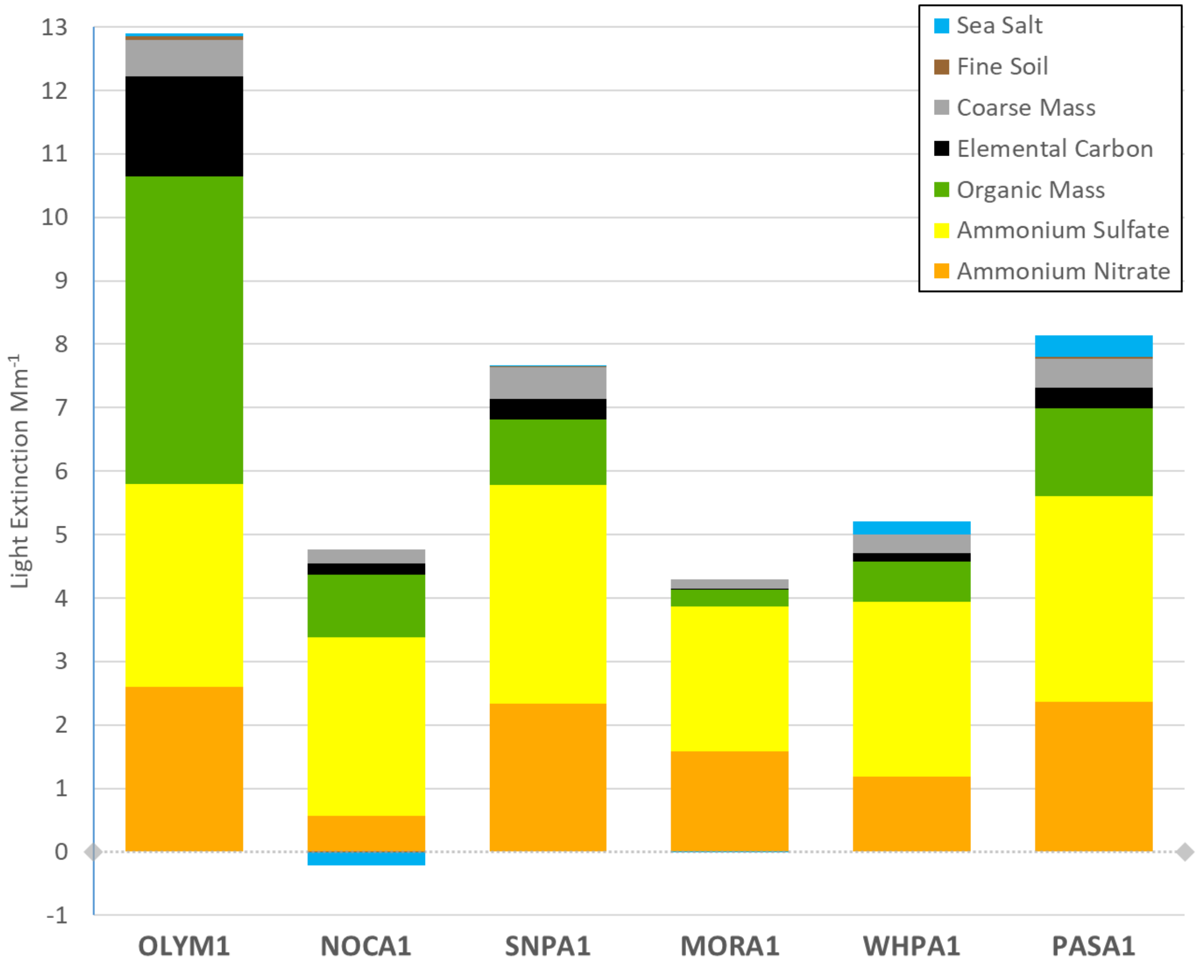

Figure 5–1. Average model bias of light extinction in the 2014 modeling scenario for 2014 clearest days at all sites.

The CAMx performance at Class 1 Area IMPROVE monitors in Washington for MID is shown in Figures 5-2 thru 5-7. Sulfates, nitrates, and organic mass are over-predicted in the model for Washington. Upon further analysis of individual model days, it is evident that fire emissions included in the modeling were severely over-estimated on MIDs. The representative baseline and 2028 OTB model simulations used a different fire dataset than the 2014 simulations, shifting the largest model bias from the PASA1 site to SNPA1 and other locations. Overestimation of emissions from prescribed burning in Washington is not surprising, given that fire emissions calculations from EPA (2014 model scenario) and WRAP (representative baseline and 2028 OTB scenarios) do not accurately represent pile burning, which is the dominant form of prescribed burning in Washington. Wildfire emissions also had negative impacts on model performance, especially for representative baseline and 2028 OTB scenarios, because the wildfire days screened from the 2014 MID are not the same days with highest wildfire impacts in the model. Despite the model performance issues related to fire emissions, they do not negatively influence the RRFs (and therefore the future visibility projection) because the 2028 future scenario holds fire emissions constant relative to the baseline. In fact, over-prediction of model species causes visibility projections (RPGs) to be more conservative since the proportional change in model scenario predictions due to OTB emissions controls is reduced, thereby constraining the RRF closer to one (no projected change).

Ecology used the CAMx modeling results with the understanding that they were the best tool available to forecast concentrations of visibility-impairing pollutants and projected visibility in 2028, the end of the second implementation period. Despite known model performance issues, we can still use CAMx results in combination with the RRF approach to evaluate the benefits of emission reduction strategies for nitrates and sulfates. The RRF allows us to project visibility changes at Class 1 Areas for regional haze planning purposes.

Model performance for MID at OLYM1

Figure 5–2 shows that elemental carbon, nitrates, and organic mass are over-predicted at OLYM1 for all model scenarios while sea salt is under-predicted. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios increased model bias for MID due to clear over-predictions of organic mass in August and September. The largest model bias occurred in October, December, and January due to over-predictions of nitrates and organic mass, but these were not related to wildland fire emissions and persisted across all model scenarios.

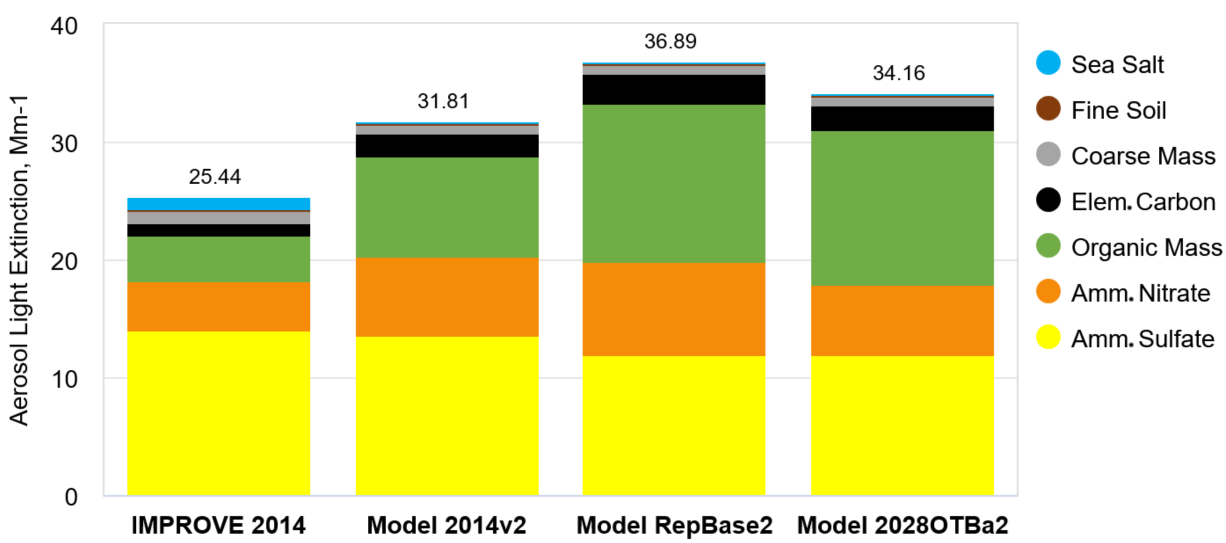

Figure 5–2. Average annual light extinction on MID observed at OLYM1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions.

Model performance for MID at NOCA1

Figure 5–3 shows that nitrates and organic mass are over-predicted at NOCA1 for all model scenarios. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios greatly increased model bias for MID due to clear over-predictions of organic mass in September and October, likely due to over-predictions of prescribed burning emissions in the representative fire dataset. There is also consistent over-prediction of nitrates for 2014 MID across most months.

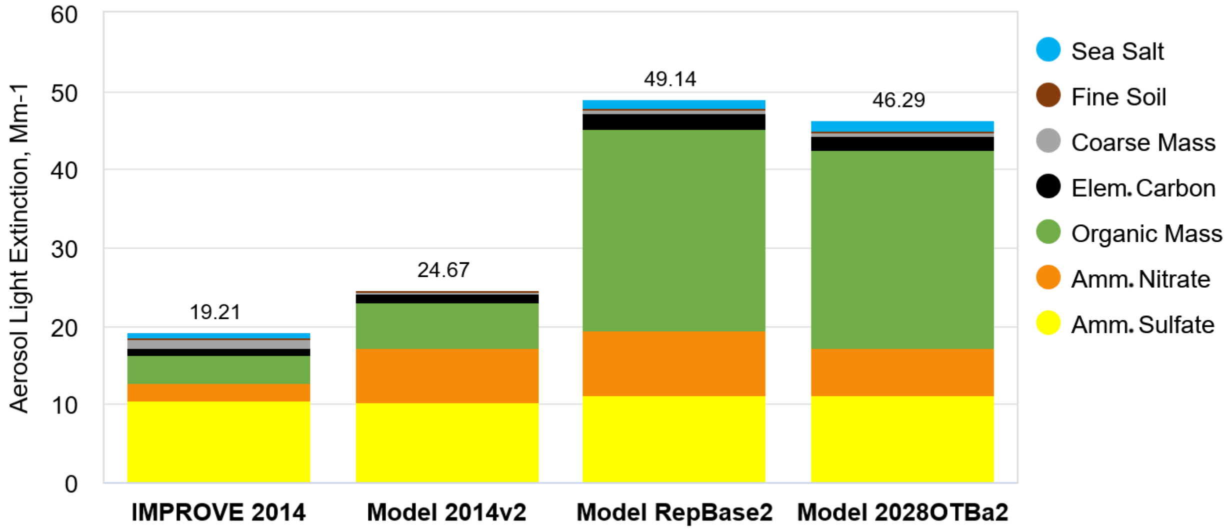

Figure 5–3. Average annual light extinction on MID observed at NOCA1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions.

Model performance for MID at SNPA1

Figure 5–4 shows that all pollutants are extremely over-predicted at SNPA1 for the representative baseline and 2028 OTB scenarios. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios severely increased model bias for MID due to clear over-predictions of organic mass in August, due to over-predictions or incorrect timing of wildfire emissions in the representative fire dataset. There is also clear over-prediction of nitrates from all model scenarios on springtime MIDs.

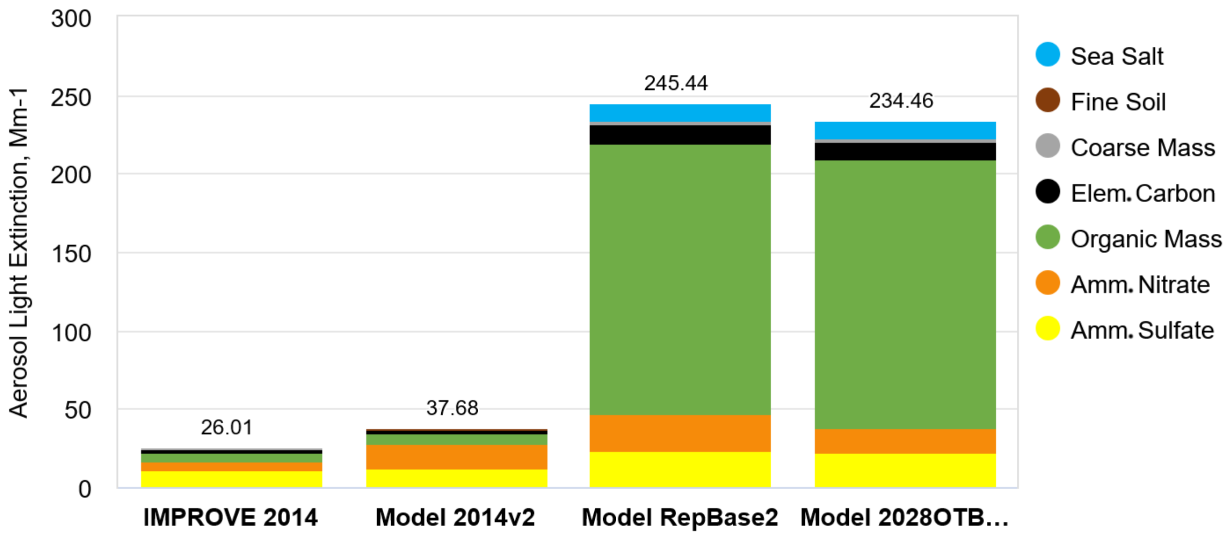

Figure 5–4. Average annual light extinction on MID observed at SNPA1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions.

Model performance for MID at MORA1

Figure 5–5 shows that nitrates and organic mass are over-predicted at MORA1 for all model scenarios. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios greatly increased model bias for MID due to clear over-predictions of organic mass in August, likely due to over-predictions or incorrect timing of wildfire emissions in the representative fire dataset. There is also clear over-prediction of nitrates from all model scenarios on springtime MIDs.

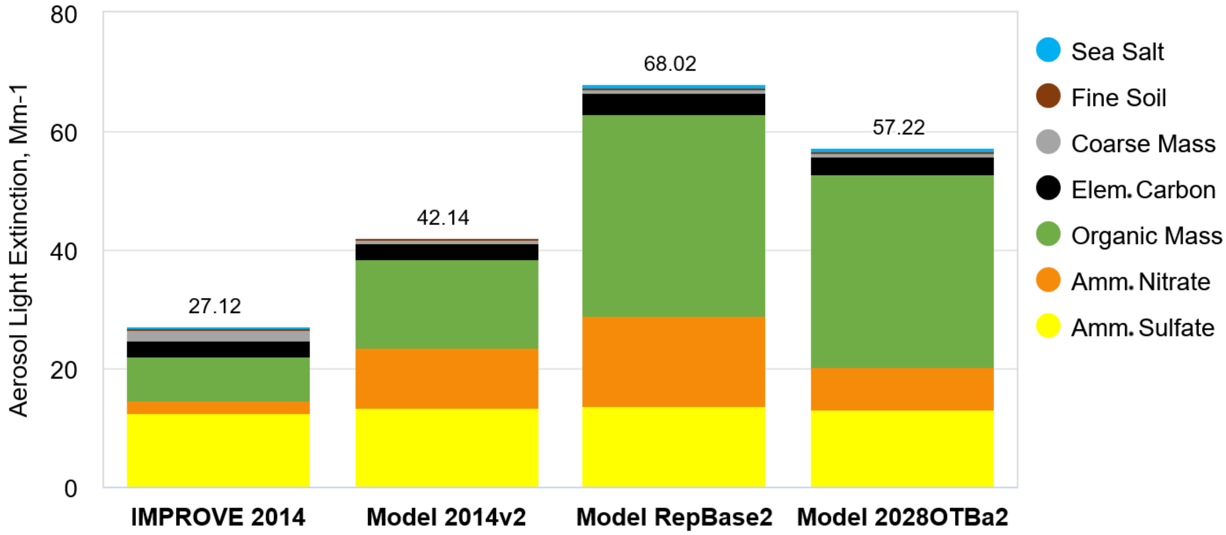

Figure 5–5. Average annual light extinction on MID observed at MORA1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions

Model performance for MID at WHPA1

Figure 5–6 shows that nitrates and organic mass are over-predicted at WHPA1 for all model scenarios. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios had only a small effect on organic mass performance. There is a clear over-prediction of nitrates from all model scenarios on MIDs across all months.

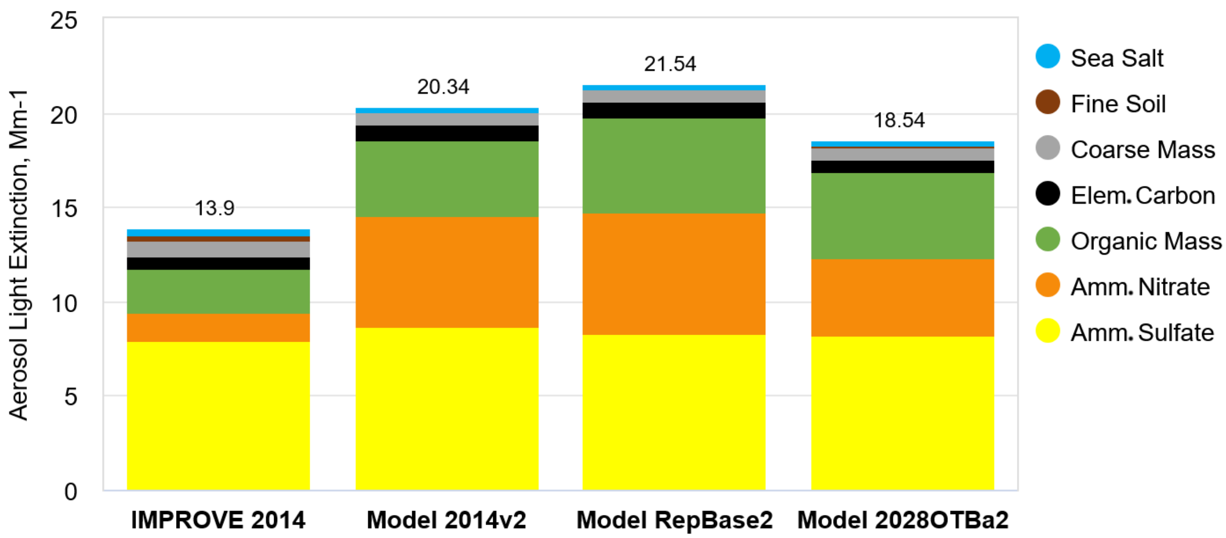

Figure 5–6. Average annual light extinction on MID observed at WHPA1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions.

Model performance for MID at PASA1

Figure 5–7 shows that nitrates and organic mass are over-predicted at PASA1 for all model scenarios. The representative fire emissions dataset used for the representative baseline and 2028 OTB scenarios greatly improved model performance, due to removal of an incorrectly modeled prescribed fire in October from the 2014 model scenario. There is a clear over-prediction of nitrates from all model scenarios on MIDs across all months.

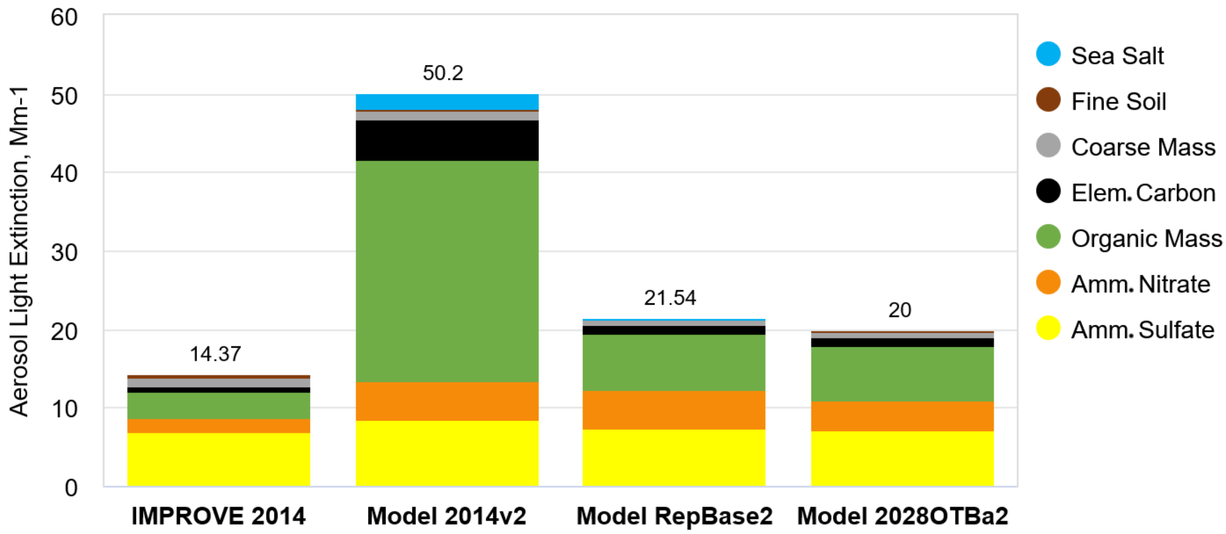

Figure 5–7. Average annual light extinction on MID observed at PASA1 in 2014 compared to the 2014, representative baseline, and 2028 OTB model scenarios predictions.

5.3 Source apportionment options

In order to determine the significant sources contributing to haze in Washington's Class 1 Areas, we rely upon source apportionment analysis provided on the WRAP TSS website[11].

WRAP provided two options for analyzing source apportionment of light extinction caused by pollutants at IMPROVE monitors:

1. The WEP tool, which was used to attribute sources of sulfate, nitrate, organic mass, and elemental carbon.
2. The PSAT tool, which was used to attribute sources of sulfate and nitrate. Source apportionment is especially important for anthropogenic sources of sulfate and nitrate because they have major impacts on visibility at Class 1 Areas.

The WEP is a screening tool that helps to identify source regions that have the potential to contribute to haze formation at specific Class 1 Areas. WEP combines emission inventories, meteorological model data, and the calculated residence time of air masses over each model grid-cell, to estimate the potential for a visibility-impairing pollutant to affect a specific

[11] http://views.cira.colostate.edu/tssv2/.

Class 1 Area. WEP is obtained by combining the emissions weighted residence time at IMPROVE monitors with 2028 OTB emissions of light extinction precursors. The WEP analysis provided a broad overview of potential contributions from within and near Washington but does not look at emissions from outside the domain or Pacific offshore, nor does it account for chemistry or deposition. Ecology used the WEP tool to estimate anthropogenic source locations for light-extinction precursors: sulfur dioxide for ammonium sulfate extinction, nitrogen oxides for ammonium nitrate, primary organic aerosol for organic mass, and elemental carbon for itself. Chapter 6 discusses the WEP results.

The PSAT tool was used to further analyze sulfate and nitrate source apportionment for the 2028 OTB CAMx scenario that, unlike the WEP, accounts for all known physical and chemical processes in the atmosphere. The PSAT results also provide more information than the WEP, because they estimate contributions from all regions. PSAT allows a comparison of the relative contributions from Washington, USA, international, natural, and wildland fire sources. PSAT results also estimate contributions from various emissions categories within the source regions. 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, other countries, and Pacific offshore). Chapter 6 discusses the PSAT results.

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 Class 1 Area. WEP only estimates impacts from the residence time of the air mass over an area and the total annual anthropogenic emissions in that area without consideration of natural sources, chemistry, or sources outside the model domain.

Chapter 6. Source Apportionment and Washington's Impacts on Mandatory Class 1 Areas

This chapter discusses the following:

- Expected contributions from regional anthropogenic emissions to light extinction at Washington's mandatory Class 1 Areas in 2028,
- Expected contributions from international, natural, and wildland fire sources to light extinction at Washington's Class 1 Areas in 2028,
- Expected sulfate and nitrate contributions from Washington anthropogenic emissions to light extinction at out-of-state Class 1 Areas in 2028.

The contributions from regions and source categories were determined using Particulate Matter Source Apportionment (PSAT) and Weighted Emissions Potential (WEP), described in Chapter 5. The WEP includes elemental carbon, organic mass, nitrates, and sulfates but is only for nearby anthropogenic emissions. PSAT only includes nitrates and sulfates, but accounts for all global sources.

The WEP and PSAT analyses presented in this chapter are based purely on model data generated by CAMx, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, and related pre-processors. Model simulations used 2014 meteorology and the 2028 on-the-books (OTB) emissions inventory. WEP and PSAT results did not adjust using relative response factors (RRFs), as is done for the reasonable progress goals (RPGs), due to the computational expense and time that would have been required to do source apportionment for all visibility-impairing species.

We discuss baseline monitored haze and the 2028 RPGs in this chapter for reference. This is because it is important to consider actual observations when attempting to extrapolate model results to the real world. W compared modeled light extinction by species to the baseline monitoring to take into account model bias. Model bias is a consideration when attempting to infer relative source contributions from PSAT and WEP analyses (see Chapter 5). In general, the model bias analysis shows an over-prediction of anthropogenic pollutants.

The Western Regional Air Partnership (WRAP) modeling does not include source apportionment analysis for the Representative Baseline (RepBase) model scenario. However, emissions inventory changes between RepBase and 2028 OTB are the only factors responsible for differences between the two model scenarios. We held constant emissions from non-point, international, natural, and wildland fire for both model scenarios. Reductions of projected visibility impairment in the model-generated results (and thereby the RPGs) are likely from a short list of notable changes:

- Shutdown of TransAlta Centralia coal-fired power plant boilers is a significant reduction in Washington SO_2 emissions.
- Reduction in on-road mobile NOx emissions by 74 percent in Washington, which caused the majority of modeled nitrate reductions. Less significant reductions of NOx from other source categories were also included.

- There were significant reductions in point and mobile emissions outside of Washington. However, anthropogenic emissions from other states likely have a non-significant impact on visibility at Washington Class 1 Areas. This is a result of the predominant wind-flow in Washington.

The WEP does not consider wildland fire. The PSAT model tracks wildland fire, but the model analyses do not provide the necessary information to make reasonable conclusions about source apportionment of wildland fire. This is because organic mass is not part of the PSAT analysis, the PSAT does not track wildland fire geographically, and a "representative" fire dataset in the CAMx model simulations replaced actual 2014 fire emissions. The WRAP state generally agreed that recent revisions to the Regional Haze Rule (RHR) make it clear that days impacted by wildland fire should not be used to track reasonable progress. Therefore, calculating modeled wildland fire contributions to Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors by state was not needed. However, several conducted "no fire" simulations are viewable on the WRAP Technical Support System (TSS) website (https://views.cira.colostate.edu/tssv2/).

Each Class 1 Area organizes the data. Where two Class 1 Areas share an IMPROVE monitor the areas are discussed together. Presentation of the data is in the following order:

- Olympic National Park – OLYM1
- North Cascades National Park and Glacier Peak Wilderness - NOCA1
- Alpine Lakes Wilderness – SNPA1
- Mount Rainer National Park – MORA1
- Goat Rocks Wilderness and Mount Adams Wilderness – WHPA1
- Pasayten Wilderness – PASA1

The area of influence (AOI), determined by HYSPLIT, and the WEP analyses of sulfate, nitrate, organic mass, and elemental carbon on most impaired days (MID) are presented. The WEP considers 2028 OTB anthropogenic emissions in the Western US modeling domain but does not consider natural, international, or wildland fire (wildfire and prescribed fire) emissions. The WEP analyses summarizes using the following categories:

- EGU: includes emissions from major point sources that are electric generating units.
- Non-EGU: includes emissions from major point sources that are not electric generating units. Note that insignificant upstream and midstream processes from the oil and gas industry are included with non-EGU in Chapter 4 but not shown here.
- On-road: includes emissions from all vehicles that travel on roads.
- Non-road: includes emissions from locomotives, commercial marine vessels, mobile equipment, and other non-road vehicles.
- Non-point: includes emissions from all other anthropogenic sources, not categorized elsewhere such as institutional, commercial, residential, and agricultural.

Discussed in this chapter as well is the rank point analysis, which presents the relative contribution of out-of-state point sources to the total point source WEP.

Also presented are the PSAT analyses of sulfate and nitrate on MID and clearest days, which considers all sources. The following categories summarize the PSAT analyses:

- Washington anthropogenic: includes industrial, institutional, commercial, residential, agricultural, and mobile sources within Washington. This source category has very little uncertainty because it was specifically developed for the RH modeling.
- USA anthropogenic: includes industrial, institutional, commercial, residential, agricultural, and mobile sources within the USA (but not Washington). This source category has very little uncertainty because it was specifically developed for the RH modeling.
- International anthropogenic: includes industrial, institutional, commercial, residential, agricultural, and mobile sources outside of the USA. This source category has moderate uncertainty because it is influenced by international sources from many countries both inside and outside the model domain.
- Natural: vegetation, soils, sea salt, and volcanos. Note that this is not the same as the RHR definition of "natural" sources because wildfire is not included. This source category has moderate uncertainty due to the parameterization of natural emissions.
- Wildland fire: wildfire (WF) and prescribed fire (Rx) for USA, Canada, and Mexico. This source category has large uncertainty and is greatly overestimated in the CAMx modeling for MID in Washington.

Within the state-level PSAT results, anthropogenic sources are further separated into similar categories as the WEP, except on-road and non-road sources are lumped together. Remaining anthropogenic sources are effectively the sum of all non-point categories. Most state-level PSAT results show similar expectations for 2028 light extinction impacts from within Washington:

- Mobile sources will be the largest source of nitrates. For reference, the 2028 OTB mobile emissions inventory of NOx for Washington is 44% on-road vehicles, 23% commercial marine vessels, 15% locomotives, and 18% other non-road vehicles and equipment.
- Non-EGU will be the largest source of sulfates. For reference, the 2028 OTB non-EGU emissions inventory of SO_2 for Washington is 62% aluminum production, 16% paper manufacturing, and 12% petroleum refineries.

Note that there are small inconsistencies between the reported model species light extinction values in the various tools on the TSS, due to the processes needed to convert model concentrations to light extinction and the lack of PSAT results for all species. For consistency, the reported model values for each species in this chapter were taken from the model performance analysis on the TSS, which vary slightly compared to the total of all components in the state-level PSAT bar charts.

6.1 Olympic National Park

The OLYM1 IMPROVE monitoring site represents the visibility at Olympic National Park. The 2014 to 2018 average conditions in Chapter 3 show that sulfates (44%), organic mass (21%), and nitrates (19%) together contribute to 84% of the light extinction on MID. On the clearest days, sulfates (30%), organic mass (22%), and nitrates (20%) contributed to 72% of the light extinction at OLYM1.

WEP and rank point analyses

The WEP analysis for the OLYM1 site on MID for the 2028 OTB scenario is summarized in Figure 6.1, showing an AOI of sources in western Washington and the Puget Sound region. There is also some minimal influence from sources in the Portland, OR and Vancouver, BC metropolitan areas. Nitrates at OLYM1 show considerable influence from non-EGU point, on-road, non-road, and non-point sources. Sulfates at OLYM1 show considerable influence from non-EGU Point, non-road, and non-point sources. Non-point sources mostly influence organic mass at OLYM1. Non-point sources mostly influence elemental carbon, but also shows a large influence from on-road and non-road sources.

The rank point WEP analysis attributed 98.9% of point source nitrates to Washington, with 1.0% and 0.3% attributed to Oregon and California, respectively. The rank point WEP analysis attributed 99.4% of point source sulfates to Washington, with 0.5% attributed to Oregon.

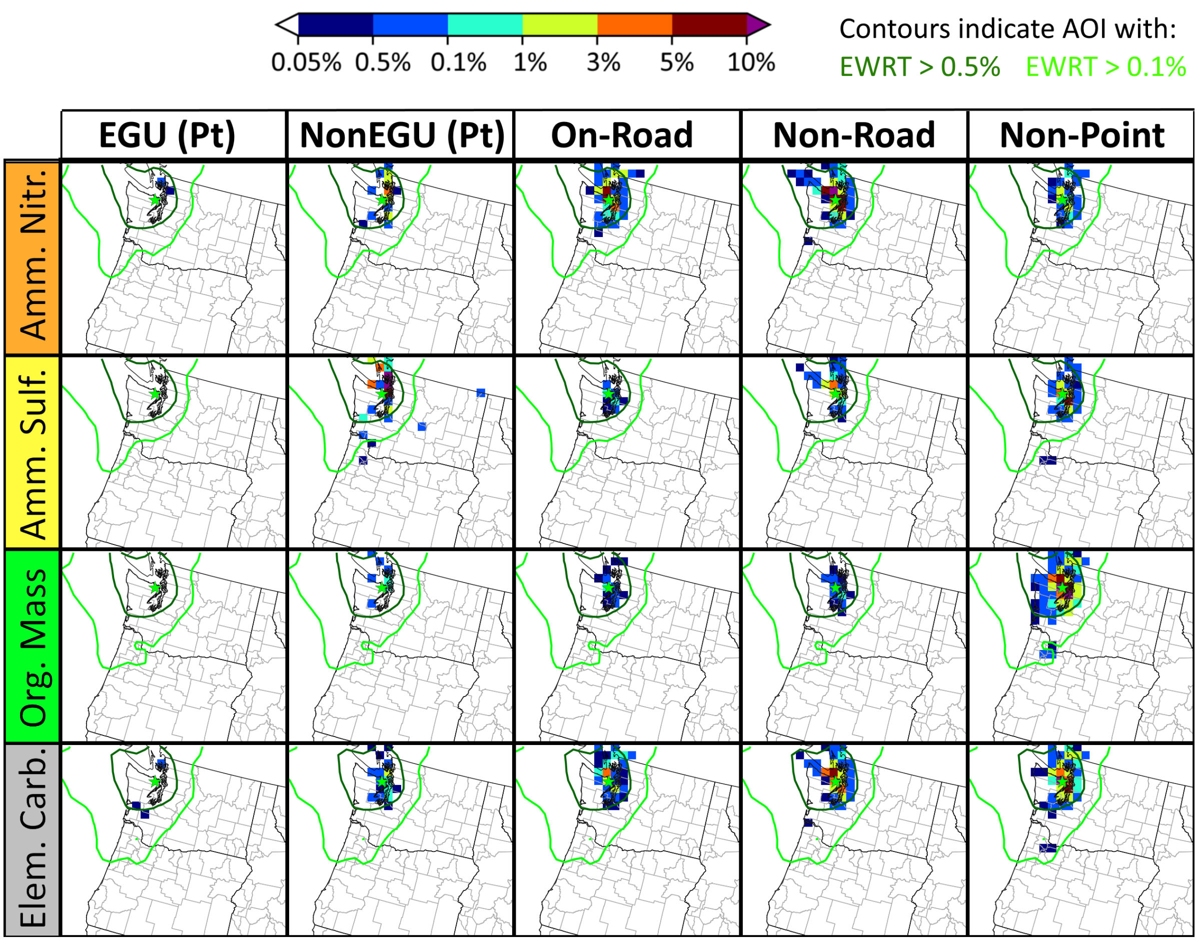

Figure 6-1: WEP for source area potential to contribute to extinction on MID by pollutant at the OLYM1 IMPROVE monitor (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at OLYM1.

Most Impaired Days

The PSAT tracer analysis shows that 2028 MID visibility impacts of sulfates at OLYM1 are expected to come primarily from natural (52%), international anthropogenic (22%) and wildland fire (13%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 9% of the sulfates responsible for light extinction at OLYM1. See Figure 6-2 for more information.

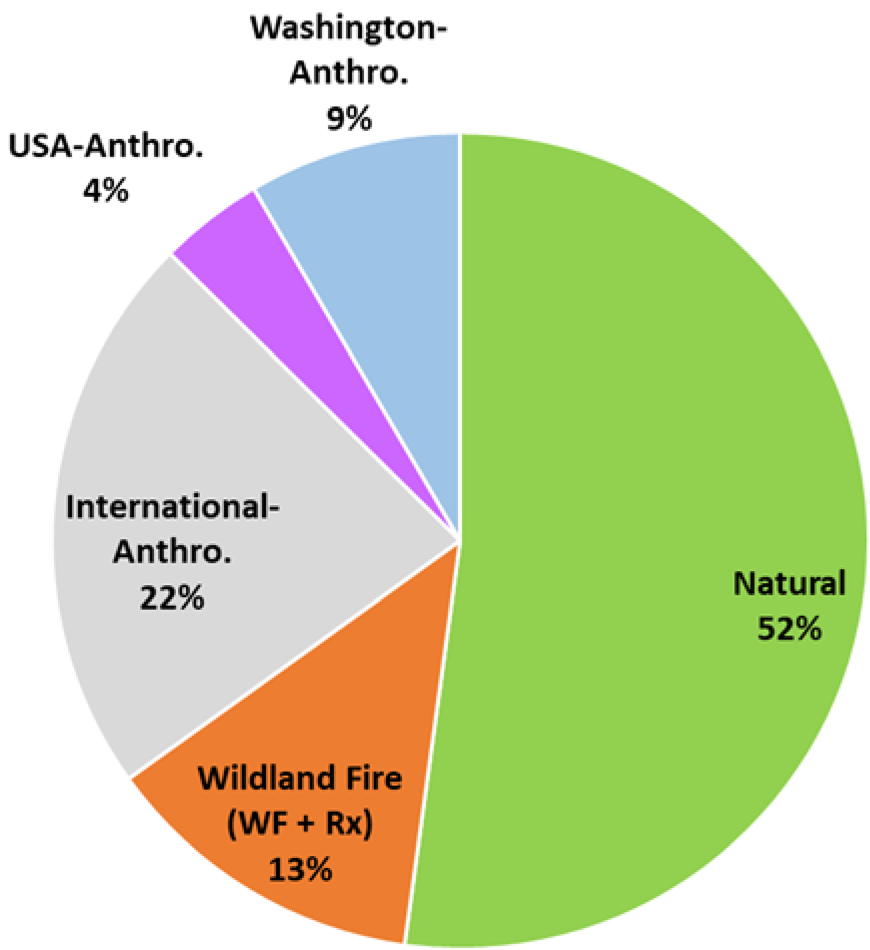

Figure 6-2: Expected source regions of sulfates (SO4) in 2028 at OLYM1 for MID (CAMx total = 11.9 Mm^{-1}).

The modeled sulfates for 2028 MID at OLYM1 was 11.9 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 10.03 Mm^{-1} and 10.00 Mm^{-1}, respectively.

Figure 6-3 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the OLYM1 monitoring site on 2028 MID.

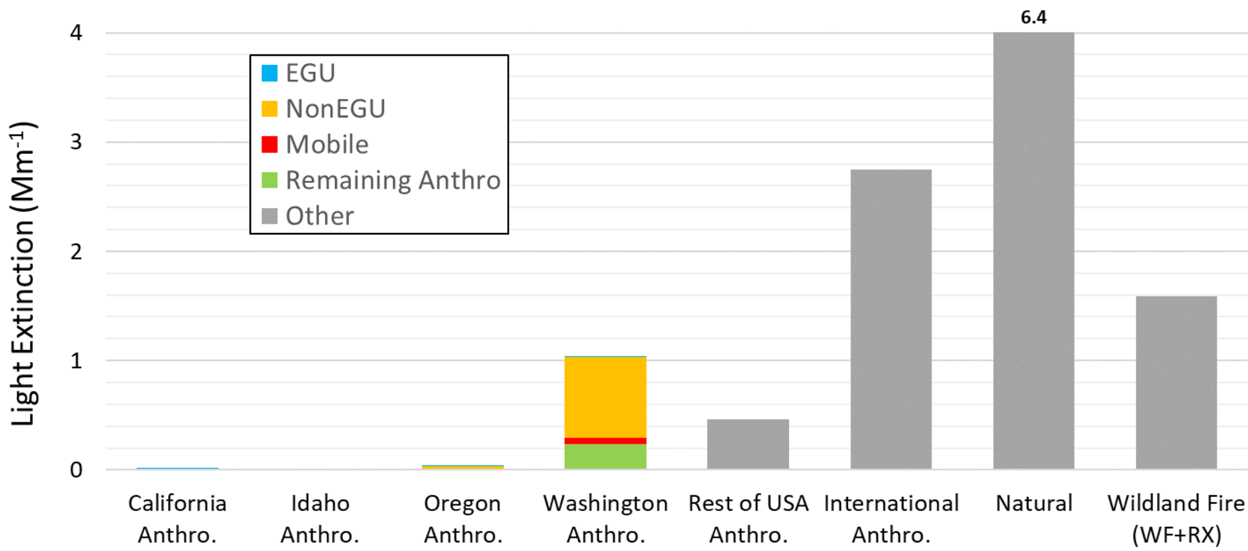

Figure 6-3: Expected source categories and regions of SO_4 in 2028 at OLYM1 for MID (CAMx total = 11.9 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at OLYM1 are expected to come primarily from natural (37%), out-of-state US anthropogenic (24%), and international anthropogenic (19%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 16% of the sulfates responsible for light extinction at OLYM1. See Figure 6-4 for more information.

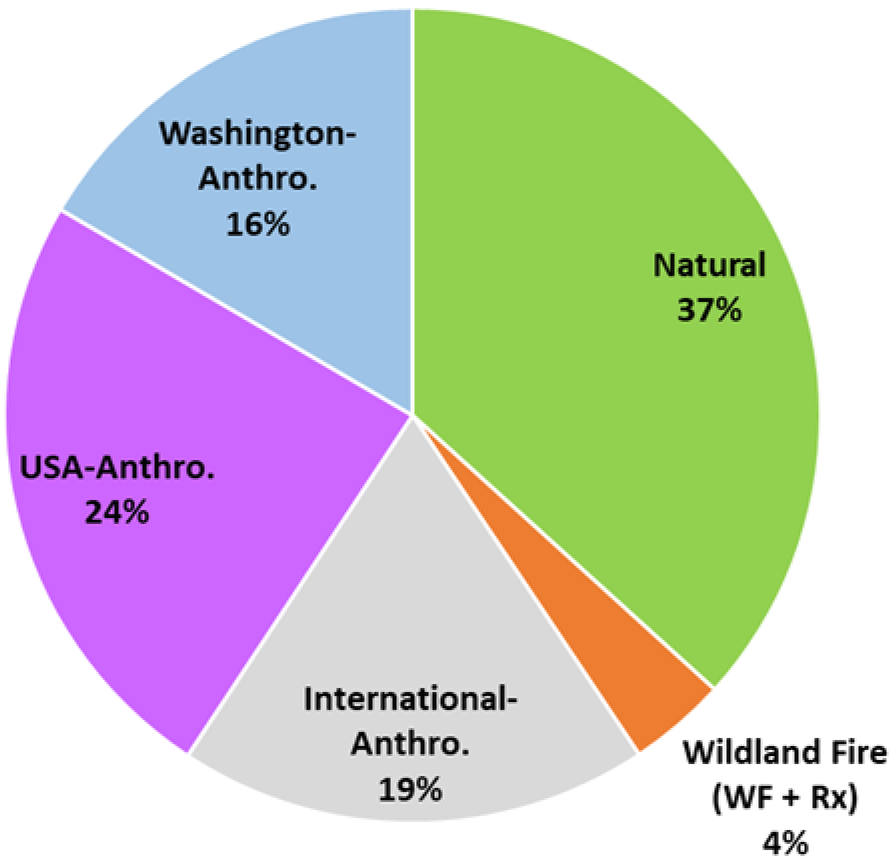

Figure 6-4: Expected source regions of SO_4 in 2028 at OLYM1 for clearest days (CAMx total = 4.2 Mm^{-1}).

The modeled sulfates for 2028 clearest days at OLYM1 was 4.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 1.01 Mm^{-1} and 1.00 Mm^{-1}, respectively. Figure 6-5 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at OLYM1 on 2028 clearest days.

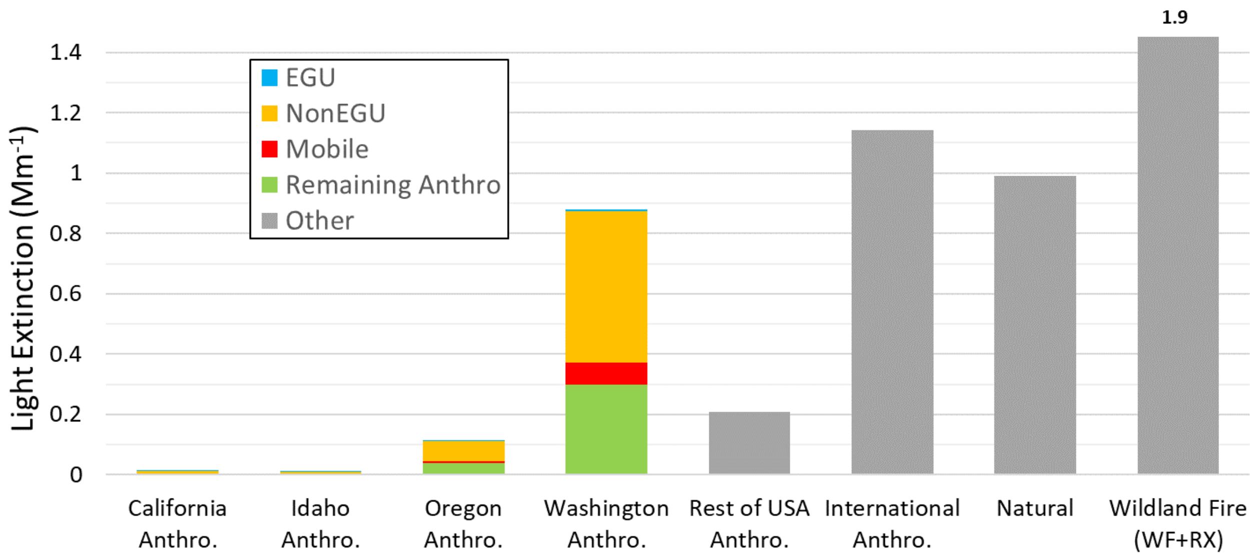

Figure 6-5: Expected source categories and regions of SO_4 in 2028 at OLYM1 for clearest days ($CAMx$ total = 4.2 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the third largest species contribution to light extinction for the MID and second largest species contribution for the clearest days during the 2014-2018 baseline at OLYM1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at OLYM1 are expected to come primarily from international anthropogenic sources (47%) while natural sources (8%), and wildland fires (2%) are expected to have minimal impacts. All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 36% of the nitrates responsible for light extinction at OLYM1 on MID. See Figure 6-6 for more information.

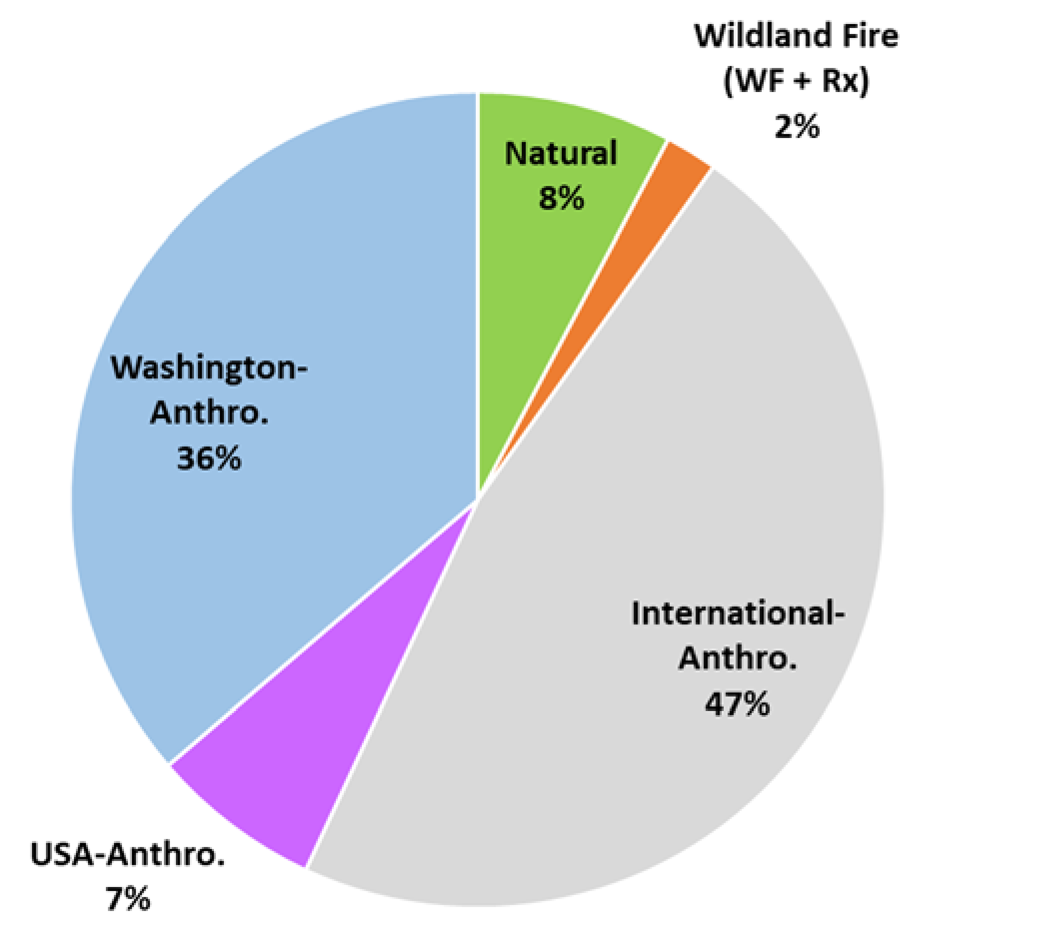

Figure 6-6: Expected source regions of NO_3 in 2028 at OLYM1 for MID (CAMx total = 5.9 Mm^{-1}).

The modeled nitrates for 2028 MID at OLYM1 was 5.9 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 4.28 Mm^{-1} and 3.28 Mm^{-1}, respectively.

Figure 6-7 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at OLYM1 on 2028 MID.

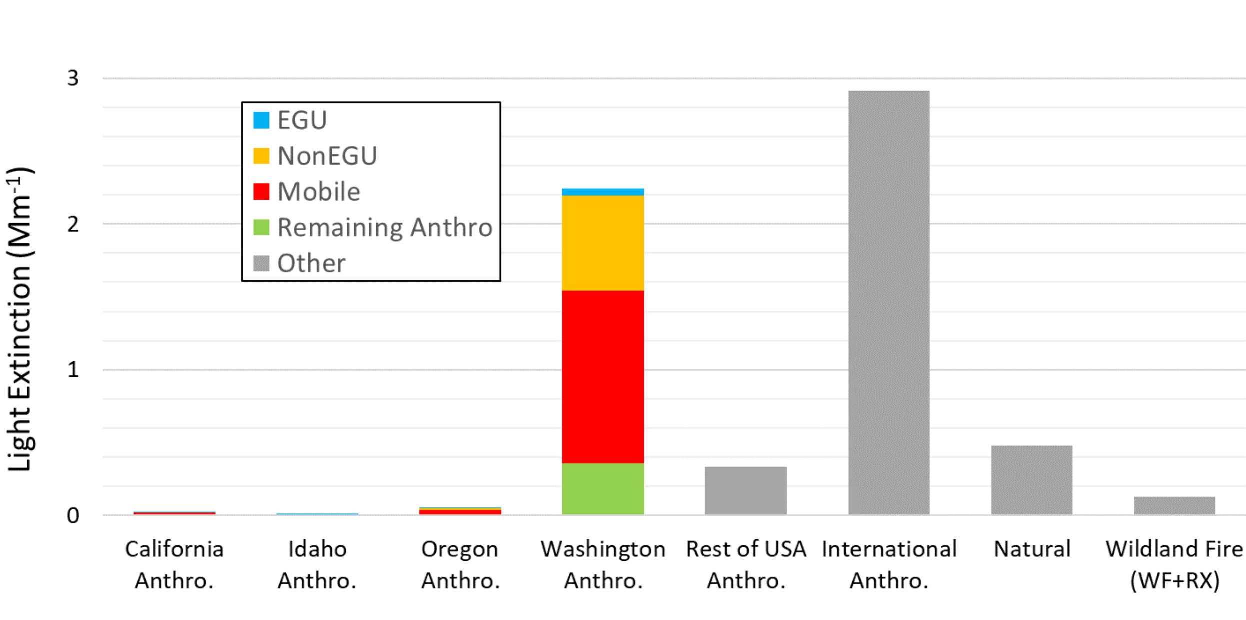

Figure 6-7: Expected source categories and regions of NO_3 in 2028 at OLYM1 for MID (CAM_X total = 5.9 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of nitrates at OLYM1 are expected to come primarily from out-of-state US anthropogenic (44%) sources. Washington anthropogenic sources are expected to contribute 33% of the nitrates responsible for light extinction at OLYM1 on clearest days. See Figure 6-8 for more information.

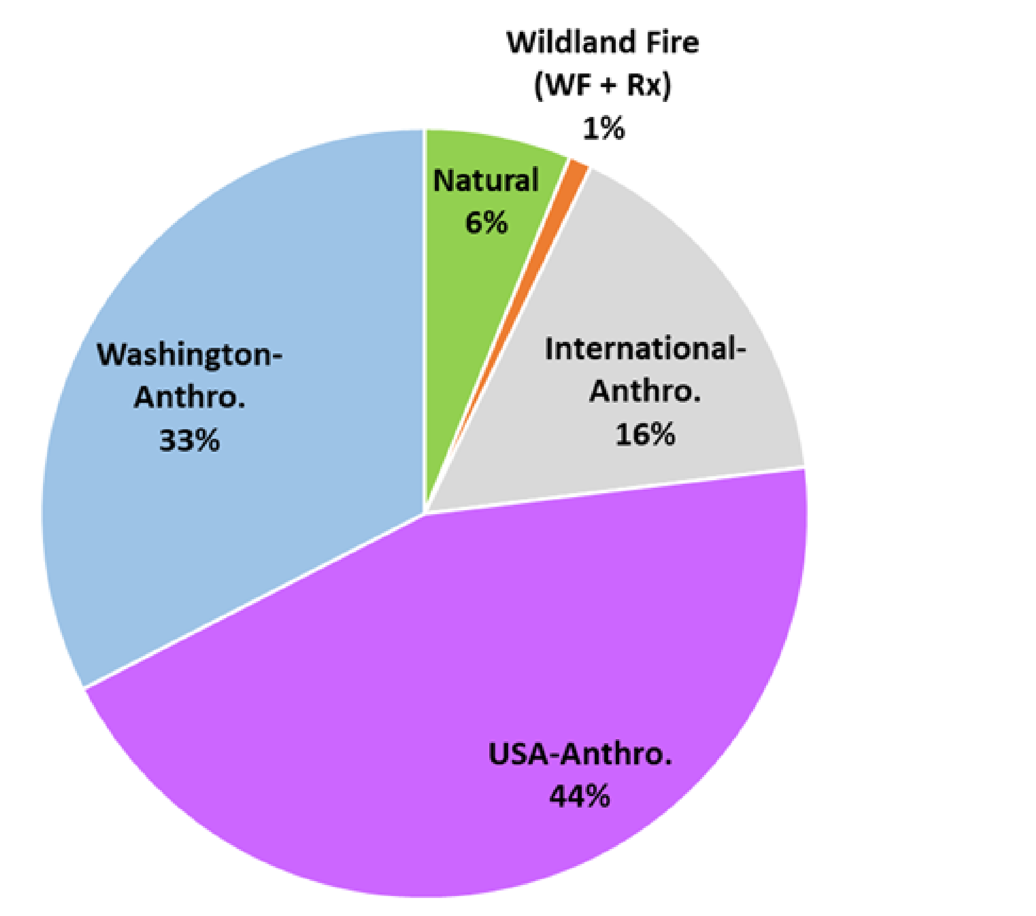

Figure 6-8: Expected source regions of NO_3 in 2028 at OLYM1 for clearest days (CAMx total = 2.5 Mm^{-1}).

The modeled nitrates for 2028 clearest days at OLYM1 was 2.5 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.65 Mm^{-1} and 0.46 Mm^{-1}, respectively. Figure 6-9 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at OLYM1 on 2028 clearest days.

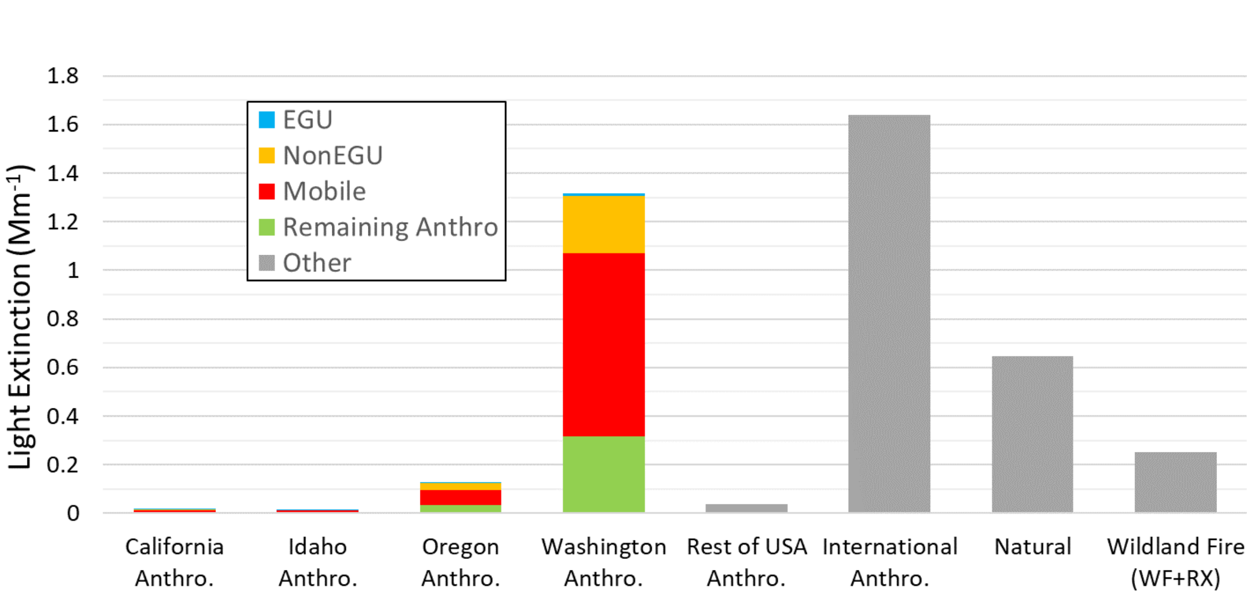

Figure 6-9: Expected source categories and regions of NO_3 in 2028 at OLYM1 for clearest days (CAMx total = 2.5 Mm^{-1}).

6.2 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 3 show that together organic mass (24%), sulfates (49%), and nitrates (10%) contributed to 83% of the light extinction on the MID at this monitoring site. On the clearest days, sulfates (36%), organic mass (26%), and nitrates (13%) contributed to 75% of the light extinction at this monitoring site.

WEP and rank point analyses

The WEP analysis for the NOCA1 site on MID for the 2028 OTB scenario is summarized in Figure 6-10, showing an AOI of sources in western Washington and the Puget Sound region, including considerable influence from the Vancouver, BC metropolitan area. Nitrates at NOCA1 show considerable influence from non-EGU Point, on-road, non-road, and non-point sources. Sulfates at NOCA1 show considerable influence from non-EGU point and non-point sources. Organic mass at NOCA1 is mostly influenced by non-point sources. Elemental carbon is mostly influenced by non-point sources but also shows a considerable influence from non-road sources. The rank point WEP analysis attributed 99.6% of point source nitrates to Washington, with 0.3% attributed to Oregon. The rank point WEP analysis attributed 99.6% of point source sulfates to Washington, with 0.3% attributed to Oregon.

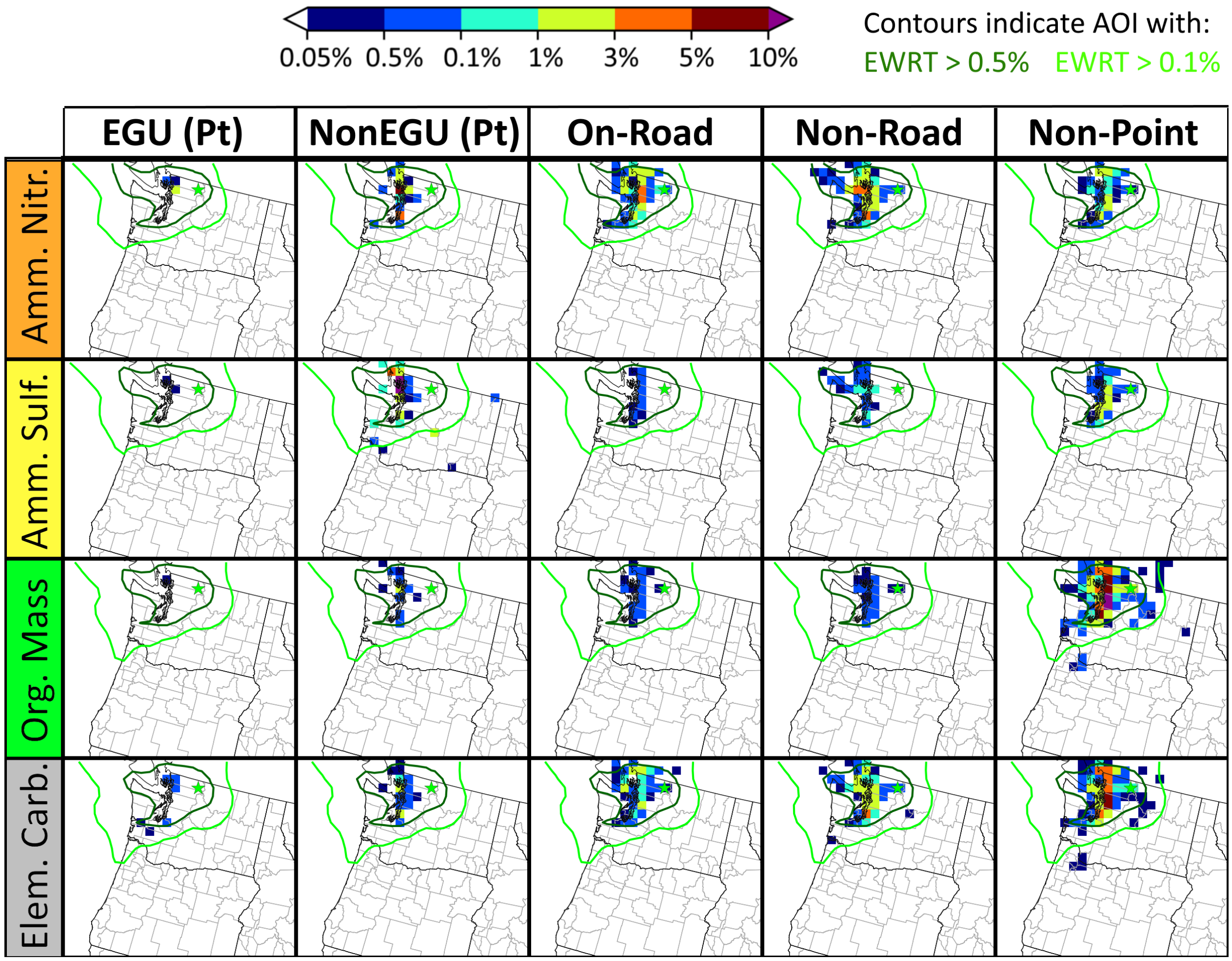

Figure 6-10: WEP for source area potential to contribute to extinction on MID by pollutant at the NOCA1 IMPROVE monitor (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at NOCA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of sulfates at NOCA1 are expected to come primarily from natural (35%), international anthropogenic (26%) and wildland fire (26%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 10% of the sulfates responsible for light extinction at NOCA1. See Figure 6-11 for more information.

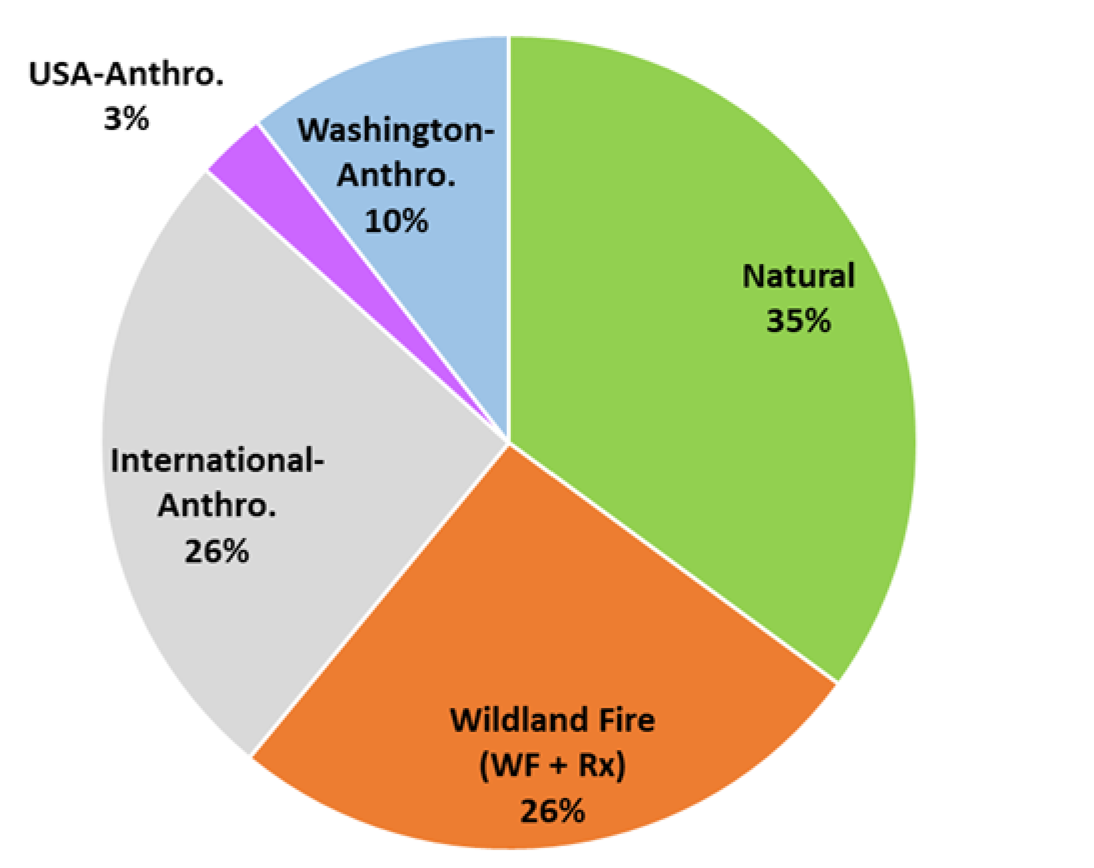

Figure 6-11: Expected source regions of SO_4 in 2028 at NOCA1 for MID (CAMx total = 11.3 Mm^{-1}).

The modeled sulfates for 2028 MID at NOCA1 was 11.3 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 8.14 Mm^{-1} and 8.16 Mm^{-1}, respectively. Figure 6-12 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the NOCA1 monitoring site on 2028 MID.

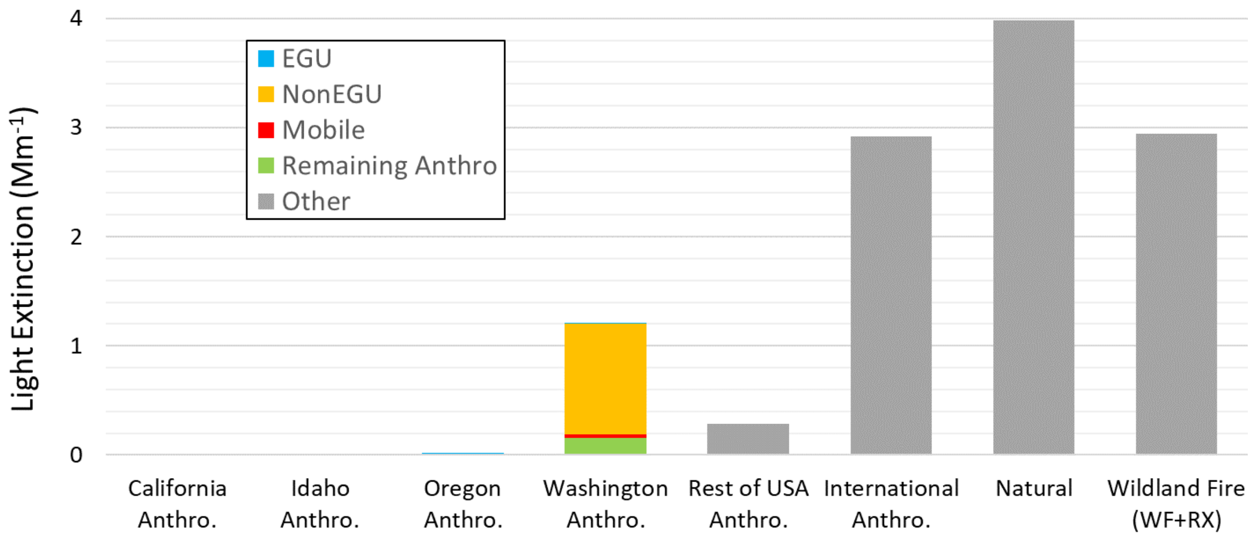

Figure 6-12: Expected source categories and regions of SO_4 in 2028 at NOCA1 for MID (CAMx total = 11.3 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at NOCA1 are expected to come primarily from natural (46%), international anthropogenic (30%), and out-of-state US anthropogenic (12%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 8% of the sulfates responsible for light extinction at OLYM1. See Figure 6-13 for more information.

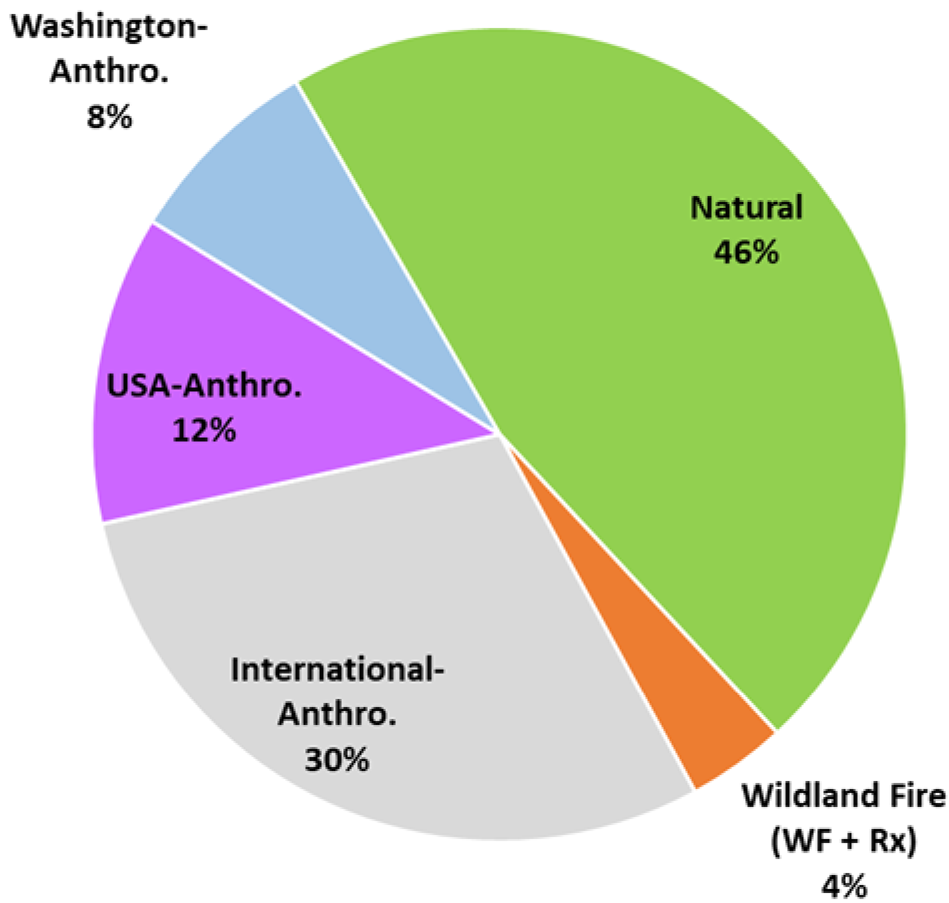

Figure 6-13: Expected source regions of SO_4 in 2028 at NOCA1 for clearest days (CAMx PSAT total = 3.6 Mm^{-1})

The modeled sulfates for 2028 clearest days at NOCA1 was 3.6 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.66 Mm^{-1} and 0.65 Mm^{-1}, respectively. Figure 6-14 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at NOCA1 on 2028 clearest days.

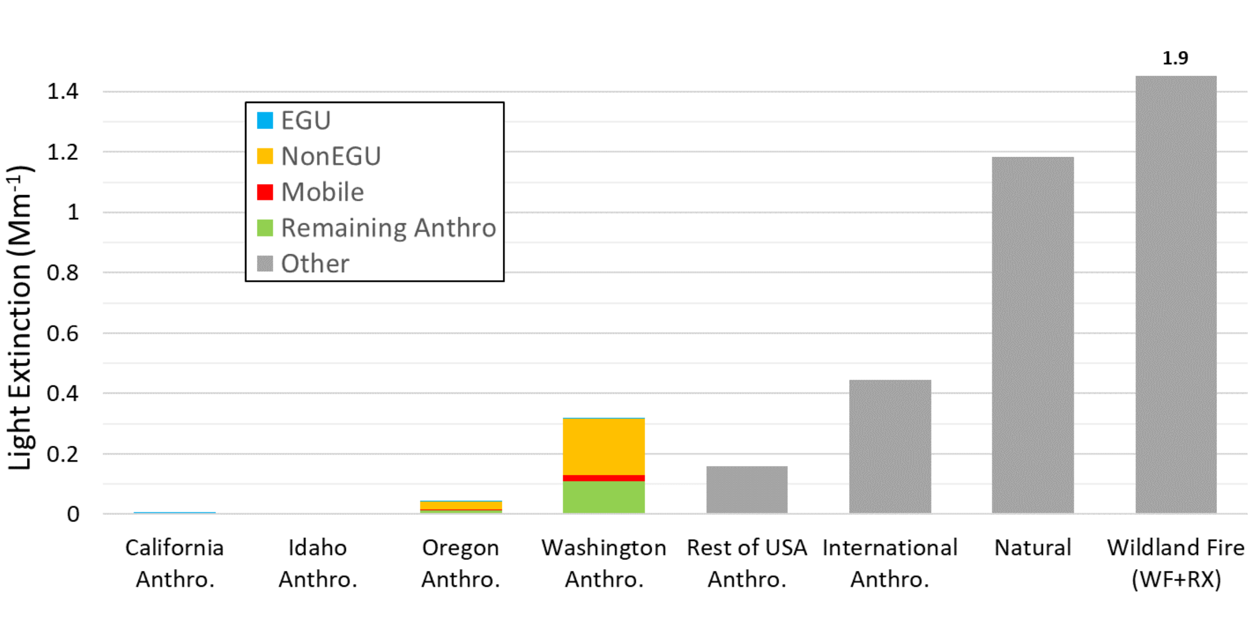

Figure 6-14: Expected source categories and regions of SO_4 in 2028 at NOCA1 for clearest days (CAMx total = 3.6 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the third largest species contribution to light extinction for the MID and clearest days during the 2014-2018 baseline at NOCA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at NOCA1 are expected to come primarily from international anthropogenic sources (45%) while natural sources (18%), and wildland fires (5%) are expected to have minimal impacts. All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 25% of the nitrates responsible for light extinction at NOCA1. See Figure 6-15 for more information.

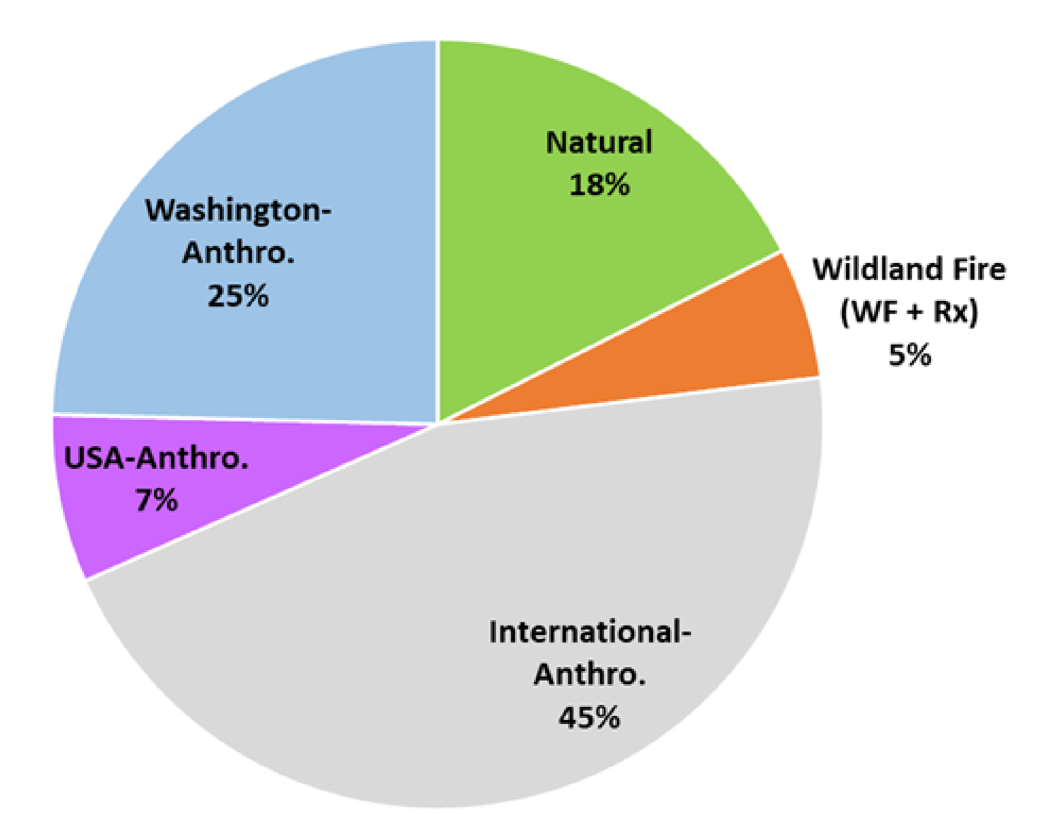

Figure 6-15: Expected source regions of NO_3 in 2028 at NOCA1 for MID (CAMx total = 5.9 Mm-1).

The modeled nitrates for 2028 MID at NOCA1 was 5.9 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 1.73 Mm^{-1} and 1.24 Mm^{-1}, respectively.

Figure 6-16 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at NOCA1 on 2028 MID.

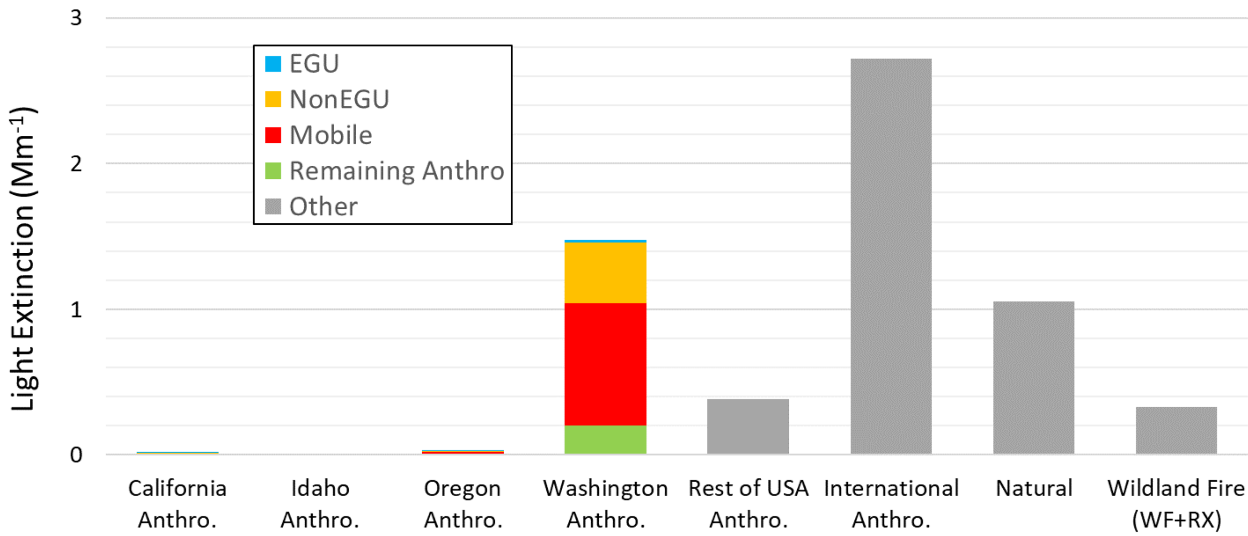

Figure 6-16: Expected source categories and regions of NO3 in 2028 at NOCA1 for MID (CAMx total = 5.9 Mm-1).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of nitrates at NOCA1 are expected to come primarily from out-of-state US anthropogenic (33%), and international anthropogenic (25%) sources. Washington anthropogenic sources are expected to contribute 22% of the nitrates responsible for light extinction at NOCA1 on clearest days. See Figure 6-17 for more information.

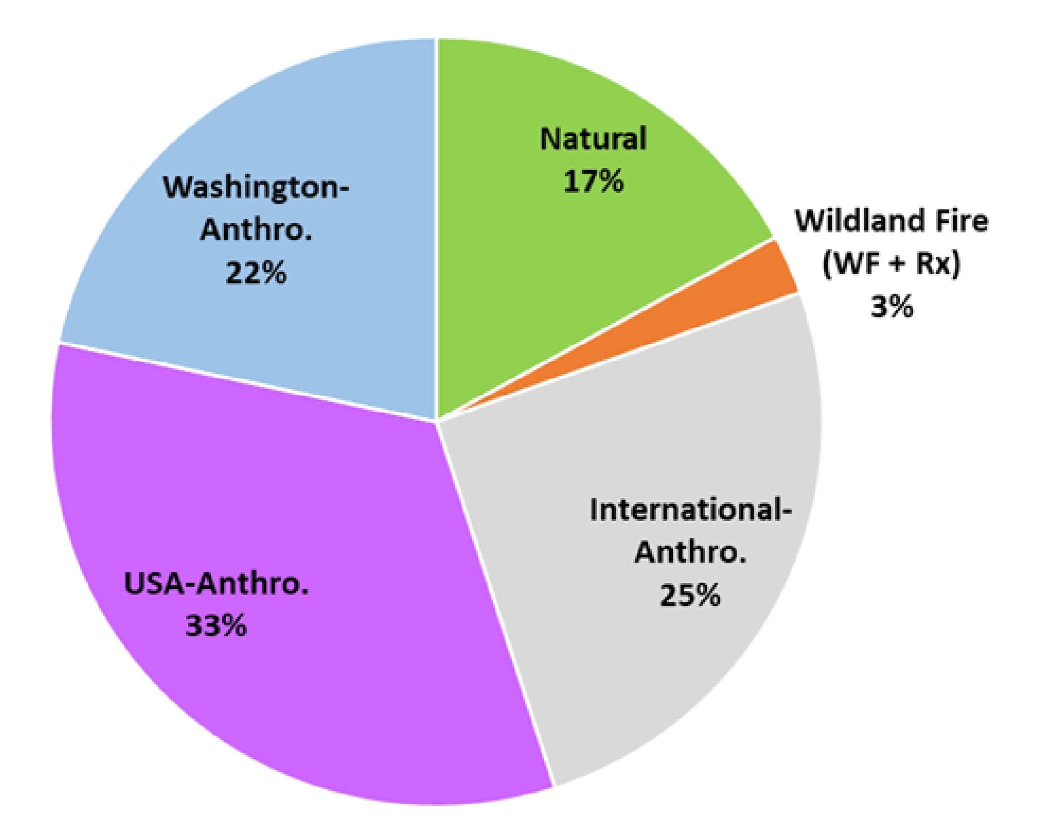

Figure 6-17: Expected source regions of NO_3 in 2028 at NOCA1 for clearest days (CAMx total = 0.8 Mm^{-1}).

The modeled nitrates for 2028 clearest days at NOCA1 was 0.8 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.24 Mm^{-1} and 0.19 Mm^{-1}, respectively. Figure 6-18 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at the NOCA1 monitoring site on 2028 clearest days.

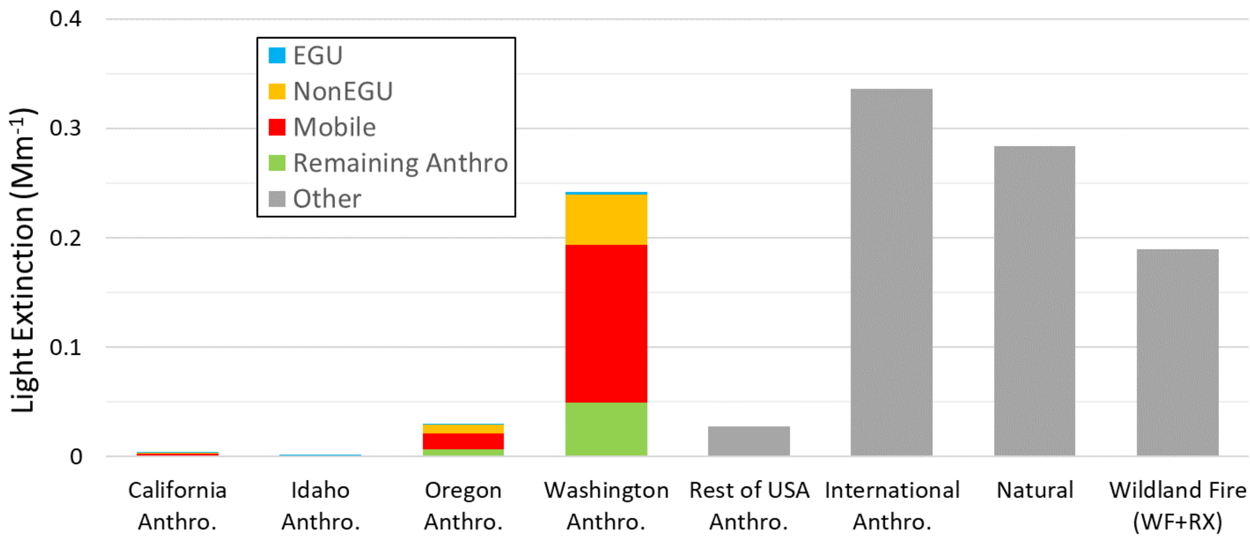

Figure 6-18: Expected source categories and regions of NO_3 in 2028 at NOCA1 for clearest days (CAMx total = 0.8 Mm^{-1}).

6.3 Alpine Lakes Wilderness

Alpine Lakes Wilderness is represented by the SNPA1 IMPROVE monitoring site. The baseline conditions presented in Chapter 3 show that sulfates (35%), organic mass (25%), and nitrates (26%) together contribute to 76% of the light extinction on the MID at this site. On the clearest days sulfates (33%), nitrates (20%), and organic mass (22%) contribute to 75% of the light extinction at this monitoring site.

WEP and rank point analyses

The WEP analysis for the SNPA1 site on MID for the 2028 OTB scenario is summarized in Figure 6-19, showing an AOI of sources that span western and central Washington, the Puget Sound area, and the Vancouver, BC and Portland, OR metropolitan areas. Nitrates at SNPA1 show considerable influence from on-road, Non-road, and non-point sources. Sulfates at NOCA1 show considerable influence from non-EGU Point and non-point sources. Organic mass at SNPA1 is mostly influenced by non-point sources. Elemental carbon is mostly influenced by non-point sources but also shows influence from non-EGU Point, on-road, and non-road sources. The rank point WEP analysis attributed 90.9% of point source nitrates to Washington, with 8.2%, 0.4%, 0.3%, and 0.2% attributed to Oregon, California, Idaho, and tribal lands, respectively. The rank point WEP analysis attributed 98.3% of point source sulfates to Washington, with 1.4% and 0.2% attributed to Oregon and California, respectively.

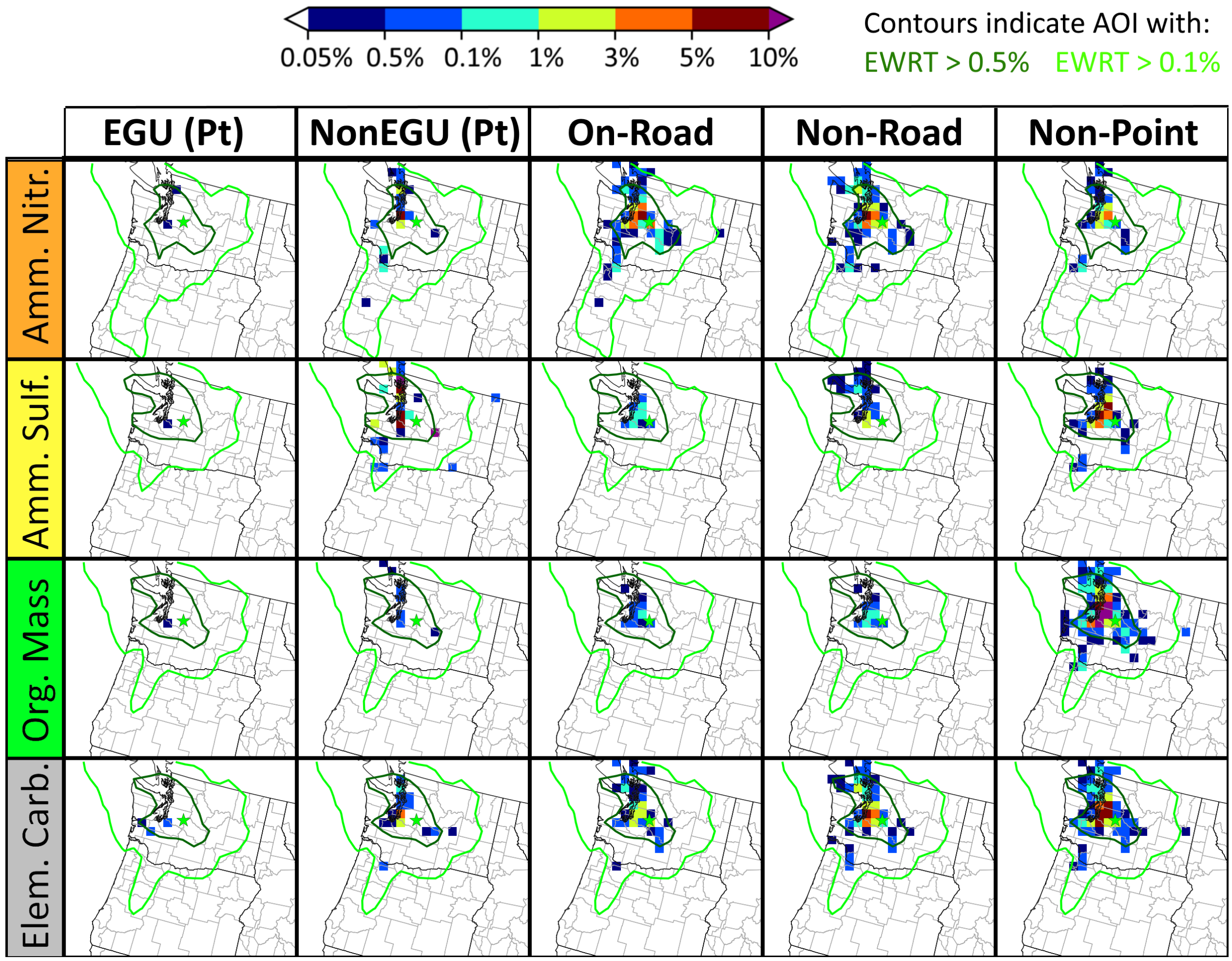

Figure 6-19: WEP for source area potential to contribute to extinction on MID by pollutant at SNPA1 (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at SNPA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of sulfates at SNPA1 are expected to come primarily from wildland fire (55%), natural (21%), and international anthropogenic sources (14%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 8% of the sulfates responsible for light extinction at SNPA1. See Figure 6-20 for more information.

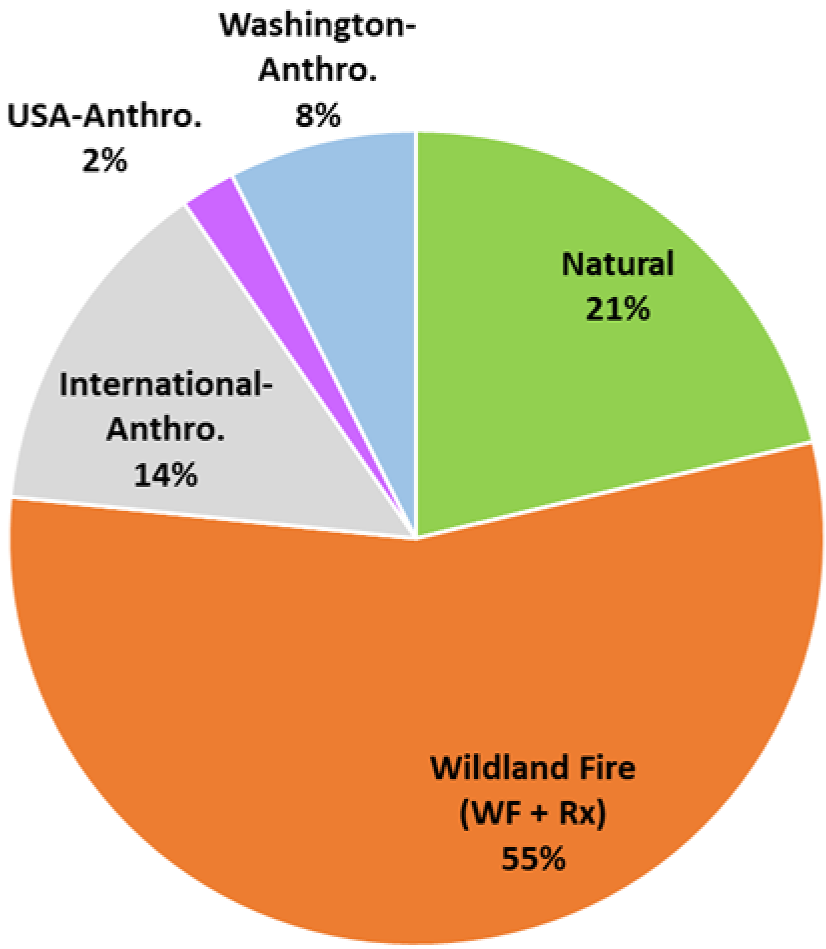

Figure 6-20: Expected source regions of SO_4 in 2028 at SNPA1 for MID (CAMx total = 22.9 Mm^{-1}).

The modeled sulfates for 2028 MID at SNPA1 was 22.9 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 8.84 Mm^{-1} and 8.75 Mm^{-1}, respectively. The impacts of wildland fire on MID are clearly overestimated in the model for SNPA1, which is supported by the immense organic mass modeled at the site (171.3 Mm^{-1}). Figure 6-21 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the OLYM1 monitoring site on 2028 MIDs.

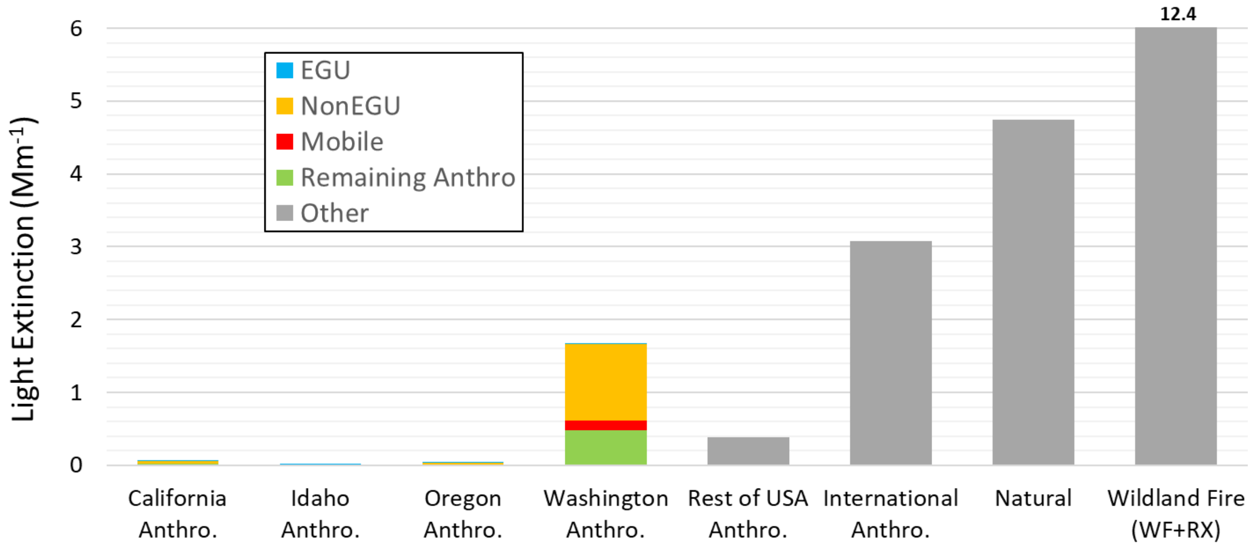

Figure 6-21: Expected source categories and regions of SO_4 in 2028 at SNPA1 for MID (CAMx total = 22.4 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at SNPA1 are expected to come primarily from natural (47%), international anthropogenic (22%), and out-of-state US anthropogenic (18%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 11% of the sulfates responsible for light extinction at SNPA1. See Figure 6-22 for more information.

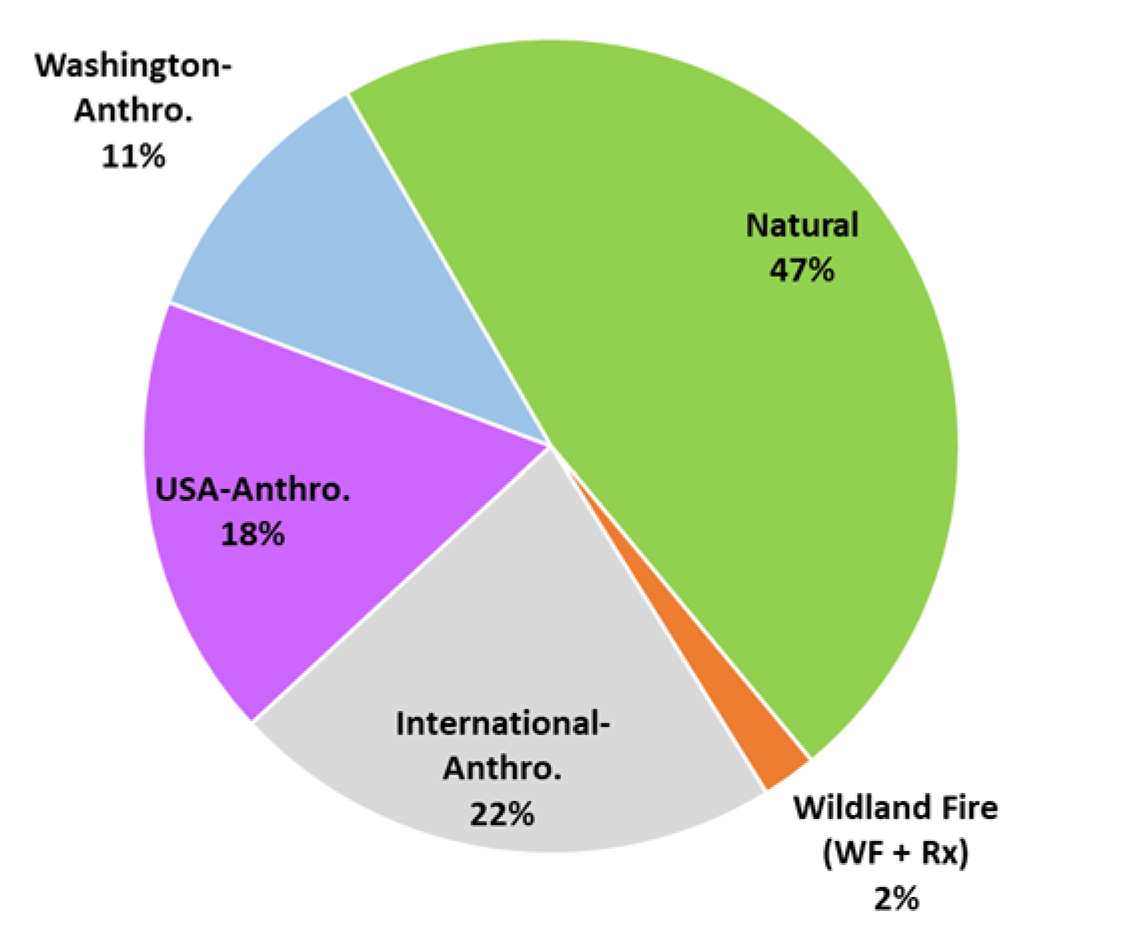

Figure 6-22: Expected source regions of SO_4 in 2028 at SNPA1 for clearest days (CAMx total = 4.4 Mm^{-1}).

The modeled sulfates for 2028 clearest days at SNPA1 was 4.4 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 1.01 Mm^{-1} and 0.98 Mm^{-1}, respectively.

Figure 6-23 shows an expectation within Washington that non-EGU point sources contribute the most sulfate light extinction at SNPA1 on 2028 clearest days.

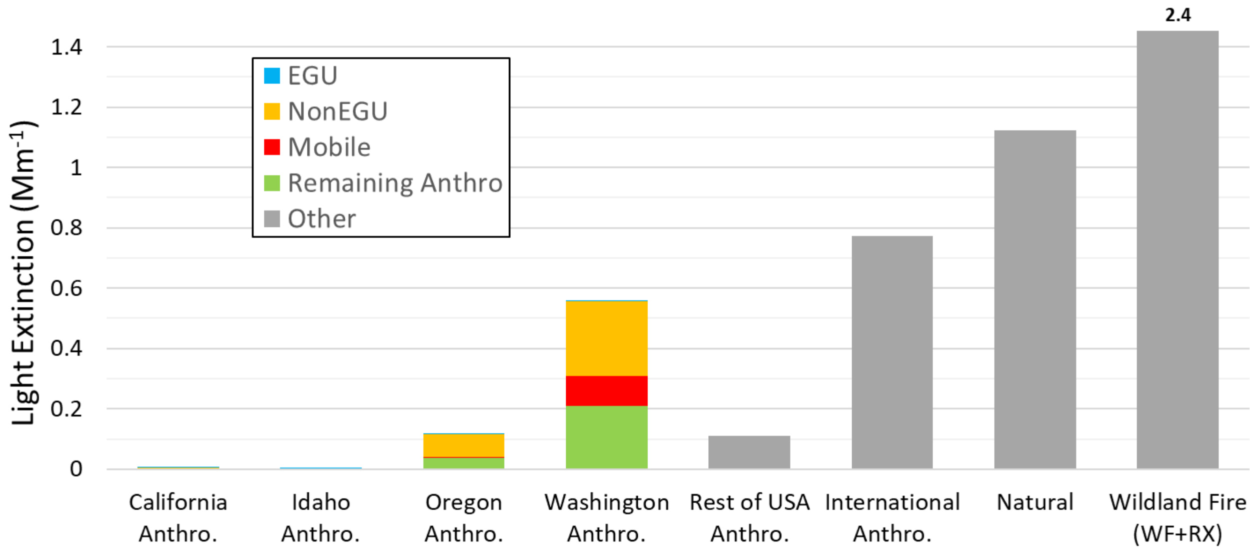

Figure 6-23: Expected source categories and regions of SO_4 in 2028 at SNPA1 for clearest days (CAMx total = 4.4 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the 2nd largest species contribution to light extinction for the MID clearest days during the 2014-2018 baseline at SNPA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at SNPA1 are expected to be most influenced from Washington anthropogenic sources (38%). Wildland fires (26%), international anthropogenic (19%), and natural sources (11%) are expected to have some impacts but are beyond Washington's control. See Figure 6-24 for more information.

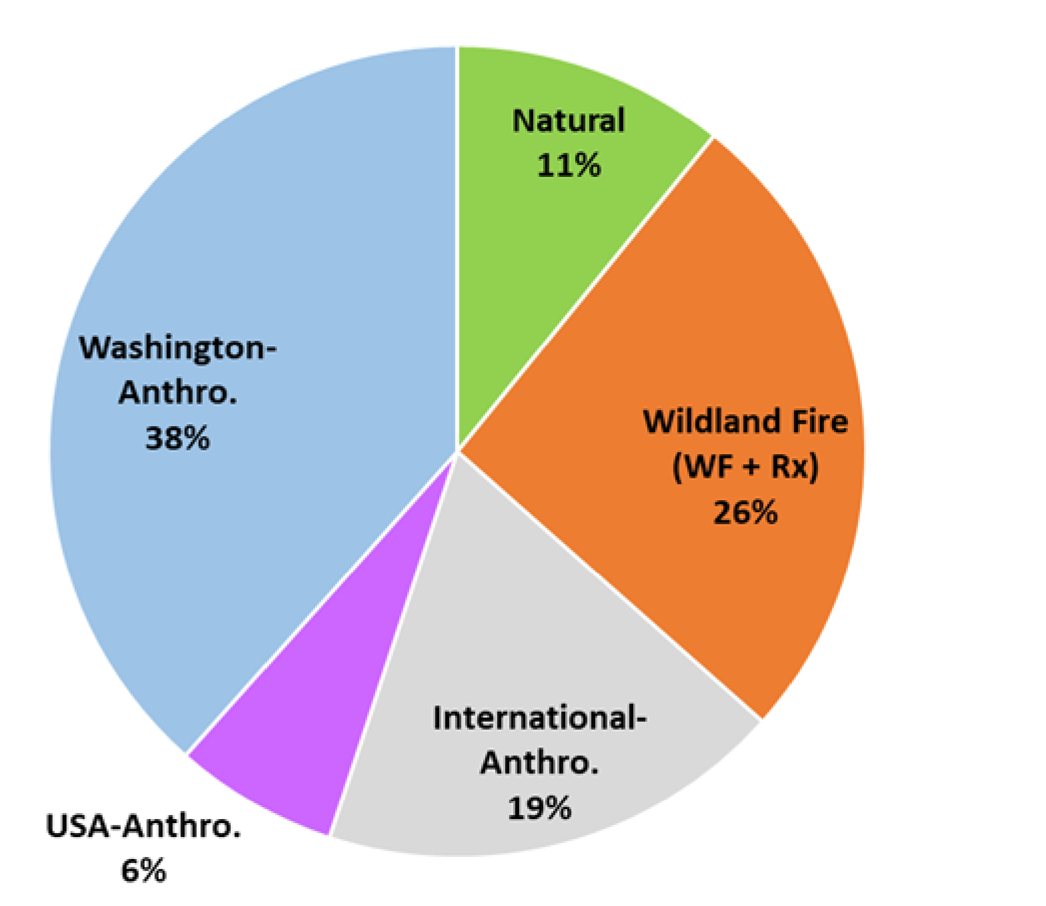

Figure 6-24: Expected source regions of NO_3 in 2028 at SNPA1 for MID (CAMx total = 14.9 Mm^{-1}).

The modeled nitrates for 2028 MID at SNPA1 was 14.9 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 6.75 Mm^{-1} and 4.26 Mm^{-1}, respectively.

Figure 6-25 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at SNPA1 on 2028 MIDs.

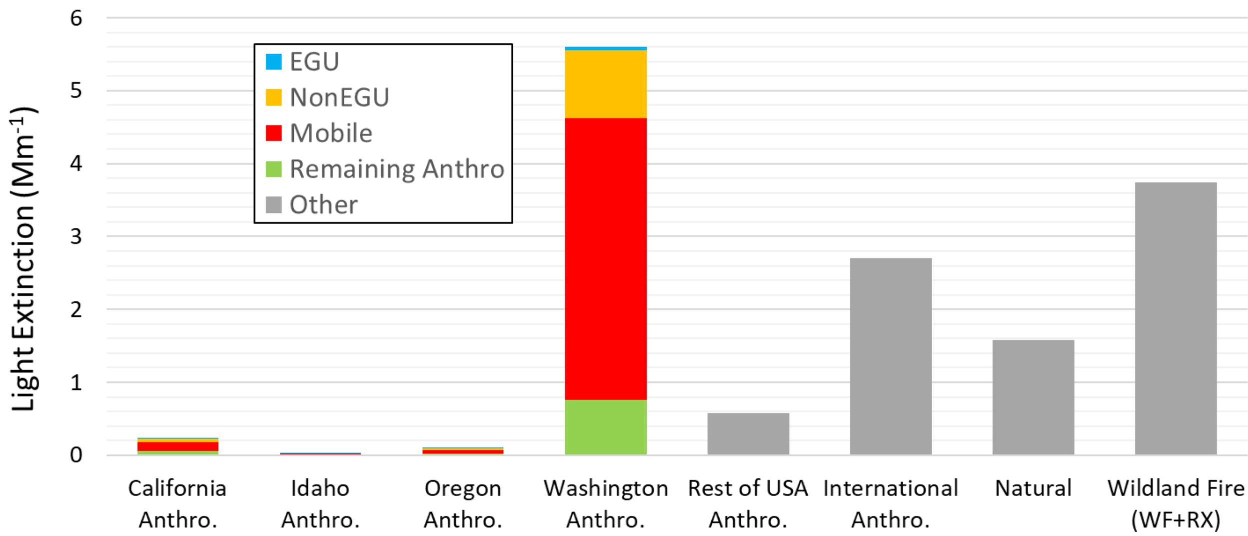

Figure 6-25: Expected source categories and regions of NO_3 in 2028 at SNPA1 for MID (CAMx total = 14.9 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days' visibility impacts of nitrates at SNPA1 are expected to come primarily from out-of-state US anthropogenic (40%) sources. Washington anthropogenic sources are expected to contribute 26% of the nitrates responsible for light extinction at SNPA1 on clearest days. See Figure 6-26 for more information.

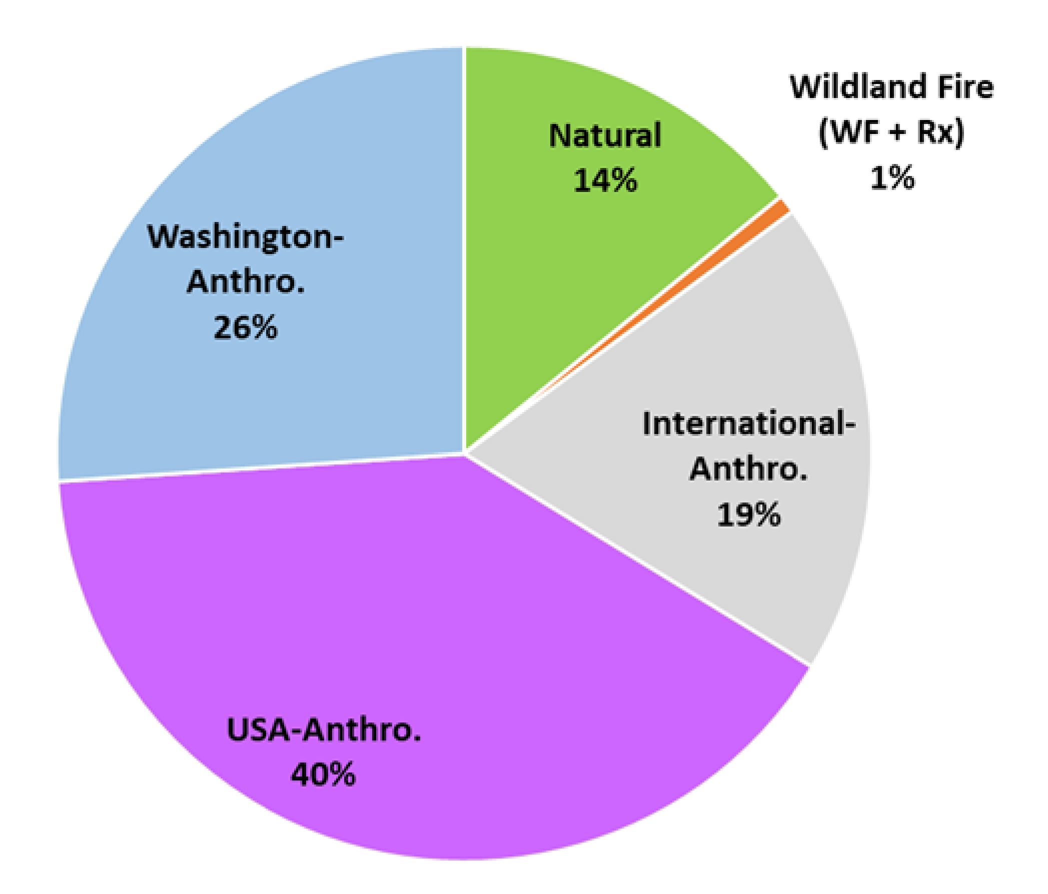

Figure 6-26: Expected source regions of NO_3 in 2028 at SNPA1 for clearest days (CAMx PSAT total = 2.2 Mm^{-1}).

The modeled nitrates for 2028 clearest days at SNPA1 was 2.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.61 Mm^{-1} and 0.45 Mm^{-1}, respectively.

Figure 6-27 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at the SNPA1 monitoring site on 2028 clearest days.

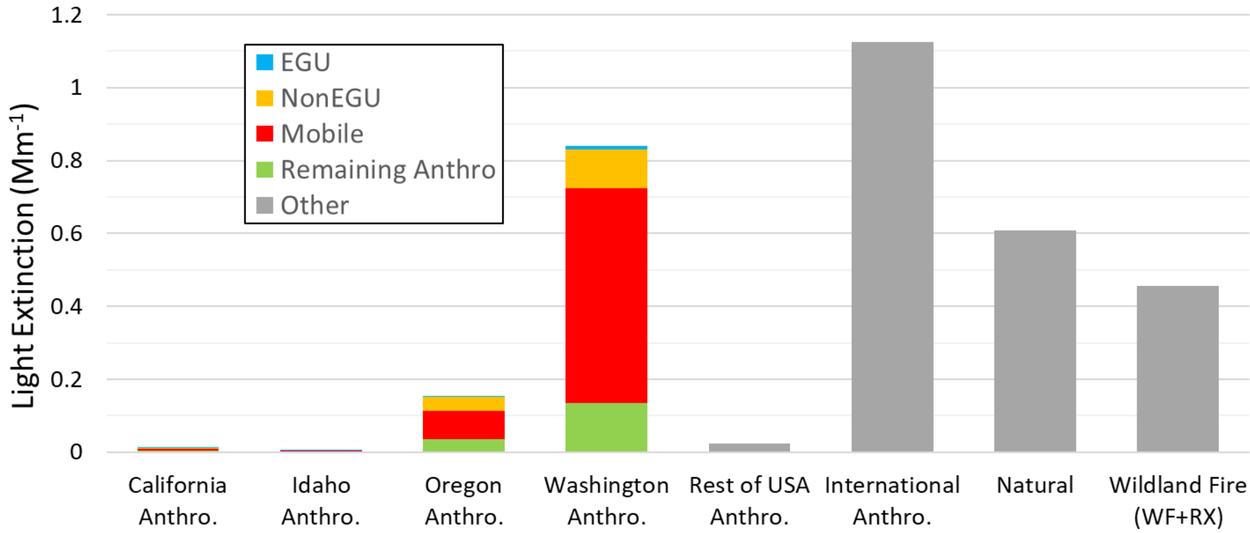

Figure 6-27: Expected source categories and regions of NO_3 in 2028 at SNPA1 for clearest days (CAMx PSAT total = 2.2 Mm^{-1}).

6.4 Mount Rainier National Park

Mount Rainier National Park is represented by the MORA1 IMPROVE monitoring site. The baseline conditions in Chapter 3 show that sulfates (41%) and organic mass (31%) make up 72% of the light extinction on the MID at this monitoring site. Nitrates (7%) and elemental carbon (9%) contribute to another 16% of the light extinction on the MID at this monitoring site. On the clearest days, sulfates (34%) and organic mass (26%) make up 60% of the light extinction at this monitoring site. Nitrates (8%) and elemental carbon (10%) contribute to another 18% of the light extinction on the clearest days at this monitoring site.

WEP and rank point analyses

The WEP analysis for the MORA1 site on MID for the 2028 OTB scenario is summarized in Figure 6-28, showing an AOI of sources in western Washington and the Puget Sound region. There is also some minimal influence from sources in the Portland, OR and Vancouver, BC metropolitan areas. Nitrates at MORA1 show considerable influence from non-EGU Point, on-road, non-road, and non-point sources. Sulfates at MORA1 show considerable influence from non-EGU Point, non-road, and non-point sources. Organic mass at MORA1 is mostly influenced by non-point sources. Elemental carbon is influenced by non-EGU Point, on-road, non-road, and non-point sources. The rank point WEP analysis attributed 97.3% of point source nitrates to Washington, with 2.6% attributed to Oregon. The rank point WEP analysis attributed 95.6% of point source sulfates to Washington, with 4.2% and 0.2% attributed to Oregon and California, respectively.

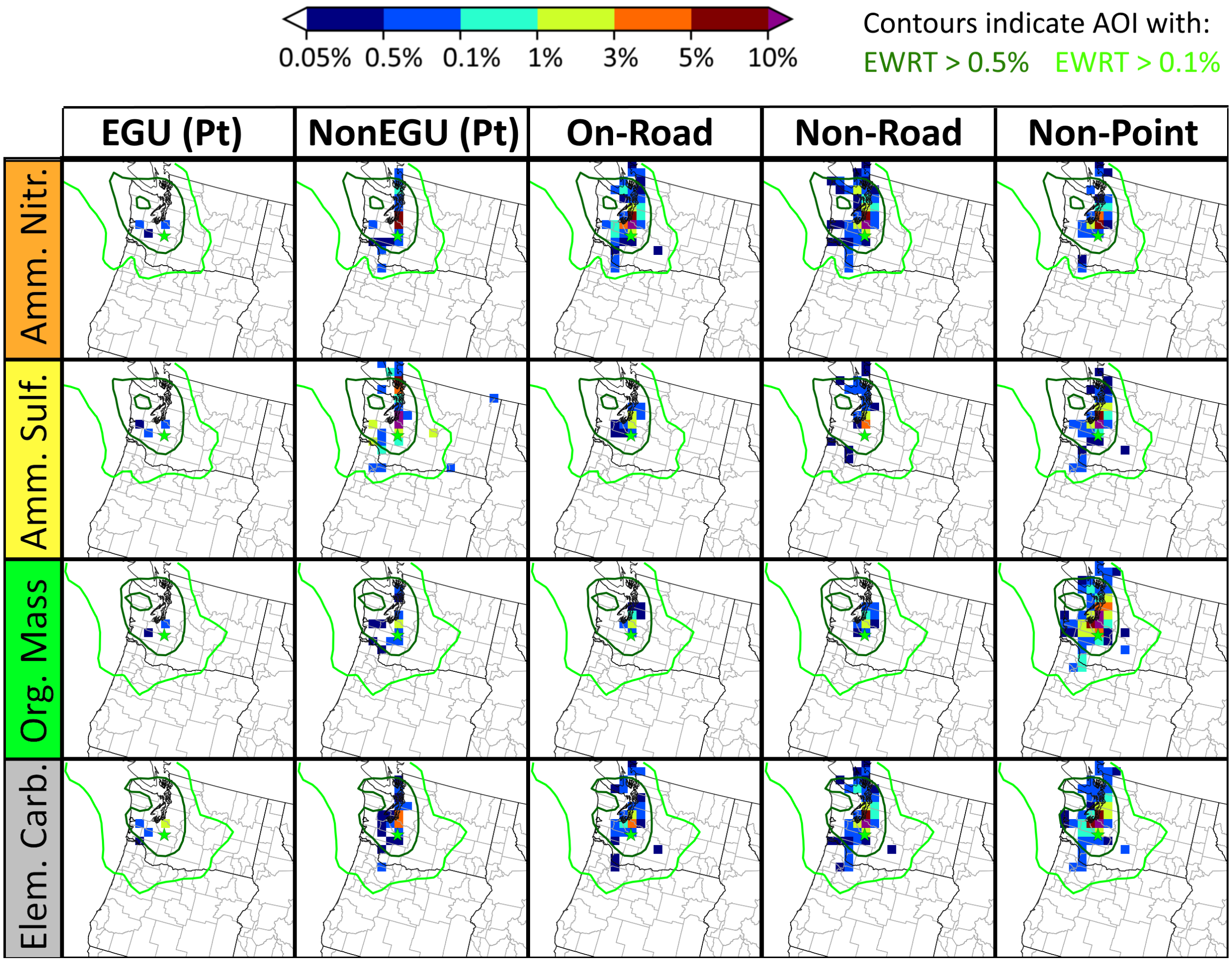

Figure 6-28: WEP for source area potential to contribute to extinction on MID by pollutant at the MORA1 IMPROVE monitor (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at MORA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of sulfates at MORA1 are expected to come primarily from natural (39%), wildland fire (25%), and international anthropogenic sources (23%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 10% of the sulfates responsible for light extinction at MORA1. See Figure 6-29 for more information.

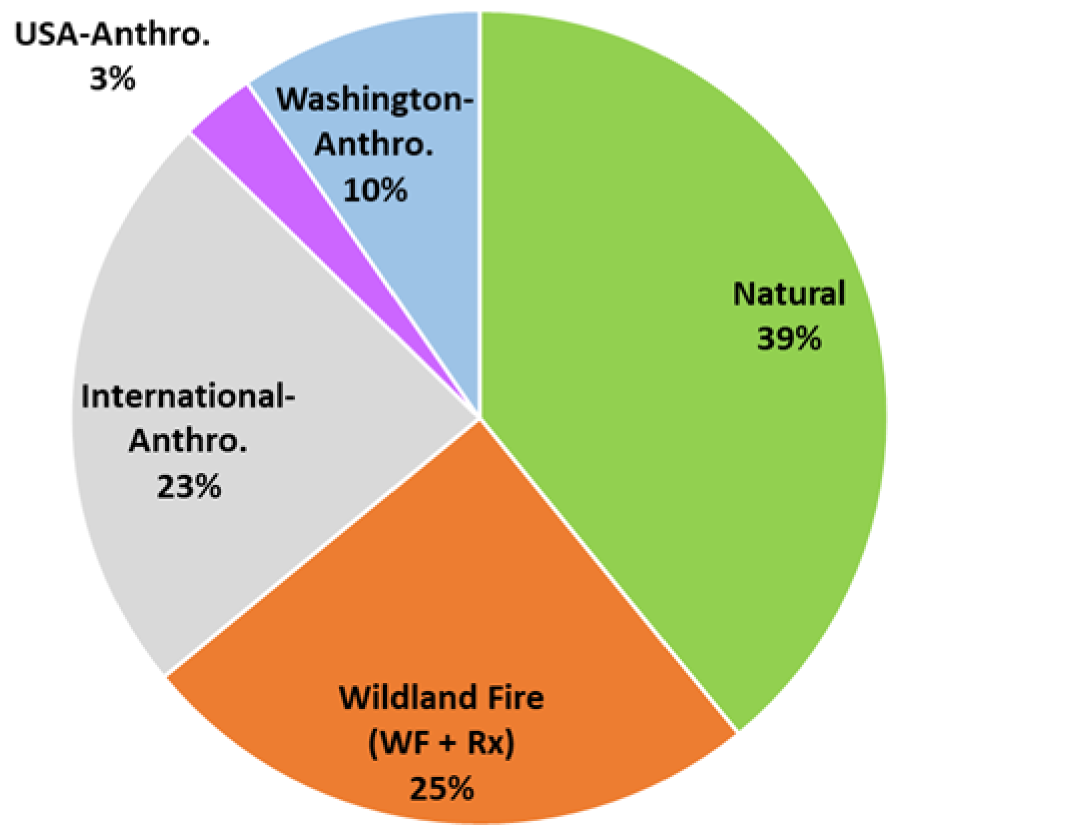

Figure 6-29: Expected source regions of SO_4 in 2028 at MORA1 for MID (CAMx total = 13.2 Mm^{-1}).

The modeled sulfates for 2028 MID at MORA1 was 13.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 10.15 Mm^{-1} and 9.7 Mm^{-1}, respectively.

Figure 6-30 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the OLYM1 monitoring site on 2028 MIDs.

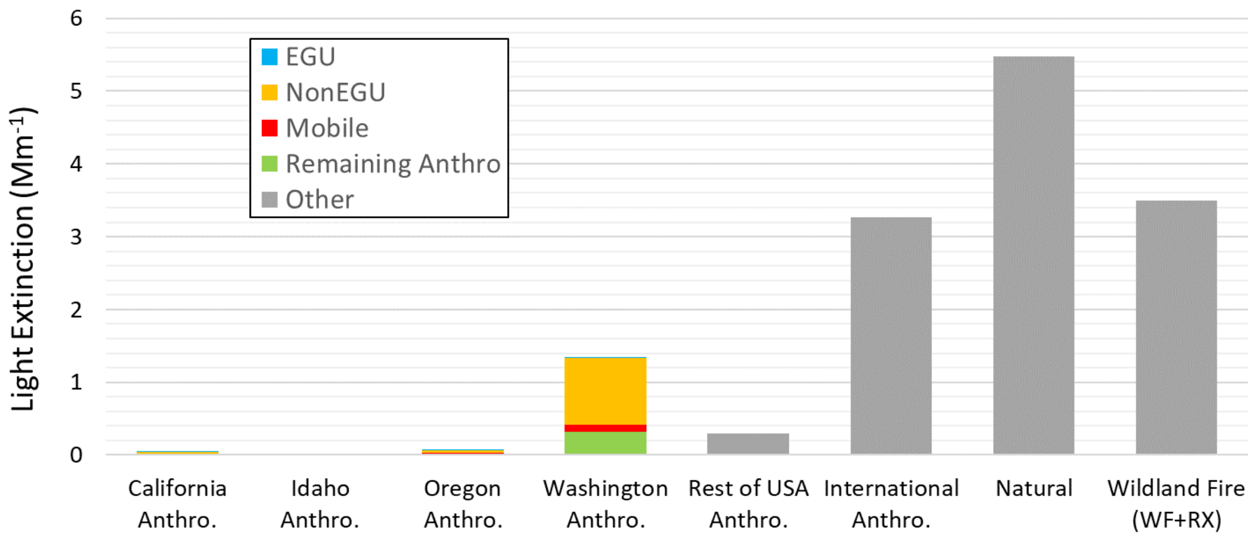

Figure 6-30: Expected source categories and regions of SO_4 in 2028 at MORA1 for MID (CAMx total = 13.2 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at MORA1 are expected to come primarily from natural (36%), out-of-state US anthropogenic (28%), and international anthropogenic (26%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 7% of the sulfates responsible for light extinction at SNPA1. See Figure 6-31 for more information.

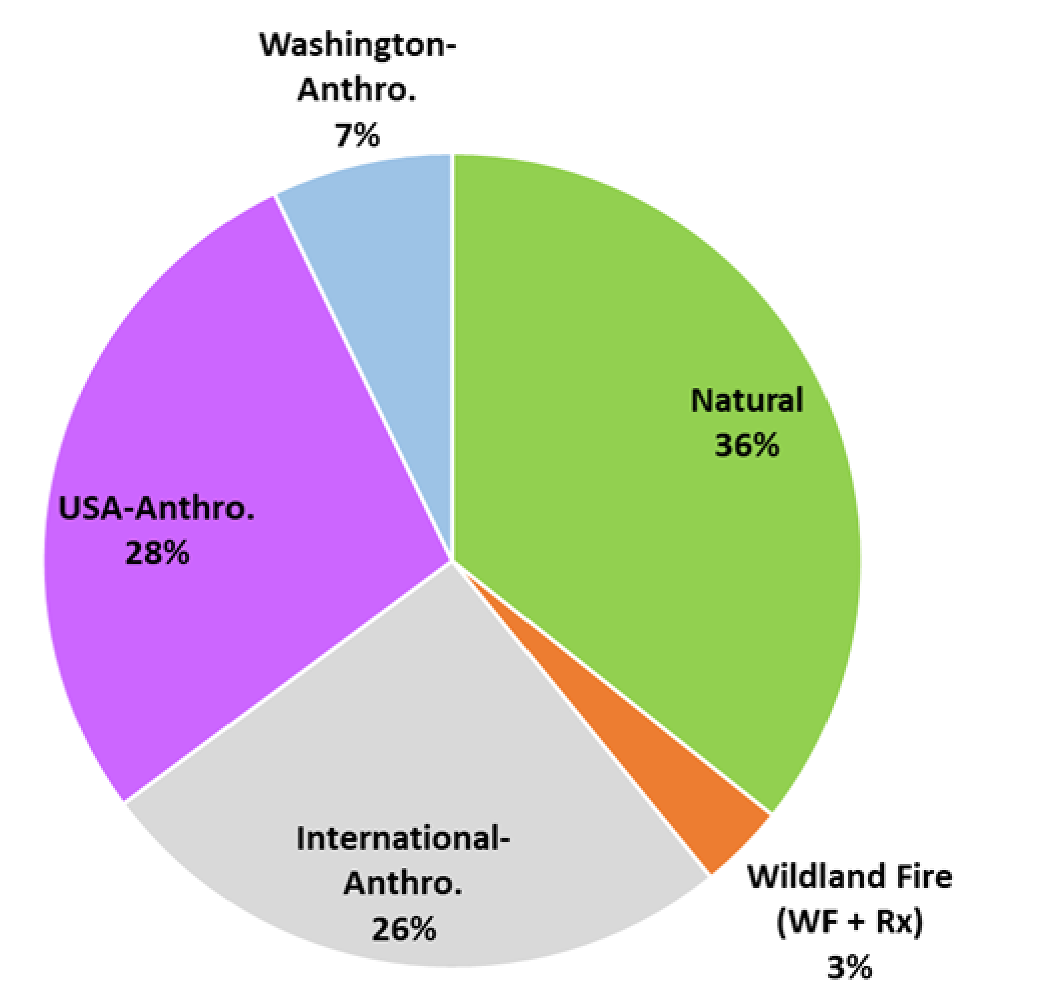

Figure 6-31: Expected source regions of SO_4 in 2028 at MORA1 for clearest days (CAMx total = 3.7 Mm^{-1}).

The modeled sulfates for 2028 clearest days at MORA1 was 3.7 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 1.3 Mm^{-1} and 1.22 Mm^{-1}, respectively.

Figure 6-32 shows an expectation within Washington that, non-EGU point sources contribute the majority of sulfate light extinction at MORA1 on 2028 clearest days.

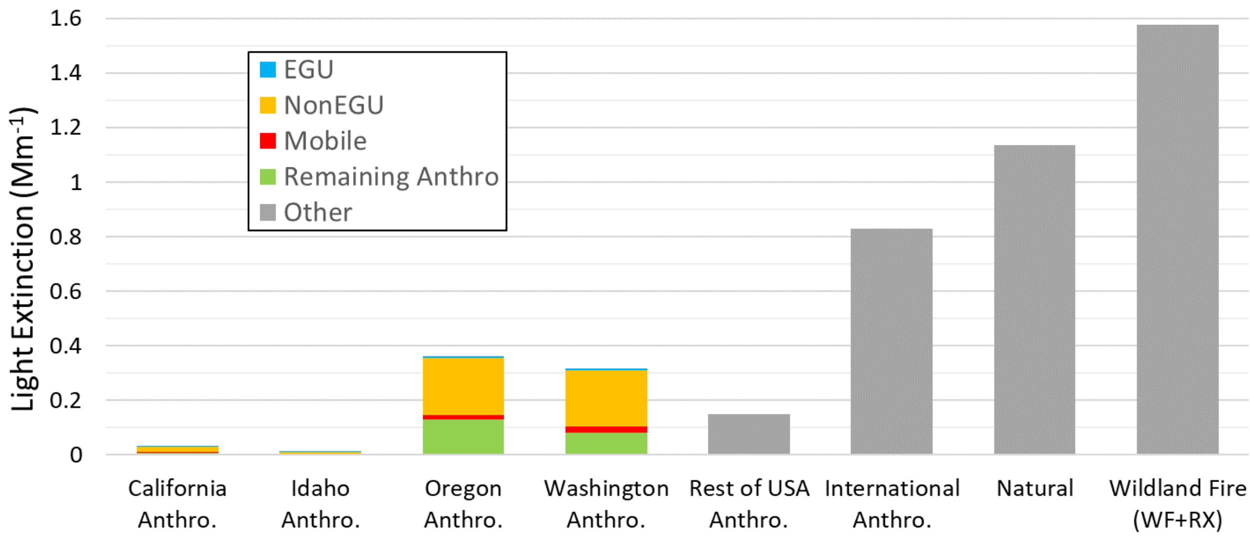

Figure 6-32: Expected source categories and regions of SO_4 in 2028 at MORA1 for clearest days (CAMx total = 3.7 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the 3rd largest species contribution to light extinction for the MID and 6th largest species contribution for the clearest days during the 2014-2018 baseline at MORA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at MORA1 are expected to be most influenced from Washington anthropogenic sources (46%). International anthropogenic (18%), Wildland fires (15%), and natural sources (14%) are expected to have some impacts but are beyond Washington's control. See Figure 6-33 for more information.

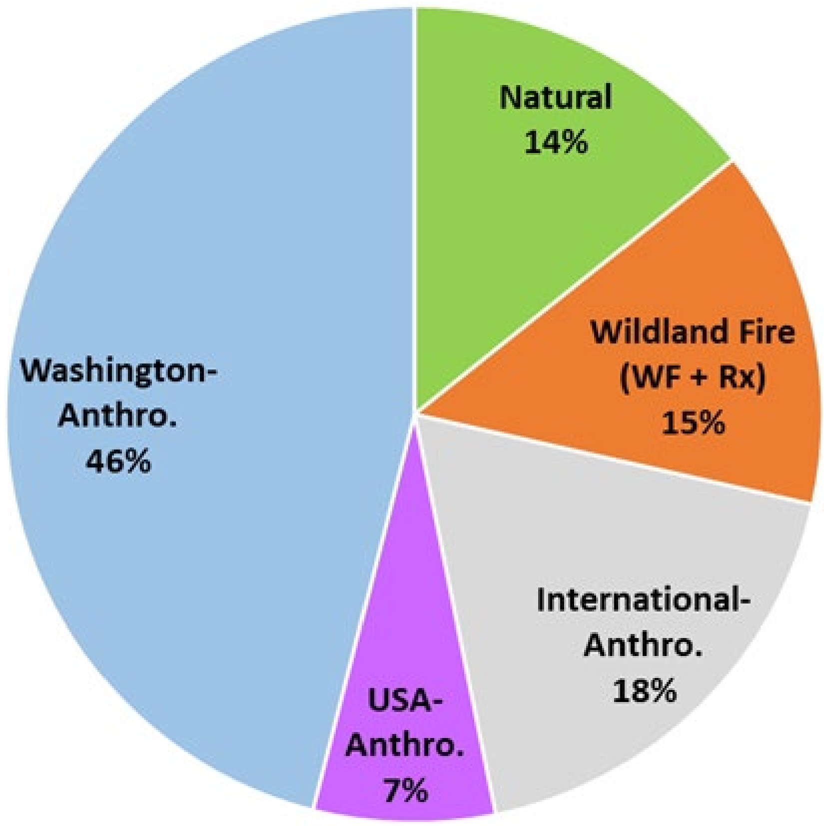

Figure 6-33: Expected source regions of NO_3 in 2028 at MORA1 for MID (CAMx total = 7.2 Mm^{-1}).

The modeled nitrates for 2028 MID at MORA1 was 7.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 2.27 Mm^{-1} and 1.13 Mm^{-1}, respectively.

Figure 6-34 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at MORA1 on 2028 MIDs.

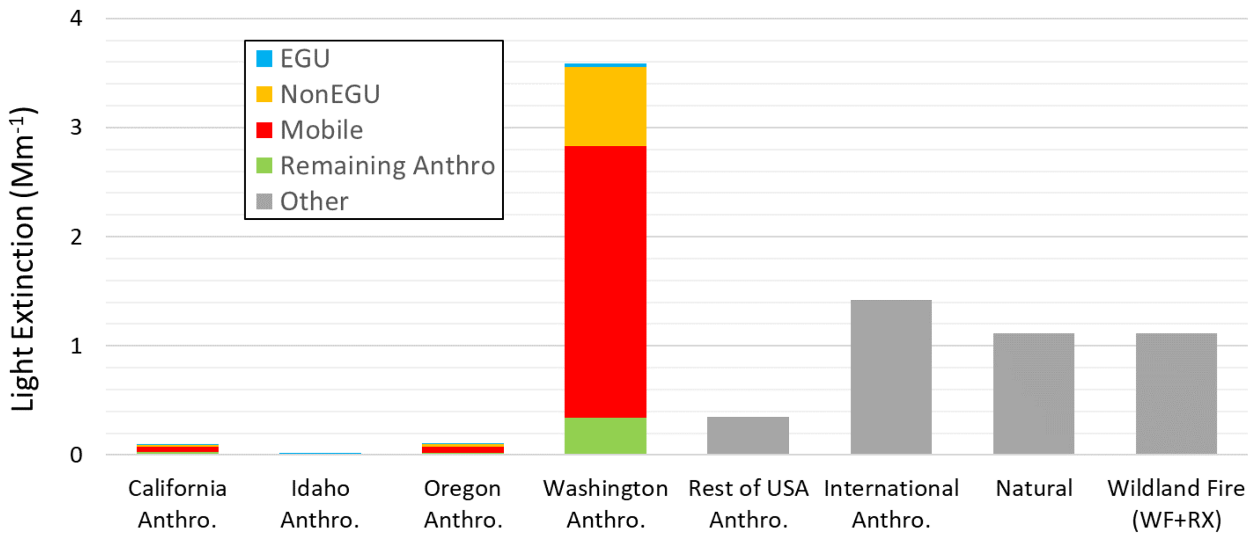

Figure 6-34: Expected source categories and regions of NO_3 in 2028 at MORA1 for MID (CAMx total = 7.2 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of nitrates at MORA1 are expected to come primarily from out-of-state US anthropogenic (54%) and international anthropogenic (20%) sources. Washington anthropogenic sources are expected to contribute 15% of the nitrates responsible for light extinction at MORA1 on clearest days. See Figure 6-35 for more information.

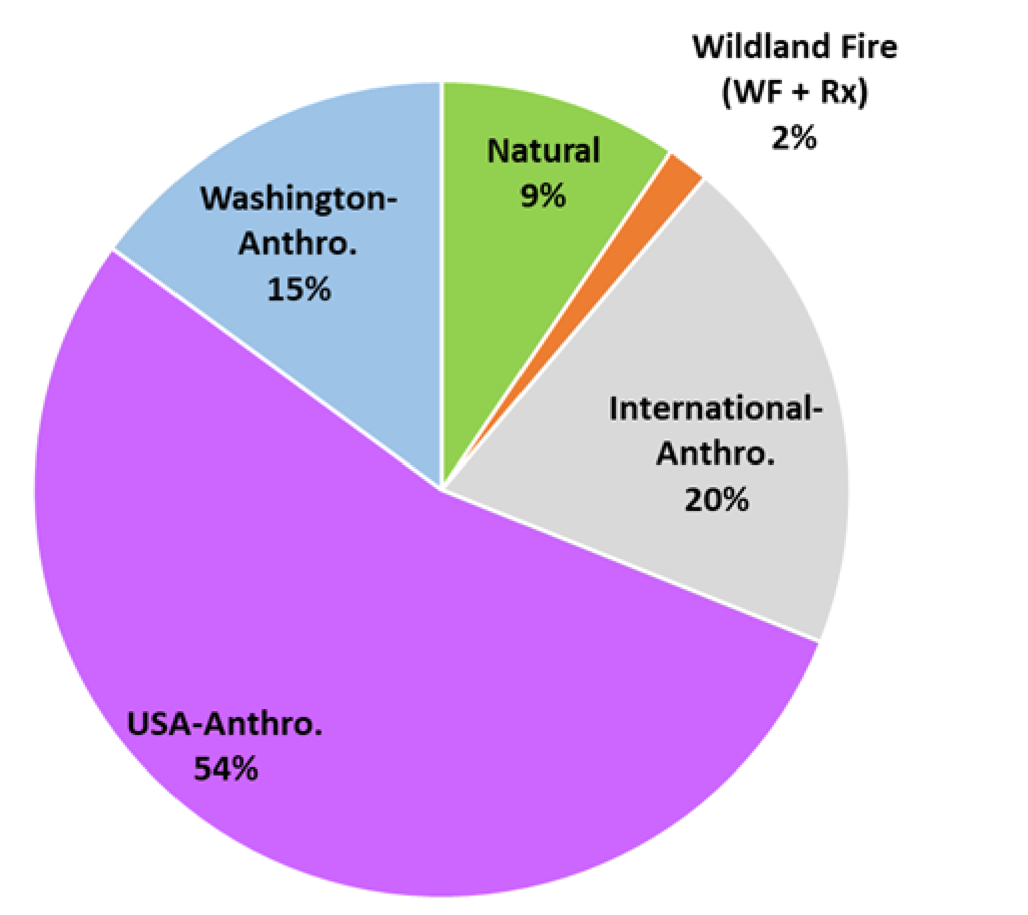

Figure 6-35: Expected source regions of NO_3 in 2028 at MORA1 for clearest days (CAMx total = 1.6 Mm^{-1}).

The modeled nitrates for 2028 clearest days at MORA1 was 1.6 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.32 Mm^{-1} and 0.24 Mm^{-1}, respectively.

Figure 6-36 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at MORA1 on 2028 clearest days.

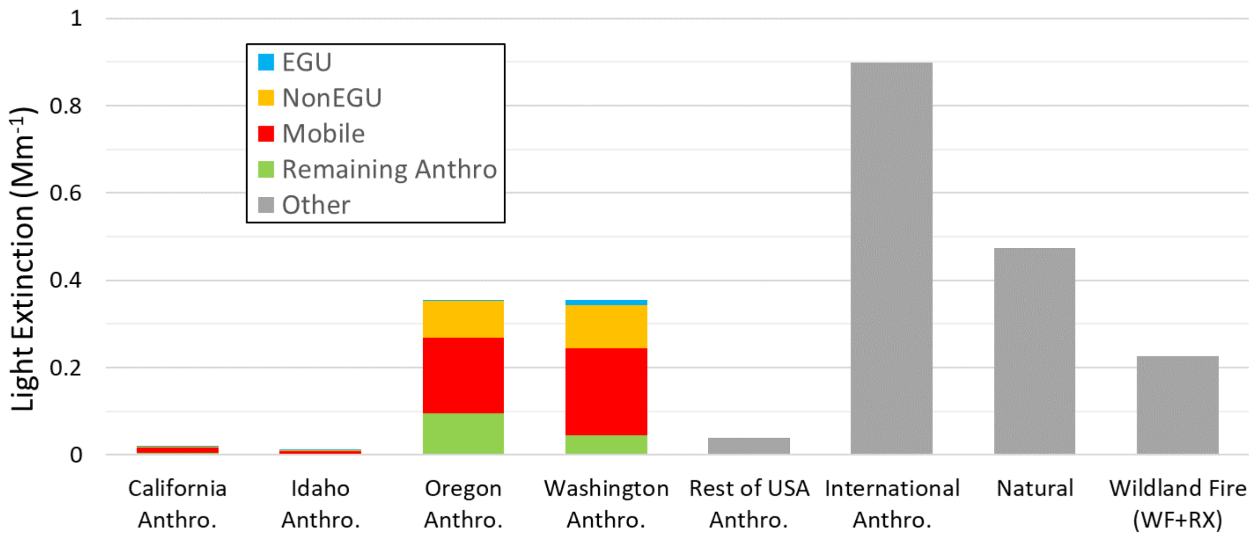

Figure 6-36: Expected source categories and regions of NO_3 in 2028 at MORA1 for clearest days (CAMx total = 1.6 Mm^{-1}).

6.5 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 3 show that sulfates (50%), organic mass (22%), and nitrates (12%) together contribute to 84% of the light extinction on the MID at this monitoring site. On the clearest days sulfates (39%), organic mass (14%), and nitrates (14%) contribute to 67% of the light extinction at this monitoring site.

WEP and rank point analyses

The WEP analysis for the WHPA1 site on MID for the 2028 OTB scenario is summarized in Figure 6-37, showing an AOI of sources that span western and central Washington, the Puget Sound area, and the Vancouver, BC and Portland, OR metropolitan areas. Nitrates at WHPA1 show considerable influence from non-EGU Point, on-road, non-road, and non-point sources. Sulfates at WHPA1 show considerable influence from non-EGU Point and non-point sources. Organic mass at WHPA1 is mostly influenced by non-point sources. Elemental carbon is mostly influenced by non-point sources but also shows influence from non-EGU Point, on-road, and non-road sources. The rank point WEP analysis attributed 86.7% of point source nitrates to Washington, with 11.9%, 0.9%, 0.3%, and 0.1% attributed to Oregon, tribal lands, Idaho, and California, respectively. The rank point WEP analysis attributed 89.1% of point source sulfates to Washington, with 10.4%, 0.2%, and 0.2% attributed to Oregon, tribal lands, and California, respectively.

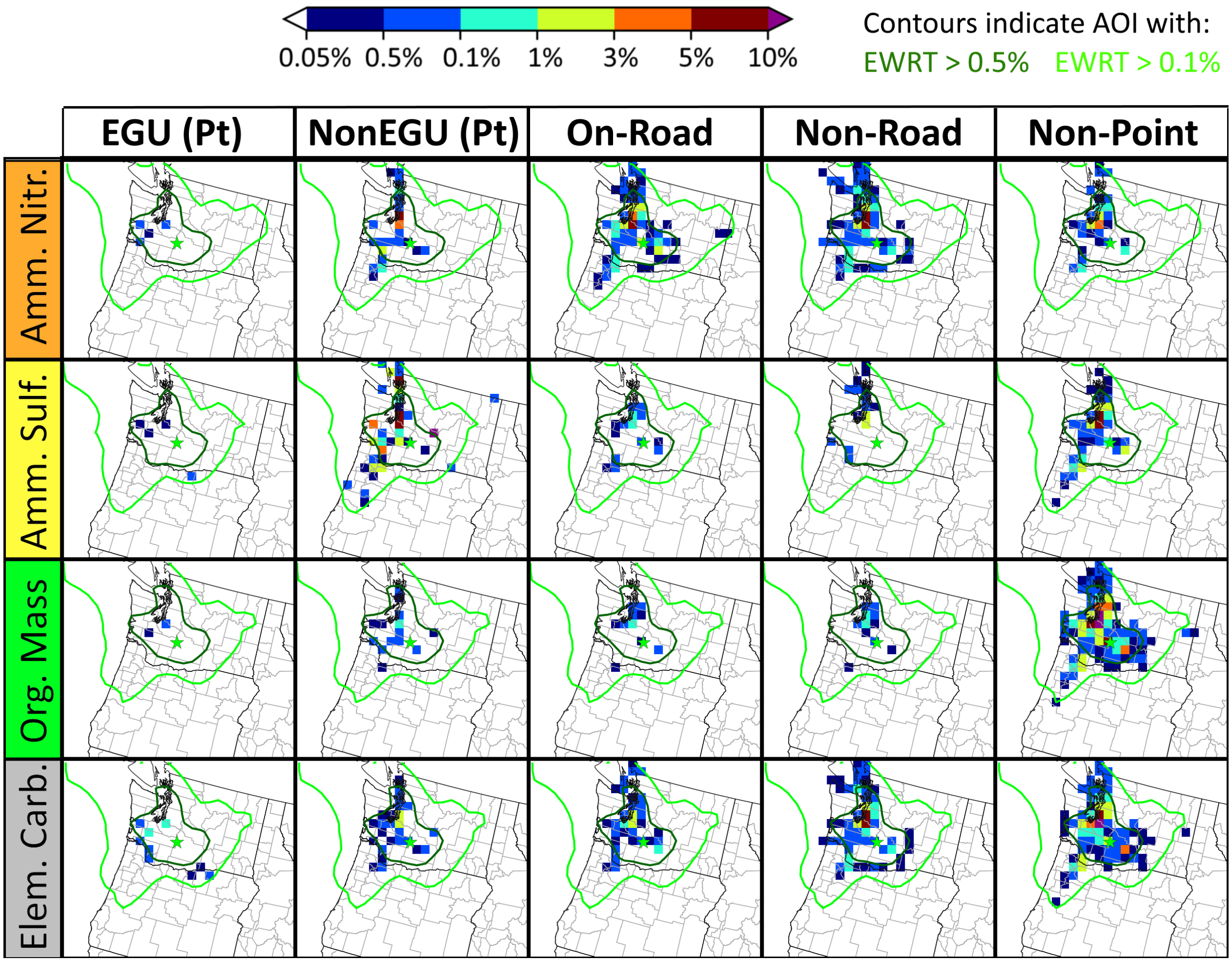

Figure 6-37: WEP for source area potential to contribute to extinction on MID by pollutant at the WHPA1 IMPROVE monitor (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at WHPA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of sulfates at WHPA1 are expected to come primarily from international anthropogenic (52%) and natural sources (35%). These sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 6% of the sulfates responsible for light extinction at WHPA1. See Figure 6-38 for more information.

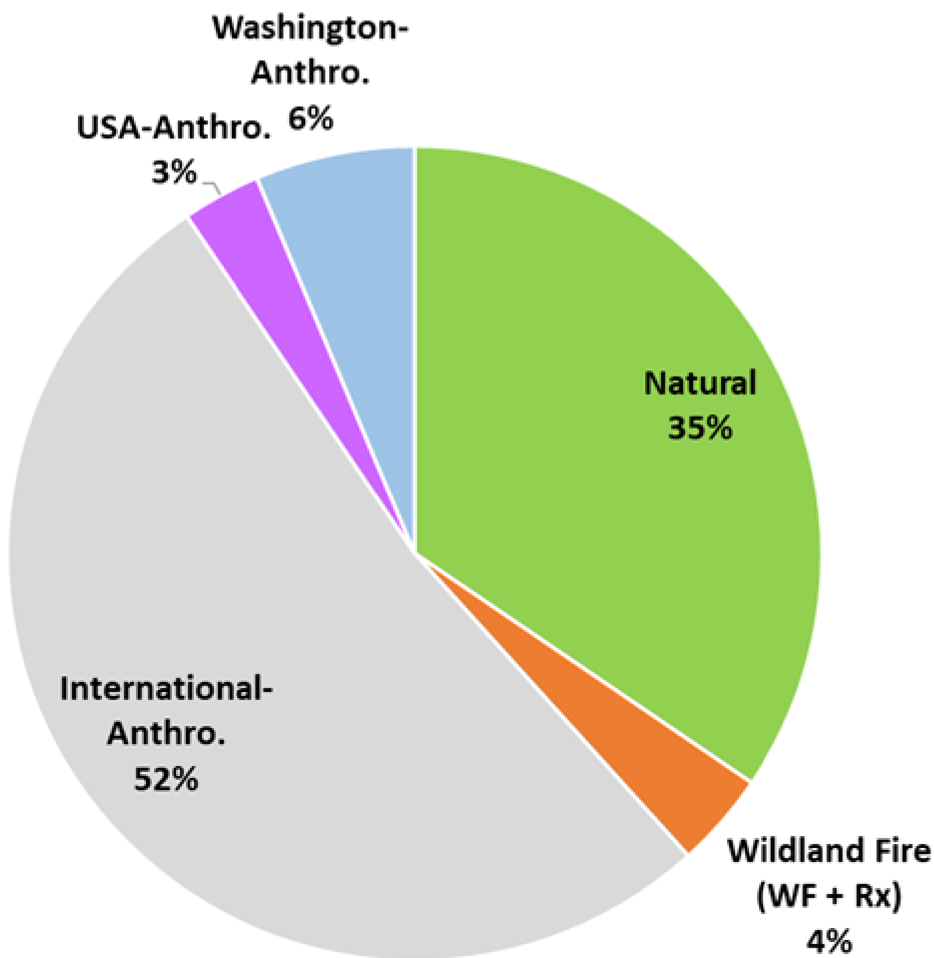

Figure 6-38: Expected source regions of SO_4 in 2028 at WHPA1 for MID (CAMx total = 8.2 Mm^{-1}).

The modeled sulfates for 2028 MID at WHPA1 was 8.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 6.37 Mm^{-1} and 6.32 Mm^{-1}, respectively.

Figure 6-39 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the OLYM1 monitoring site on 2028 MIDs.

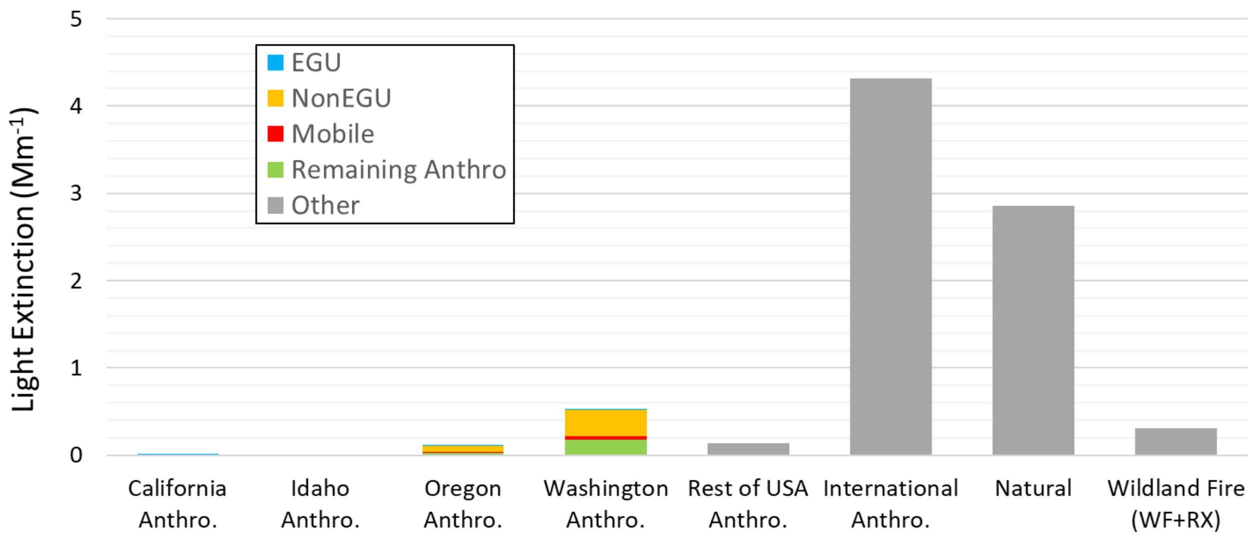

Figure 6-39: Expected source categories and regions of SO_4 in 2028 at WHPA1 for MID (CAMx total = 8.2 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at WHPA1 are expected to come primarily from natural (49%), international anthropogenic (27%), and out-of-state US anthropogenic (18%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 5% of the sulfates responsible for light extinction at WHPA1. See Figure 6-40 for more information.

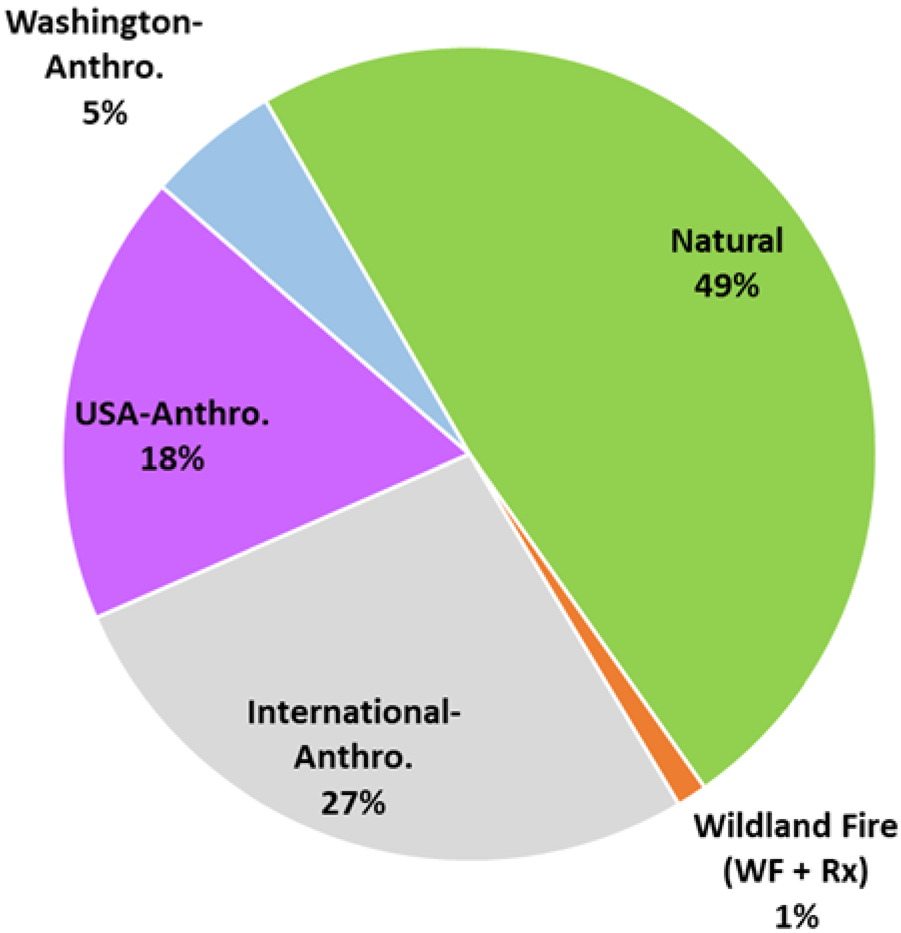

Figure 6-40: Expected source regions of SO_4 in 2028 at WHPA1 for clearest days (CAMx total = 3.0 Mm^{-1}).

The modeled sulfates for 2028 clearest days at WHPA1 was 3.0 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.41 Mm^{-1} and 0.39 Mm^{-1}, respectively.

Figure 6-41 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at WHPA1 on 2028 clearest days.

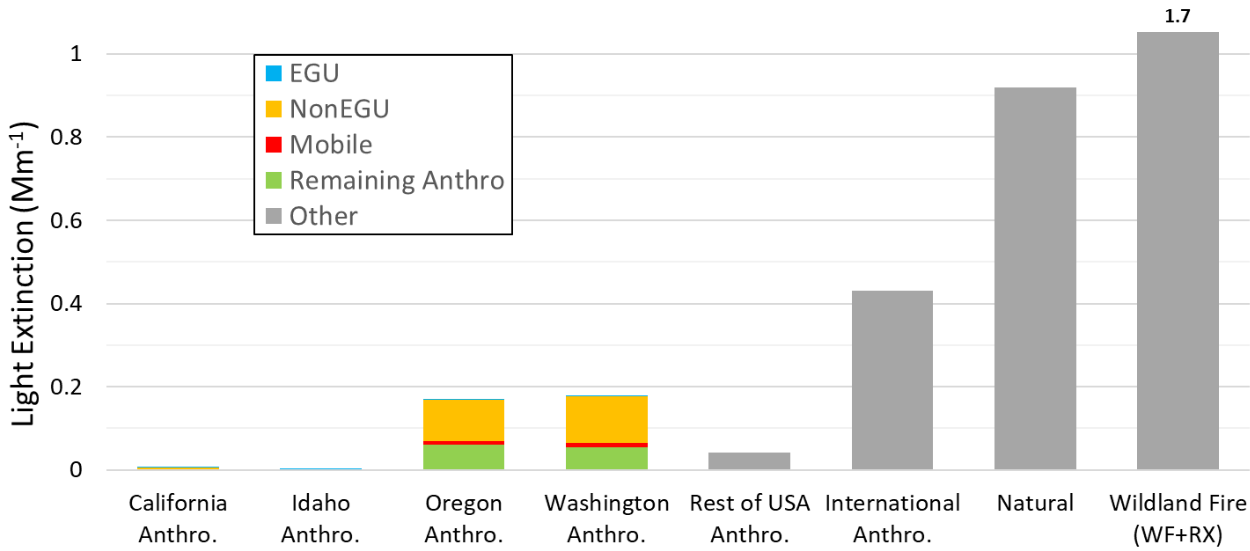

Figure 6-41: Expected source categories and regions of SO_4 in 2028 at WHPA1 for clearest days (CAMx total = 3.0 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the 3rd largest species contribution to light extinction for the MID clearest days during the 2014-2018 baseline at WHPA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at WHPA1 are expected to be considerably influenced by Washington anthropogenic sources (34%). International anthropogenic (35%) and natural sources (19%) are also expected to have considerable impacts but are beyond Washington's control. See Figure 6-42 for more information.

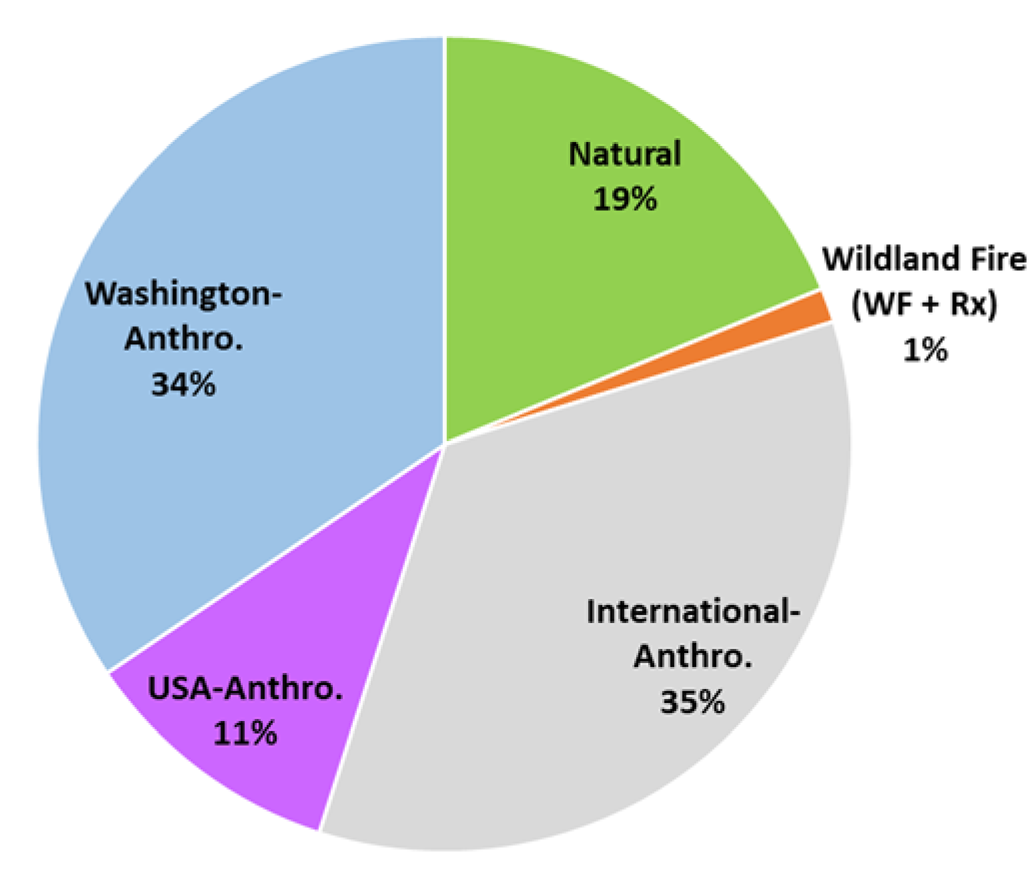

Figure 6-42: Expected source regions of NO_3 in 2028 at WHPA1 for MID (CAMx total = 4.1 Mm^{-1}).

The modeled nitrates for 2028 MID at WHPA1 was 4.1 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 1.53 Mm^{-1} and 0.97 Mm^{-1}, respectively.

Figure 6-43 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at WHPA1 on 2028 MIDs.

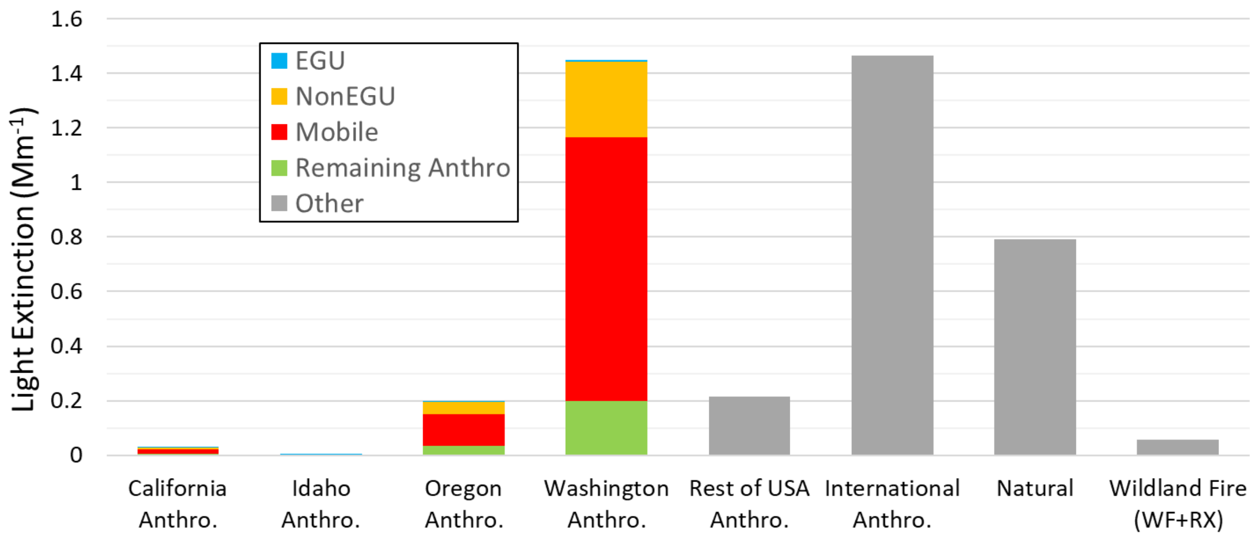

Figure 6-43: Expected source categories and regions of NO_3 in 2028 at WHPA1 for MID (CAMx total = 4.1 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of nitrates at WHPA1 are expected to come primarily from out-of-state US anthropogenic (44%) and international anthropogenic (25%) sources. Washington anthropogenic sources are expected to contribute 11% of the nitrates responsible for light extinction at WHPA1 on clearest days. See Figure 6-44 for more information.

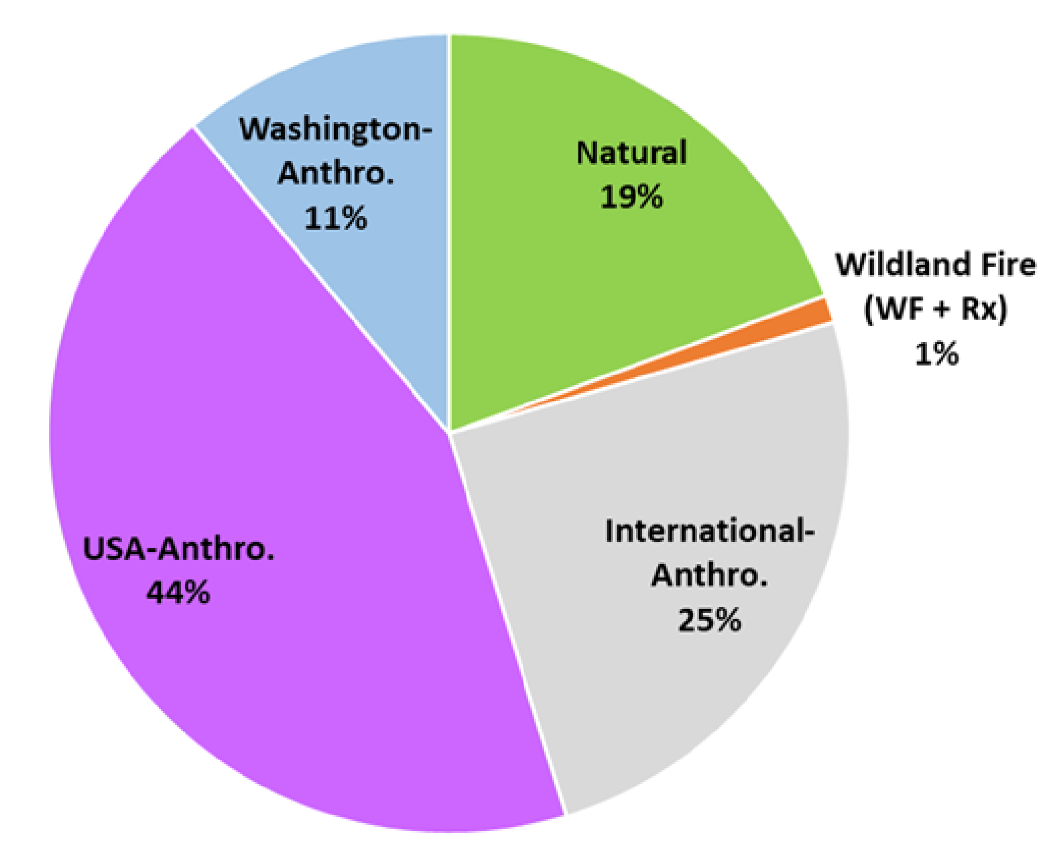

Figure 6-44: Expected source regions of NO_3 in 2028 at WHPA1 for clearest days (CAMx total = 1.1 Mm^{-1}).

The modeled nitrates for 2028 clearest days at WHPA1 was 1.1 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.15 Mm^{-1} and 0.12 Mm^{-1}, respectively.

Figure 6-45 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at WHPA1 on 2028 clearest days.

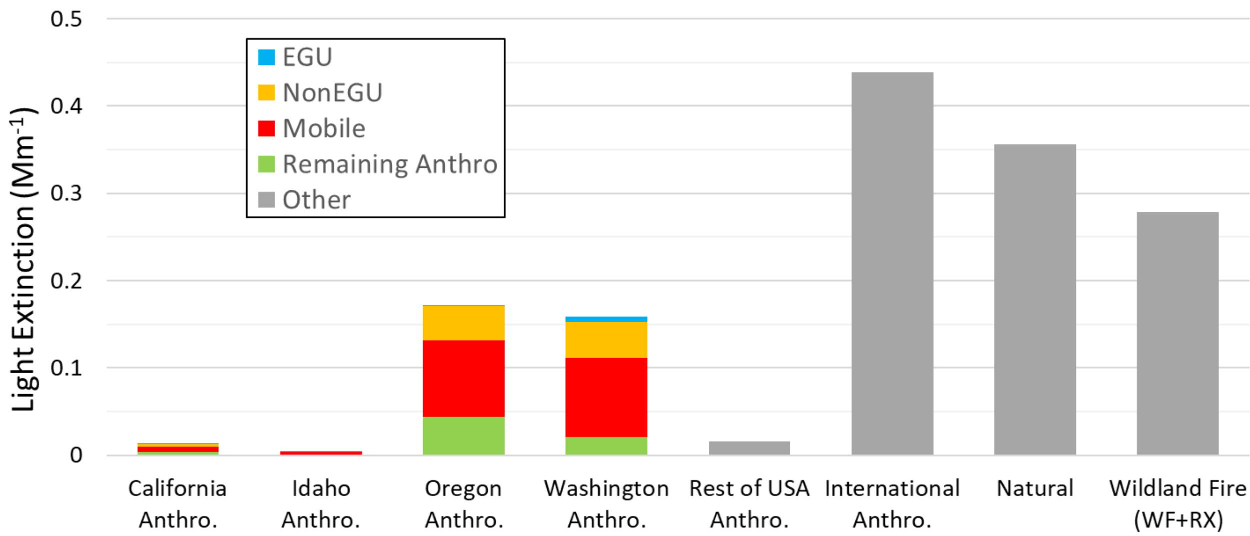

Figure 6-45: Expected source categories and regions of NO_3 in 2028 at WHPA1 for clearest days (CAMx total = 1.1 Mm^{-1}).

6.6 Pasayten Wilderness

Pasayten Wilderness is represented by the PASA1 IMPROVE monitoring site. The baseline conditions in Chapter 3 show that organic mass (32%) and sulfates (35%) make up 67% of the light extinction on the MID at this monitoring site. Elemental carbon (8%) and nitrates (14%) contribute to another 22% of the light extinction on the MID at this monitoring site. On the clearest days, sulfates make up 35% of the light extinction at this monitoring site. Organic mass (32%) and nitrates (14%) make up another 46% of the light extinction on the clearest days at this monitoring site.

WEP and rank point analyses

The WEP analysis for the PASA1 site on MID for the 2028 OTB scenario is summarized in Figure 6-46, showing an AOI of sources that span Washington, the Puget Sound area, and the Vancouver, BC metropolitan area. Nitrates at PASA1 show considerable influence from non-EGU Point, on-road, non-road, and non-point sources. Sulfates at PASA1 show considerable influence from Non-Egu Point and non-point sources. Organic mass at PASA1 is mostly influenced by non-point sources. Elemental carbon is mostly influenced by non-point sources but also shows influence from non-EGU Point, on-road, and non-road sources. The rank point WEP analysis attributed 61.7% of point source nitrates to Washington, with 26.5%, 8.2%, 2.7%, 0.6%, and 0.3% attributed to tribal lands, Oregon, Idaho, California, and Montana, respectively. The rank point WEP analysis attributed 89.5% of point source sulfates to Washington, with 8.7%, 1.3%, 0.3%, 0.1%, and 0.1% attributed to tribal lands, Oregon, Idaho, Montana, and California, respectively.

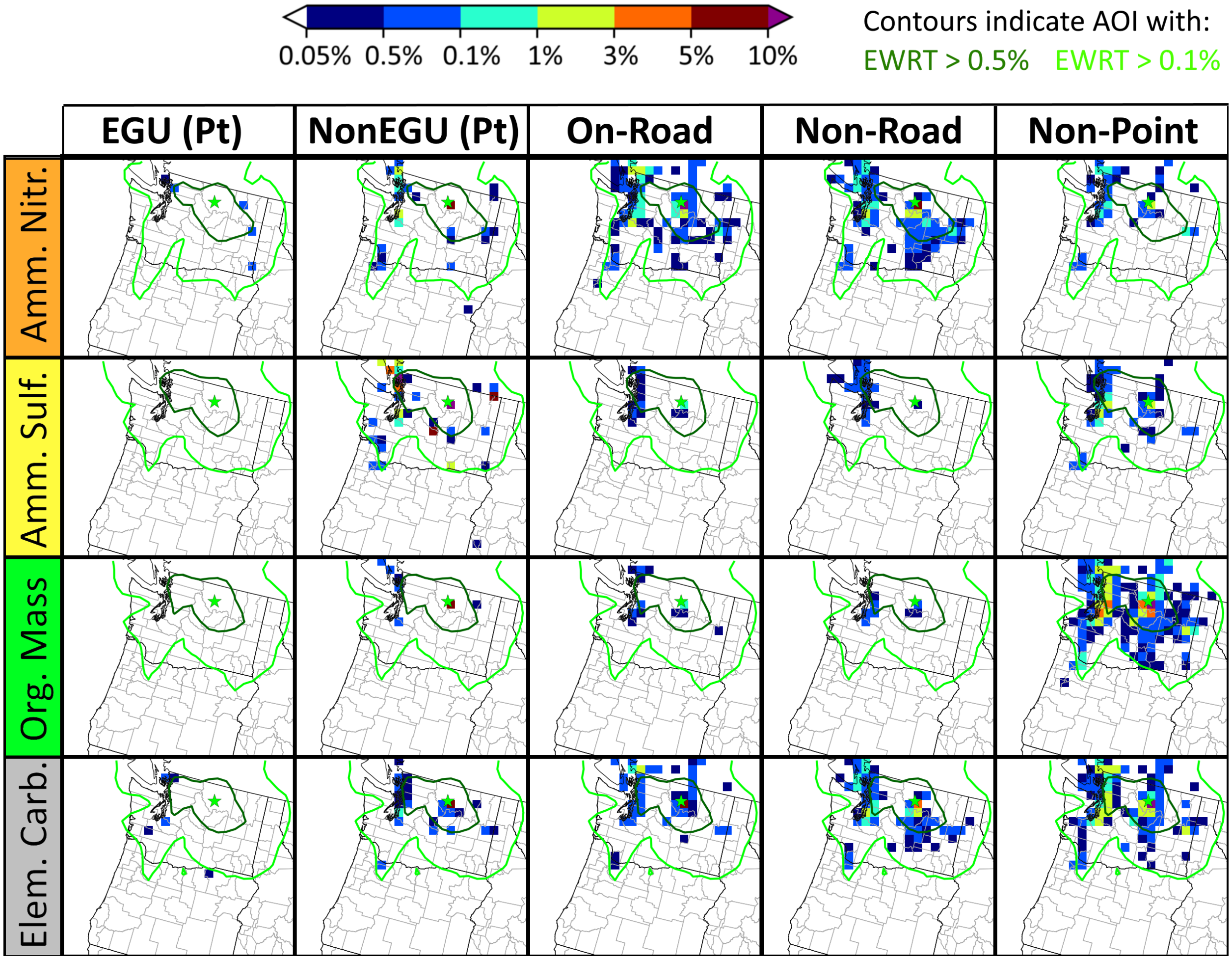

Figure 6-46: WEP for source area potential to contribute to extinction on MID by pollutant at the PASA1 IMPROVE monitor (green star), using the 2028 OTB projected emissions. Contours indicate AOI with EWRT greater than 0.5% (dark green) and 0.1% (light green) for the corresponding pollutant.

Sulfates source apportionment

Monitoring data show that sulfates were the largest species contribution to light extinction for both the MID and clearest days during the 2014-2018 baseline at PASA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of sulfates at PASA1 are expected to come primarily from international anthropogenic (49%) and natural sources (34%). These sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 7% of the sulfates responsible for light extinction at PASA1. Figure 6-47 for more information.

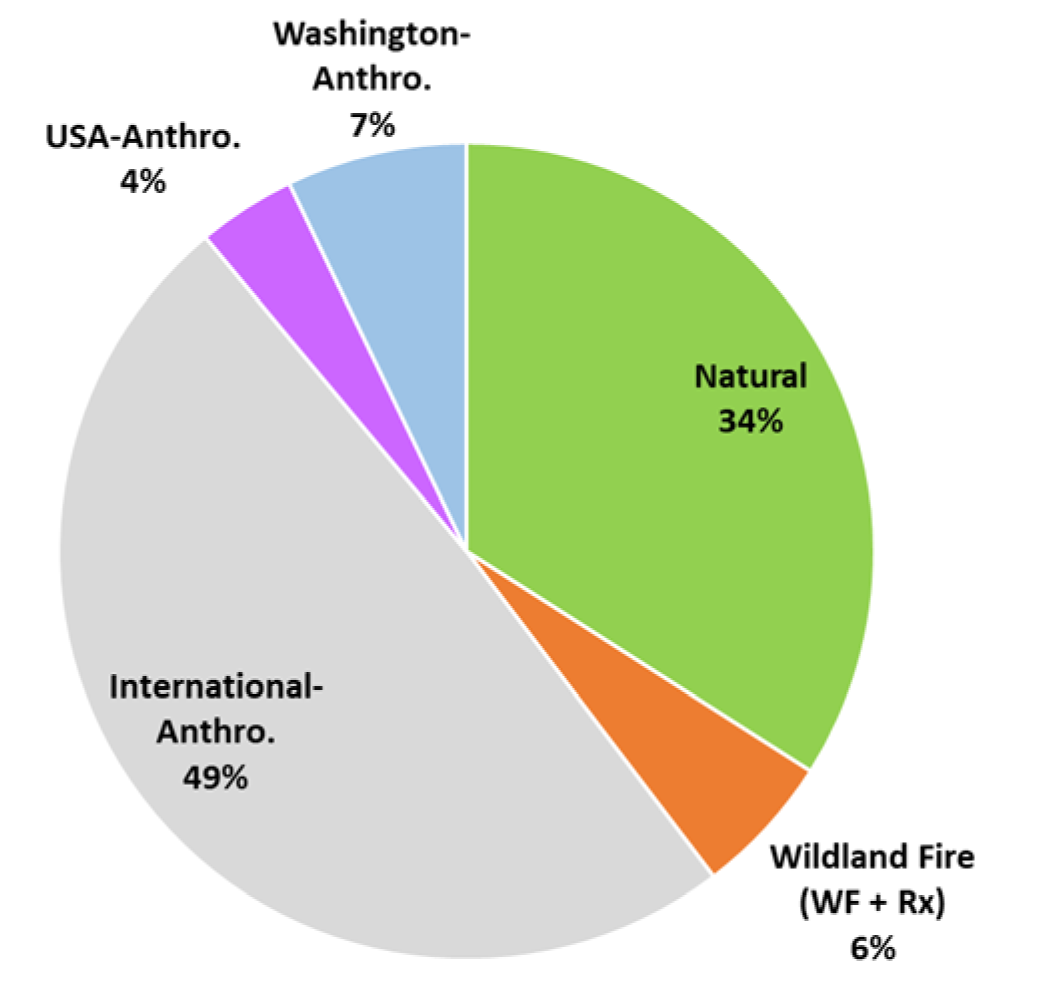

Figure 6-47: Expected source regions of SO_4 in 2028 at PASA1 for MID (CAMx total = 7.2 Mm^{-1}).

The modeled sulfates for 2028 MID at PASA1 was 7.2 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 5.78 Mm^{-1} and 5.77 Mm^{-1}, respectively.

Figure 6-48 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at the OLYM1 monitoring site on 2028 MIDs.

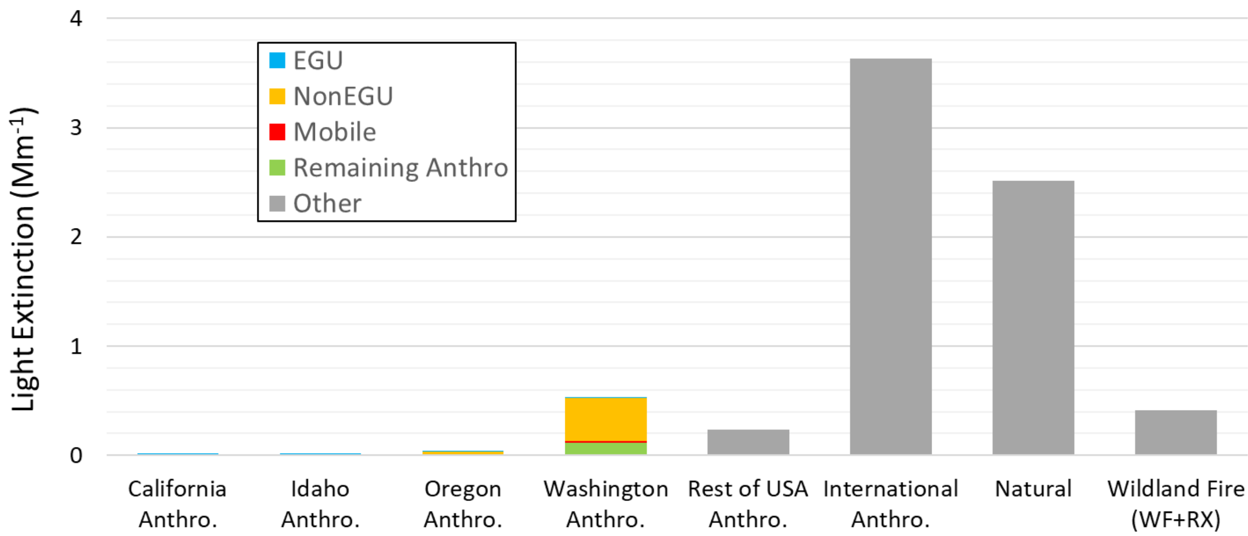

Figure 6-48: Expected source categories and regions of SO_4 in 2028 at PASA1 for MID (CAMx total = 7.2 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of sulfates at PASA1 are expected to come primarily from natural (42%), international anthropogenic (25%), and out-of-state US anthropogenic (17%). All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 13% of the sulfates responsible for light extinction at PASA1. See Figure 6-49 for more information.

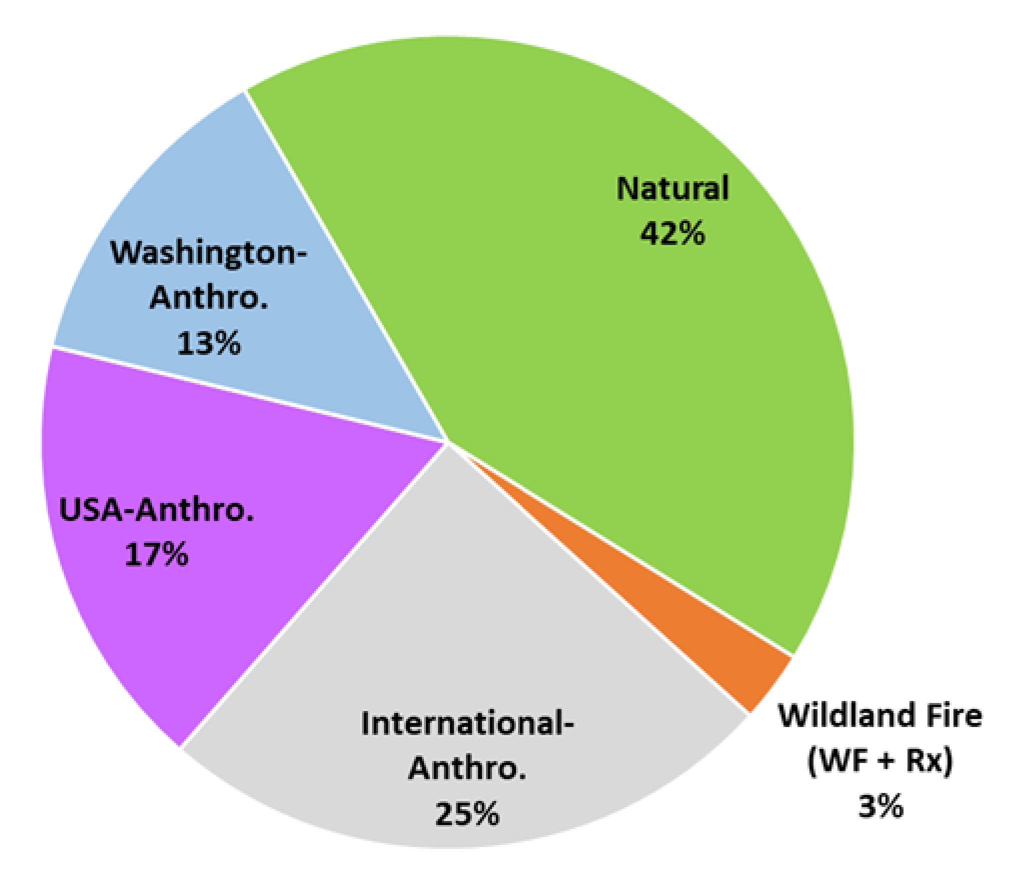

Figure 6-49: Expected source regions of SO_4 in 2028 at PASA1 for clearest days (CAMx total = 4.0 Mm^{-1}).

The modeled sulfates for 2028 clearest days at PASA1 was 4.0 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.75 Mm^{-1} and 0.71 Mm^{-1}, respectively.

Figure 6-50 shows an expectation within Washington that non-EGU point sources contribute the majority of sulfate light extinction at PASA1 on 2028 clearest days.

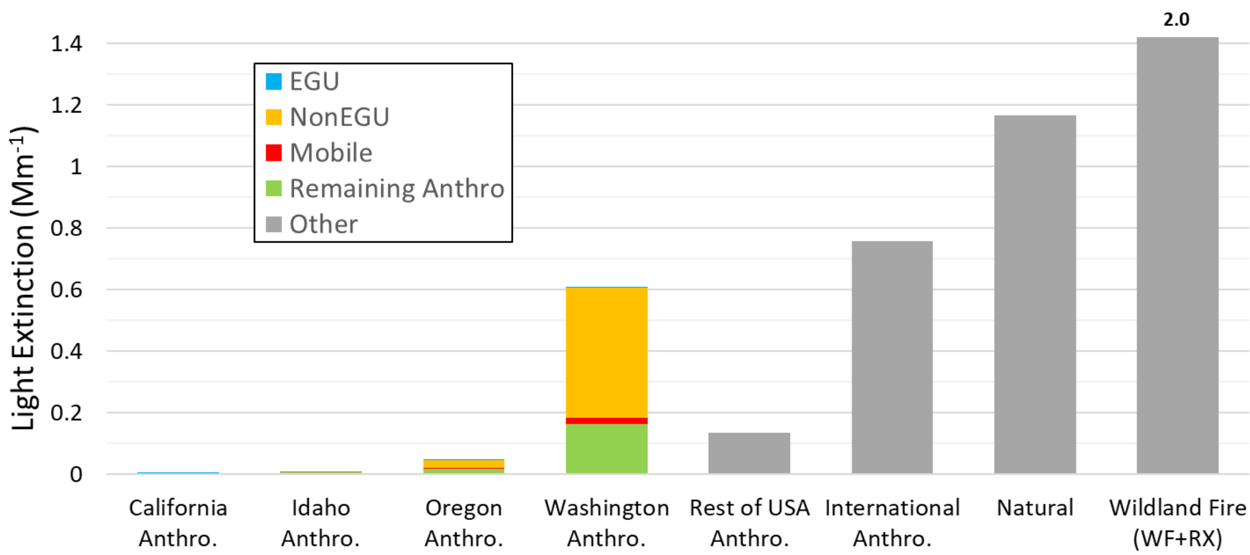

Figure 6-50: Expected source categories and regions of SO_4 in 2028 at PASA1 for clearest days (CAMx total = 4.0 Mm^{-1}).

Nitrates source apportionment

Monitoring data show that nitrates were the 3rd largest species contribution to light extinction for the MID clearest days during the 2014-2018 baseline at PASA1.

Most Impaired Days

The PSAT tracer analysis shows the 2028 MID visibility impacts of nitrates at PASA1 are expected to be most influenced from international anthropogenic sources (46%), while natural sources (16%) and wildland fires (15%) are expected to have some impacts. All of these sources are beyond Washington's control. Washington anthropogenic sources are expected to contribute 18% of the nitrates responsible for light extinction at PASA1. See Figure 6-51 for more information.

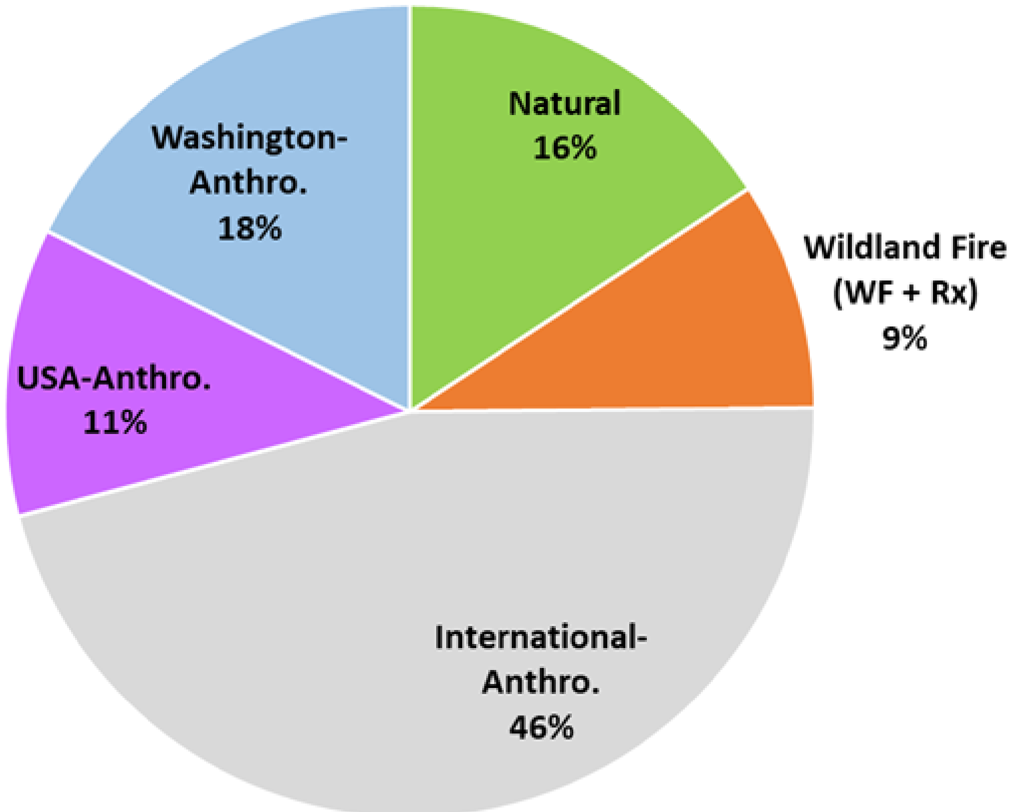

Figure 6-51: Expected source regions of NO_3 in 2028 at PASA1 for MID (CAMx total = 3.8 Mm^{-1}).

The modeled nitrates for 2028 MID at PASA1 was 3.8 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 2.34 Mm^{-1} and 1.79 Mm^{-1}, respectively.

Figure 6-52 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at PASA1 on 2028 MIDs.

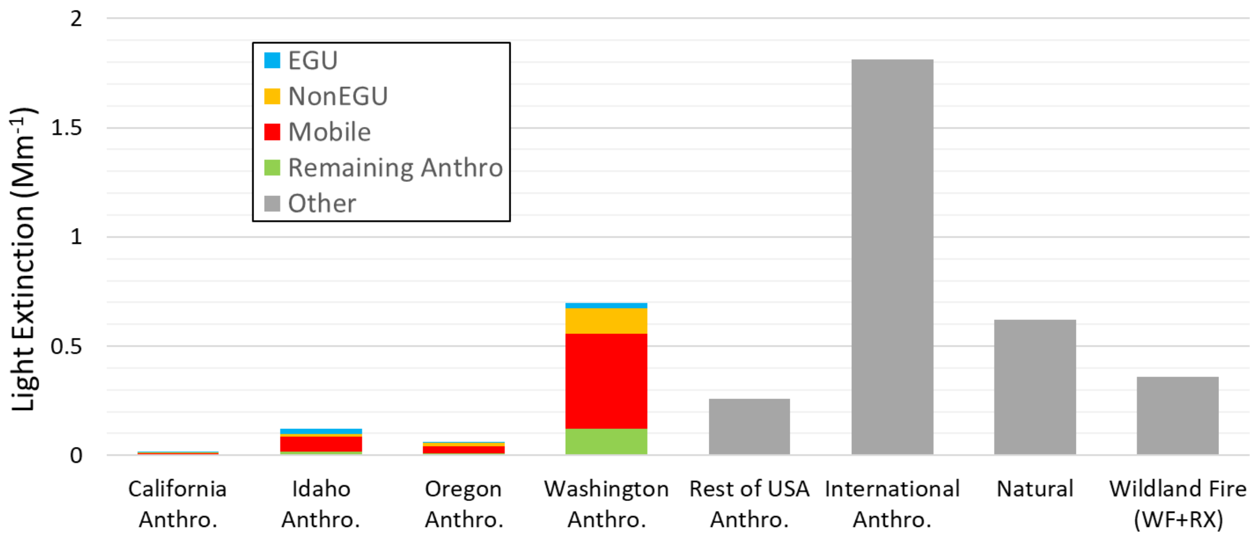

Figure 6-52: Expected source categories and regions of NO_3 in 2028 at PASA1 for MID (CAMx total = 3.8 Mm^{-1}).

Clearest Days

The PSAT tracer analysis shows that 2028 clearest days visibility impacts of nitrates at PASA1 are expected to come primarily from out-of-state US anthropogenic (39%) sources. Washington anthropogenic sources are expected to contribute 23% of the nitrates responsible for light extinction at PASA1 on clearest days. See Figure 6-53 for more information.

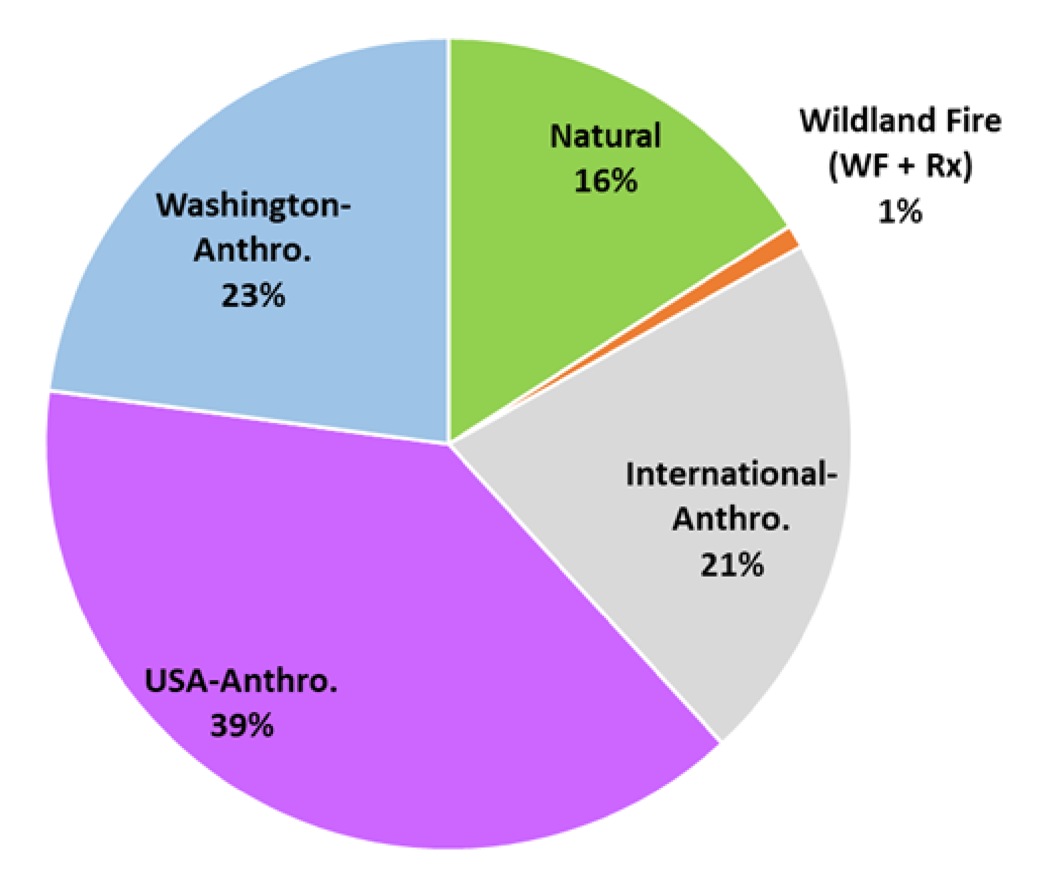

Figure 6-53: Expected source regions of NO_3 in 2028 at PASA1 for clearest days (CAMx total = 2.1 Mm^{-1}).

The modeled nitrates for 2028 clearest days at PASA1 was 2.1 Mm^{-1} while the 2014 - 2018 observed baseline and 2028 visibility projections were 0.30 Mm^{-1} and 0.23 Mm^{-1}, respectively.

Figure 6-54 shows an expectation within Washington that mobile sources contribute the majority of nitrate light extinction at PASA1 on 2028 clearest days.

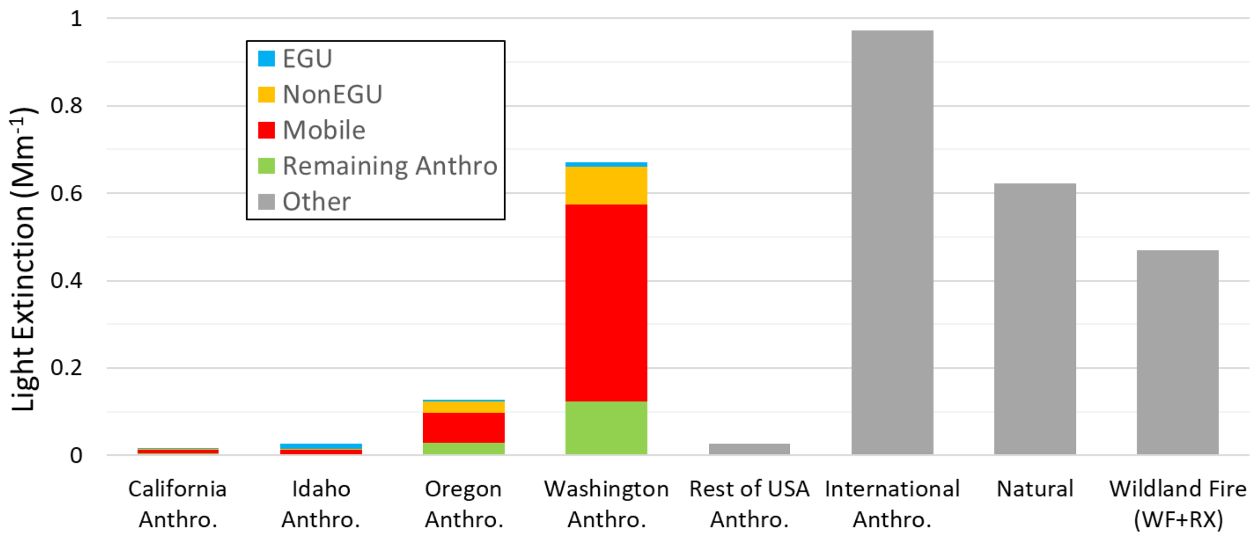

Figure 6-54: Expected source categories and regions of NO_3 in 2028 at PASA1 for clearest days (CAMx PSAT total = 2.1 Mm^{-1}).

6.7 In-State Contribution of Nitrates and Sulfates

Table 6-1 summarizes the in-state sources of sulfates by source category at each in-state mandatory Class 1 Area in 2028, as determined by the PSAT analysis. Table 6-2 summarizes the in-state sources of nitrates by source category at each in-state mandatory Class 1 Area in 2028, as determined by the PSAT analysis.

Table 6-1: Expected in-state anthropogenic sulfate contributions by source category for Washington's Mandatory Class 1 Areas in 2028.

Site	Days	Total WA Anthro.	WA EGU	WA non-EGU	WA Mobile	Remaining WA Anthro.
OLYM1	MID	8%	0%	6%	0%	2%
OLYM1	Clearest	17%	0%	9%	1%	6%
NOCA1	MID	11%	0%	9%	0%	1%
NOCA1	Clearest	8%	0%	5%	0%	3%
SNPA1	MID	7%	0%	5%	1%	2%
SNPA1	Clearest	11%	0%	5%	2%	4%
MORA1	MID	10%	0%	7%	1%	2%
MORA1	Clearest	7%	0%	5%	1%	2%
WHPA1	MID	6%	0%	4%	0%	2%
WHPA1	Clearest	5%	0%	3%	0%	2%
PASA1	MID	7%	0%	5%	0%	2%
PASA1	Clearest	13%	0%	9%	0%	3%

Table 6-2: Expected in-state anthropogenic nitrate contributions by source category for Washington's Mandatory Class 1 Areas in 2028.

Site	Days	Total WA Anthro.	WA EGU	WA non-EGU	WA Mobile	Remaining WA Anthro.
OLYM1	MID	36%	1%	11%	19%	6%
OLYM1	Clearest	33%	0%	6%	19%	8%
NOCA1	MID	25%	0%	7%	14%	3%
NOCA1	Clearest	22%	0%	4%	13%	4%
SNPA1	MID	38%	0%	6%	27%	5%
SNPA1	Clearest	26%	0%	3%	18%	4%
MORA1	MID	46%	0%	9%	32%	4%
MORA1	Clearest	15%	1%	4%	8%	2%
WHPA1	MID	34%	0%	7%	23%	5%
WHPA1	Clearest	11%	0%	3%	6%	1%
PASA1	MID	18%	1%	3%	11%	3%
PASA1	Clearest	23%	0%	3%	15%	4%

6.8 Other Mandatory Class 1 Areas Impacted by Washington Anthropogenic Emissions

The PSAT source apportionment modeling results were evaluated to determine which mandatory Class 1 Areas in nearby states are expected to be affected by emissions from Washington anthropogenic sources for sulfates and nitrates. Washington anthropogenic sources are expected to contribute a small percentage (e.g. less than 5%) of nitrates or sulfates to all IMPROVE monitors in nearby states on MID. However, some larger contributions are expected from Washington anthropogenic sources to several Montana (CABI1, FLAT1, GLAC1, MONT1, SULA1) and Oregon (KALM1, MOHO1, STAR1, THSI1) IMPROVE sites on MID that range from 5% to 22% of nitrates and 2% to 4% of sulfates. Though not shown here, the PSAT details confirm that the majority of anthropogenic emissions originating in Washington that affect out-of-state IMPROVE sites are from non-EGU (sulfates) and mobile sources (nitrates) identifies the percentage of the total modeled light extinction by species due to anthropogenic emissions from sources within Washington at IMPROVE monitors in California, Oregon, Idaho, Nevada, Montana, Utah, and Wyoming. Table 6-3 identifies all IMPROVE monitors where Washington anthropogenic sources are expected to contribute at least 0.1% of the nitrate or sulfate light extinction, based on the PSAT results. The percentage contribution is based on contributions from all modeled source areas relative to the total sulfates or nitrates, separately.

Washington anthropogenic sources are expected to contribute a small percentage (e.g. less than 5%) of nitrates or sulfates to all IMPROVE monitors in nearby states on MID. However, some larger contributions are expected from Washington anthropogenic sources to several Montana (CABI1, FLAT1, GLAC1, MONT1, SULA1) and Oregon (KALM1, MOHO1, STAR1, THSI1) IMPROVE sites on MID that range from 5% to 22% of nitrates and 2% to 4% of sulfates. Though not shown here, the PSAT details confirm that the majority of anthropogenic emissions originating in Washington that affect out-of-state IMPROVE sites are from non-EGU (sulfates) and mobile sources (nitrates).

Table 6-3: Washington's Anthropogenic Emissions Contribution to Sulfate and Nitrate Light Extinction at Mandatory Class 1 Areas outside of Washington.

State	Site	MID Sulfates (% from WA Anthro)	Clearest Days Sulfates (% from WA Anthro)	MID Nitrates (% from WA Anthro)	Clearest Days Nitrates (% from WA Anthro)
CA	AGTI1	0.1%	0.1%	0.0%	0.1%
CA	BLIS1	0.2%	0.3%	0.1%	0.3%
CA	DOME1	0.1%	0.2%	0.1%	0.2%
CA	HOOV1	0.1%	0.1%	0.1%	0.2%
CA	JOSH1	0.1%	0.3%	0.0%	0.2%
CA	KAIS1	0.1%	0.0%	0.1%	0.0%
CA	LABE1	0.1%	0.3%	0.3%	0.1%
CA	LAVO1	0.2%	0.4%	0.5%	0.1%
CA	PINN1	0.3%	0.1%	0.3%	0.0%
CA	PORE1	0.3%	0.2%	1.1%	1.3%
CA	RAFA1	0.2%	0.1%	0.2%	0.1%
CA	REDW1	0.5%	0.5%	4.6%	4.4%
CA	SAGA1	0.1%	0.1%	0.0%	0.0%
CA	SAGO1	0.1%	0.1%	0.0%	0.1%
CA	SEQU1	0.2%	0.1%	0.1%	0.1%
CA	TRIN1	0.2%	0.3%	0.3%	0.1%
CA	YOSE1	0.1%	0.2%	0.1%	0.1%
ID	CRMO1	0.8%	1.8%	1.7%	4.5%
ID	SAWT1	1.4%	3.2%	3.3%	7.2%
MT	CABI1	2.6%	10.1%	8.6%	21.7%
MT	FLAT1	2.7%	7.1%	6.6%	15.3%
MT	FOPE1	0.6%	0.8%	0.8%	0.8%
MT	GAMO1	2.1%	2.1%	4.5%	6.0%
MT	GLAC1	2.4%	3.9%	6.3%	8.1%
MT	MELA1	0.5%	0.4%	0.5%	0.5%
MT	MONT1	2.3%	4.2%	5.1%	10.8%
MT	NOCH1	0.5%	1.3%	0.6%	2.5%
MT	SULA1	2.8%	2.2%	7.4%	7.6%
MT	ULBE1	0.5%	2.8%	0.7%	4.3%
NV	JARB1	1.0%	1.5%	2.9%	4.8%

State	Site	MID Sulfates (% from WA Anthro)	Clearest Days Sulfates (% from WA Anthro)	MID Nitrates (% from WA Anthro)	Clearest Days Nitrates (% from WA Anthro)
OR	CRLA1	0.9%	0.1%	3.9%	0.2%
OR	HECA1	2.0%	2.6%	3.6%	10.1%
OR	KALM1	1.5%	0.2%	7.3%	0.9%
OR	MOHO1	4.4%	2.0%	22.1%	13.1%
OR	STAR1	3.5%	2.0%	15.3%	8.7%
OR	THSI1	1.9%	0.2%	9.4%	0.4%
UT	BRCA1	0.2%	0.2%	0.4%	0.3%
UT	CANY1	0.2%	0.5%	0.4%	1.0%
UT	CAPI1	0.2%	0.5%	0.4%	0.8%
UT	ZICA1	0.1%	0.5%	0.1%	0.7%
WY	BRID1	0.6%	1.0%	1.4%	2.6%
WY	NOAB1	1.4%	0.9%	1.9%	2.5%
WY	YELL2	1.2%	1.1%	2.9%	1.6%

Chapter 7. Source Selection and Four-factor Analysis

7.1 Introduction

The Regional Haze Rule (RHR, 40 CFR 51) requires Washington to submit a long-term strategy that includes enforceable emissions limitations, compliance schedules, and other measures necessary to make reasonable progress toward 2064 natural visibility conditions in Class 1 Areas. Washington must determine what new emission reductions, if any, are necessary to make reasonable progress by considering the four statutory factors:

- Costs of compliance,
- The time necessary for compliance,
- The energy and non-air quality environmental impacts of compliance, and
- The remaining useful life of any potentially affected sources.

This chapter describes Washington's source selection criteria and describes the analyses to determine controls that are reasonable and needed to make reasonable progress. Controls identified are part of the long-term strategy described in Chapter 8.

EPA issued a memorandum[12] on July 8, 2021, to "help support SIP development, submittal, review, and action for the second planning period". The RHR SIP submittal was due to EPA on July 31, 2021, and Ecology has been developing the SIP submittal for the last few years. Ecology has attempted to implement the items addressed in the clarification memorandum to the maximum extent practicable considering the limited time provided between issuance of the memorandum and the due date of the RHR SIP.

7.2 Source screening analysis (Q/d)

Ecology used annual emissions and distance from the nearest Class 1 Area to select sources for the additional analysis. Q/d is a ratio of visibility-impairing emissions (in tons) produced by a source (Q) to its distance from the nearest Class 1 Area (d). We did not screen mobile sources or non-point sources with Q/d; we discuss them in Chapter 8, Long-term Strategy.

Ecology used Washington's 2014 point-source emissions data to calculate Q values. The Western Regional Air Partnership used 2014 as the base year for modeling as it was the most recent year of certified available data when the analysis was initiated. Ecology maintains an annual point-source Emissions Inventory (EI) for all major sources in Washington. Many non-major point-source emissions totals were also received from regional offices and local clean air agencies. The reported emissions of compounds that contribute to regional haze (NOx, PM_{10}, SO_2, and NH_3) were summed (Q) for each point-source. We calculated the distance (d) from the source to the nearest Class 1 Area. Sources with larger Q/d values represent larger visibility impacts on Class 1 Areas.

[12] Peter Tsirigotis, Director, "Clarifications Regarding Regional Haze Second Implementation Plans for the Second Implementation Period," memo, addressed to Regional Air Division Directors, Regions 1-10, July 8, 2021

Major and non-major point-source data from 2014 were screened initially, but the analysis was biased by the approximately 1,100 non-major sources in the inventory with a Q/d of less than one. Ecology conducted a second screening of only the major sources. The selected major sources represent approximately 80 percent of the haze-causing emissions for the entire EI.

For the second Q/d screening we removed the non-major sources and only evaluated the 119 major sources in the EI. We focused on major sources because they contribute 90 percent of the total Q/d value even though they represent only 10 percent of the total number of all stationary sources. We screened the major sources using two thresholds: the sources with a Q/d ratio of 10 or greater and the sources that were in the top 80 percent of the sum of Q/d values of all major sources. The results are shown in Table 7-1. The sum of all major Q/d values was 756. Eighty percent of the Q/d sum for major sources is 605 with a Q/d threshold of 15.6. We then considered a Q/d value of 10 or greater. The Q/d threshold of 10 or greater includes more sources than the 80 percent threshold. Therefore, we chose the Q/d value of 10 or greater for the threshold to require a four-factor analysis (FFA) since it includes more sources.

There are 16 major sources with a Q/d ≥ 10. We added two sources with a Q/d ≤ 10 so that all the facilities in a selected source category were included in the FFA. The two facilities added are Packaging Corporation of America (PCA), a paperboard mill, and U.S. Oil, an oil refinery. See Chapter 4 for more information about the annual emissions from these selected facilities.

Ecology conducted reasonableness analyses on major facilities with a Q/d of ≥ 10 along with two additional facilities. These identified stationary sources contribute 90 percent of the haze-causing emissions in Washington.

Table 7-1: Q/d of sources selected for FFA

Facility Site Name	Q (tons) of NO_X, PM_{10}, SO_2, and NH_3	d (km) to nearest CIA	Q/d	Nearest CIA	Category 1	Agency
TransAlta Centralia Generation, LLC	10749.4	71.8	149.8	Mount Rainier NP	Coal powered electric	SWCAA
McKinley Paper Company	367.2	4.4	83.1	Olympic NP	Pulp and Paper Plant	ORCAA
Alcoa Primary Metals Wenatchee Works	3461.7	42.8	80.9	Alpine Lakes Wilderness	Alumina Refining and Aluminum Production	Ecology - Industrial
Alcoa Primary Metals Intalco Works	5658.5	78.9	71.7	North Cascades NP	Alumina Refining and Aluminum Production	Ecology - Industrial
BP Cherry Point Refinery	2945.0	80.8	36.4	North Cascades NP	Petroleum Refineries	NWCAA
Tesoro Northwest Company	2312.3	75.4	30.7	Olympic NP	Petroleum Refineries	NWCAA
WestRock Tacoma	1353.7	48.4	27.9	Mount Rainier NP	Pulp, Paper, and Paperboard Mills	Ecology - Industrial
Nippon Dynawave Packaging Company Longview	2656.0	104.8	25.3	Mount Adams Wilderness	Paperboard Mills	Ecology - Industrial
Puget Sound Refining Company (Shell)	1793.1	73.0	24.5	Olympic NP	Petroleum Refineries	NWCAA

Facility Site Name	Q (tons) of NO_X, PM_{10}, SO_2, and NH_3	d (km) to nearest CIA	Q/d	Nearest CIA	Category 1	Agency
Pt Townsend Paper Corporation	848.0	35.0	24.2	Olympic NP	Paper (not Newsprint) Mills	Ecology - Industrial
Ash Grove Cement Co, E Marginal	1243.6	53.8	23.1	Alpine Lakes Wilderness	Cement Manufacturing	PSCAA
Cosmo Specialty Fibers, Inc.	973.8	58.2	16.7	Olympic NP	Paperboard Mills	Ecology - Industrial
WestRock Longview, LLC	1574.2	100.7	15.6	Mount Adams Wilderness	Paperboard Mills	Ecology - Industrial
Georgia-Pacific Consumer Operations LLC	653.0	45.4	14.4	Mount Hood Wilderness	Paper (except Newsprint) Mills	Ecology - Industrial
Phillips 66	840.6	77.2	10.9	North Cascades NP	Petroleum Refineries	NWCAA
Cardinal FG Winlock	859.8	80.1	10.7	Mount Rainier NP	Flat Glass Manufacture	SWCAA
Packaging Corporation of America (PCA) Wallowa	1048.3	111.5	9.4	Eagle Cap Wilderness	Paperboard Mills	Ecology - Industrial
U.S. Oil & Refining Co	149.2	46.4	3.2	Mount Rainier NP	Oil Refinery	PSCAA
Total	39487.5		658.7			

Facility notification of selection for four-factor analysis

Ecology contacted the facilities selected in Spring of 2019, and informed them that we had selected them for additional RH emission analyses (see Appendix G). Some of these facilities had existing legal requirements or pending permit actions to reduce emissions, so Ecology did not request a FFA from them. We requested that facilities in the pulp and paper and the refinery source categories perform a FFA and provide the results to Ecology. Ecology also requested that the Ash Grove Cement Company and Cardinal Glass perform an FFA.

7.3 Reasonableness evaluation

When performing a reasonableness analysis on the selected facilities, the emission controls already in place and enforceable are the baseline controls in the analysis. Facilities with no new controls identified rely on the existing controls for Washington to make reasonable progress.

Ecology conducted a reasonableness analysis on emission control technology for the sources selected in the Q/d analysis. This analysis determined if there were new reasonable emission controls needed to make reasonable progress at each Class 1 Area.

Four-factor analysis and reasonably available control technology (RACT) equivalency

The RHR requires states to perform a Four-Factor Analysis (FFA) to determine whether the installation of new emission controls at certain facilities is necessary for Washington to make reasonable progress toward the national visibility goal. In Washington, RCW 70A.15.2230 (the "RACT statute") is the legal mechanism that Ecology can use to require existing sources to install new emission controls that are determined to be reasonable. Because the analysis performed under Washington's RACT process is equivalent to the RHR's FFA, Ecology will use the RACT process to require the installation of reasonable emission controls for purposes of compliance with the RHR.

40 CFR 51.308(f) requires the state's long-term strategy to include all measures that are "necessary to make reasonable progress, as determined pursuant to [40 CFR 51.308](f)(2)(i) through (iv)." In turn, 40 CFR 51.308(f)(2)(i) requires the state to consider the following four statutory factors in determining which emission reductions measures are necessary to make reasonable progress:

- the costs of compliance,
- the time necessary for compliance,
- the energy and non-air quality environmental impacts of compliance, and
- the remaining useful life of any potentially affected anthropogenic source of visibility impairment.

Pursuant to RCW 70A.15.1030(20) and 70A.15.2230(5), the RACT evaluation of new emission controls at existing stationary sources requires Ecology to consider the following:

- the impact of the source upon air quality,
- the availability of additional controls,

- the emission reduction to be achieved by additional controls,
- the impact of additional controls on air quality,
- and the capital and operating costs of the additional controls.

The costs of compliance

Under the RACT analysis, Ecology characterizes and considers the cost of compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. The cost of compliance factor in 40 CFR 51.308(f)(2)(i) directly correlates to the RACT analysis consideration of capital and operating costs of the additional controls. The capital and operating costs in RACT are for purchase, installation, and operation of all equipment. These costs include the actual emission control equipment, any non-air quality equipment, and the energy costs to operate the equipment.

The time necessary for compliance

Under the RACT analysis, Ecology characterizes and considers the time necessary for compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Under the RACT analysis requirements, Ecology determines the time necessary for compliance as part of considering the capital and operating costs of the additional controls and impact of the source upon air quality. Specifically, a shorter amount of time for compliance would involve costs distributed over a shorter time and thus have a larger annualized cost. The impact of the source on air quality is also a consideration in the time for compliance. The longer it takes to install and operate the control equipment the greater the negative impact on air quality.

The energy and non-air quality environmental impacts of compliance

Under the RACT analysis, Ecology characterizes and considers the energy and non-air quality environmental impacts of compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Ecology considers the energy and non-air quality environmental impacts of compliance factor as part of analyzing the capital and operating costs of the additional controls in the RACT analysis. The RACT analysis includes costs for equipment directly related to the emissions and all indirectly required equipment needed to install and operate the new controls. The operating cost requirement in the RACT analysis also covers the energy impacts of the controls and supporting equipment.

The remaining useful life of any potentially affected anthropogenic source of visibility impairment

Under the RACT analysis, Ecology characterizes and considers the remaining useful life of any potentially affected anthropogenic source of visibility impairment consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Ecology considers the remaining useful life of an emissions control system as part of calculating the capital and operating costs of the system. Specifically, the annualized costs of the emissions control system are affected by the remaining useful life. The shorter the useful life, the larger the annual costs associated with control equipment.

Additionally, RACT requires consideration of the impact of the source upon air quality.’ This is consistent with the CAA, RHR, and EPA guidance. While the four statutory factors must be considered in determining what is necessary to make reasonable progress, they are not the only factors that states may consider in this evaluation. As explained by EPA in its 2019 guidance, states have the flexibility to consider other factors, including visibility benefits, when determining the emission reduction measures that are necessary to make reasonable progress:

> "Section 51.308(f)(2)(i) of the Regional Haze Rule requires consideration of the four factors listed in CAA section 169A(g)(1) and does not mention visibility benefits. However, neither the CAA nor the Rule suggest that only the listed factors may be considered. Because the goal of the regional haze program is to improve visibility, it is reasonable for a state to consider whether and by how much an emission control measure would help achieve that goal. Likewise, it is reasonable that such information on visibility benefits be considered in light of other factors that may weigh for or against the control at issue. Such a balancing of outcomes is consistent with CAA section 169A(b)(2), which states that SIPs must contain elements as may be necessary to make reasonable progress toward meeting the national visibility goal. Thus, EPA interprets the CAA and the Regional Haze Rule to allow a state reasonable discretion to consider the anticipated visibility benefits of an emission control measure along with the other factors when determining whether a measure is necessary to make reasonable progress."[13]

Therefore, Ecology will use the RACT process to (1) evaluate and determine the emissions reduction measures that are necessary to make reasonable progress and (2) incorporate these measures into its long-term strategy and Regional Haze SIP in a manner that is enforceable as a legal and practical matter.

Reasonable control evaluation

The Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data shows that ammonium sulfate ($(NH_4)_2SO_4$) and ammonium nitrate (NH_4NO_3) are two of the most significant pollutants impairing visibility in Washington's Class 1 Areas. $(NH_4)_2SO_4$ is primarily from point sources and offshore sources (shipping traffic), and NH_4NO_3 is primarily from point and mobile sources, with slight contributions from non-point sources. After the initial screening for source selection, the FFA in this chapter evaluates reasonable controls for point sources of nitrogen oxides (NOx) and sulfur dioxides (SO_2) emissions.

Ecology relies on current Washington laws and regulations to implement any controls identified as reasonable. Washington has four potential mechanisms for implementing identified emission controls:

- Agreed order (AO) – a legally binding order that requires agreement between the parties
- Permit modification – permittee initiated change to their facility
- Reasonably available control technology – Revised Code of Washington (RCW 70A.15.2230)

Ecology prefers to use permit modifications and AOs to achieve emission reductions as these methods have the source and Ecology working together to achieve reductions. These options

[13] EPA-457/B-10-003, *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period*, Section II.B.5.

are currently not available for use with the refinery or pulp and paper industry categories during this implementation period.

Ecology will use the RACT process to evaluate reasonable emission reductions for facilities without an AO or permit modification. The result of the RACT process is a determination of the minimum emissions controls required at a facility. The determination is made through rule making for a category of sources, or a source specific order. RACT identifies the emission control equipment and the timelines for installation and operation of the equipment. The RACT rule or RACT order is federally enforceable when EPA approves it into the SIP.

Ecology has limited resources and is choosing to prioritize the implementation of reasonable controls. As discussed in EPA's guidance:[14]

> "Another potentially reasonable approach might be for a state that identifies cost-effective new controls at a multitude of sources to choose to require controls at only a subset of those sources that constitute the vast majority of the visibility benefit. In this case, the state could rely on visibility benefits to prioritize which sources would receive new controls."

Ecology identified potential reasonable controls at a multitude of sources and is prioritizing a subset of those sources that constitute a vast majority of the visibility benefit during this implementation period. Ecology's first priority is to identify reasonable controls at the refinery facilities.

A number of factors supports the selection of refineries as the first priority. These factors include:

- Four of the five refinery facilities are located in the Puget trough, west of several Class 1 Areas. Their cumulative regional haze causing emissions influence the same Class 1 Areas.
- Predominant winds direct the emissions from the refineries toward several Class 1 Areas.
- The refineries' potential emission reductions of 4,200 tons per year account for the vast amount of potential emission reductions.

Pulp and paper mills are a subset of sources that are lower priority than refineries because:

- The pulp and paper mills are not located as close to each other as the refineries so they do not have as great of a cumulative effect.
- One mill identified with potential reasonable cost controls, Packaging Corporation of America (PCA) Wallula, is located in a direction that is downwind from the nearest Class 1 Areas. This lessens, but does not remove, the influence the mill's emissions have on Class 1 Areas.

[14] Peter Tsirigotis, Director, "Clarifications Regarding Regional Haze Second Implementation Plans for the Second Implementation Period," memo, addressed to Regional Air Division Directors, Regions 1-10, July 8, 2021.

- The potential reduction of 450 tons per year in regional haze emissions from the pulp and paper mills reasonable controls is vastly less than potential refinery emission reductions.

7.4 Facility specific reasonableness analyses

The following sections contain the facility specific FFA information and Ecology's analysis of additional emission controls. TransAlta and Cardinal Glass emission reductions were included in the long-term strategy and the 2028 modeled emission projections (on-the-books) for determining reasonable progress goals. Emission reductions from the remaining facilities were not included in the modeled 2028 projection since implementation will likely occur during the next implementation period. This is due to long planning timelines at these types of facilities combined with coordination of control installation and scheduled facility maintenance shutdowns.

Ash Grove Cement Company

Ash Grove Cement Company (Ash Grove) operates a dry process cement kiln in the Duwamish Industrial area of Seattle. The primary haze causing emissions at the plant comes from the cement kiln and its associated clinker cooler baghouses. Clinker is an intermediate product in cement production.

The existing particulate controls installed at the plant meet the regulatory requirements for dry material handling. The plant also complies with the Portland Cement Manufacturing National Emission Standards for Hazardous Air Pollutants (NESHAP). This standard regulates particulate matter (PM) as a surrogate for metals (40 CFR Part 63 Subpart LLL). This NESHAP was last updated mid 2018 when the EPA determined that there were no developments in practices, processes, and control technologies that warrant revisions to the Maximum Achievable Control Technology (MACT) standards for this source category (83 FR 35122-35136, 2018).

SO_2 emissions at the plant come from burning sulfur containing fuels. The plant is capable of burning coal, natural gas, and tire-derived fuels. The plant has not been using coal for the last couple of years, but still has the ability to use it. As the facility can still use coal, SO_2 emissions from the 2014 EI (with coal combustion) were included in the modeling to determine progress. The alkaline cement clinker removes some SO_2 from the combustion gases. The facility uses this as a primary method of SO_2 control. Nitrogen oxides (NOx) emissions from the plant also come from the combustion of all fuels allowed by permit.

Consent decree

Ash Grove entered into a consent decree with EPA, Ecology, the Puget Sound Clean Air Agency (PSCAA), and other state agencies in 2013 [See Appendix E]. The consent decree required the Seattle facility to submit an optimization protocol for the Seattle Kiln. The purpose of the protocol was to optimize the operation of the Seattle Kiln to reduce NOx emissions to the maximum extent practicable from that kiln. EPA reviewed the optimization plan in consultation with the PSCAA.

The protocols for the optimization plan included key operating parameters resulting in the minimization of emissions of NOx. The consent decree required minimization of NOx to the greatest extent practicable without:

- Incurring unreasonable cost.
- Causing an exceedance of any other applicable emissions limit.
- Impairing production quality or quantity.

The protocols also required the facility to identify all potential process and/or operational changes that they could implement to reduce emissions of NOx.

On June 30, 2016, the facility submitted the NOx demonstration period report and data related to optimization. On August 25, 2016, EPA, in consultation with Ecology and PSCAA, reviewed the data and approved the limit of 5.1 pounds of NOx per ton of clinker on a 30-day rolling average.

Four Factor Analysis

The following analysis recognizes that EPA approved the consent decree of 2013 and the optimization of the facility to limit NOx emissions in 2016. The goal was to reduce NOx emissions to the greatest extent practicable within reasonable costs. Ecology does not typically perform RACT analysis on single facilities that have had a reasonable analysis performed within the last five years. The following evaluates possible additional controls.

NOx emission controls by selective catalytic reduction

Selective catalytic reduction (SCR) is a potentially viable method to reduce NOx emissions. Efficient operation of an SCR requires consistent exhaust temperatures. Changes in the temperature of the exhaust gas result in reduced NOx removal efficiency. The exit stack temperature at the facility is typically around 350°F. The typical SCR operation temperature is 650°F so the exhaust would require heating When exhaust stream temperatures are too low, there is the potential that injected ammonia (the reducing agent) won't react (ammonia slip). Conversely, when the exhaust stream temperature is too high, ammonia (NH_3) can oxidize to NO, potentially reducing efficiencies. The reducing process needs excess NH_3 to achieve removal efficiencies in excess of 80 percent and can result in ammonia slip.

There is a risk of fouling the catalyst bed when operating an SCR. Installing the catalyst bed downstream of the particulate matter controls, (this facility uses baghouse dust collectors), can reduce fouling. The low exhaust gas temperature exiting the baghouse would require the installation of a heat exchanger system to reheat the exhaust stream to the desired reaction temperature range of between 480 °F to 800 °F. The use of a preheater or heat recovery would be required, however the use of a preheater would require additional fuel consumption and create even more NOx.

Installation of an SCR system would require storage and handling equipment for ammonia. An SCR system requires a catalytic reactor, heat exchanger, and potentially additional NOx control equipment for the emissions associated with the heat exchanger fuel combustion.

Installing the SCR in the high dust exhaust stream (e.g. before the baghouse) would put the SCR in the optimal temperature zone but there is a risk of fouling the catalyst. Faster fouling of the catalyst would result in increased operation cost and increased plant down time. A larger catalyst volume and mechanical mechanism to clean the catalyst could mitigate the fouling impacts but would require a larger physical footprint for installation.

NOx emission controls by selective non-catalytic reduction

The Consent Decree described above required the facility to optimize a selective non-catalytic reduction (SNCR) emission control system. Ash Grove submitted a new source review application with Puget Sound Clean Air Agency (PSCAA) in 2016 for the installation of the SNCR system. A permit has not been issued because of unresolved technical issues.

The main technical issue is that the permit application requested to operate the SNCR process on an “as needed” basis to achieve NOx limits determined during a 2016 demonstration period for the EPA Consent Decree. PSCAA and Ash Grove are working on resolving the technical issues in the application with the goal of issuing a permit for the SNCR system. This permit will form the basis for emission standards that will apply to the SNCR system. Ecology intends to supplement the RHR SIP once the permit is issued. In the interim, Ecology has determined the EPA Consent Decree limit of 5.1 pounds of NOx per ton of clinker on a 30-day rolling average is adequate for reasonable progress at this time until a final permit for the SNCR system is issued by Puget Sound Clean Air Agency.

Particulate matter emission controls

The facility upgraded their emission controls in 2019 with the installation of a Dustex 10-module pulse jet baghouse with rated flow rate of 185,000 actual cubic feet per minute (ACFM). They performed this upgrade under a permit modification with PSCAA. The permit modification requires the facility to meet the requirements of the Best Available Control Technology (BACT) requirements. PSCAA accepted the upgrade as BACT, so additional control analyses are not required.

Under the EPA’s July 8, 2021 Clarification Memo (page 9) “if a state can demonstrate that a source will continue to implement its existing measures and will not increase its emission rate, it may not be necessary to require those measures under the regional haze program in order to prevent future emission increases.” We note that the existing particulate controls installed at the plant meet the regulatory requirements for dry material handling. The plant also complies with the Portland Cement Manufacturing National Emission Standards for Hazardous Air Pollutants (NESHAP). This standard regulates particulate matter (PM) as a surrogate for metals (40 CFR Part 63 Subpart LLL). This NESHAP was last updated mid 2018 when the EPA determined that there were no developments in practices, processes, and control technologies that warrant revisions to the Maximum Achievable Control Technology (MACT) standards for this source category (83 FR 35122-35136, 2018). Because these emissions are unlikely to increase and are subject to a federally enforceable control, Ecology has determined that incorporation of a PM emission limit in the SIP is not necessary for reasonable progress.

SO_2 emission controls

The primary emission of SO_2 from the facility is from the burning of coal, tires, and various oils. The primary emission control for SO_2 is a wet scrubber. Space is limited at the site and installation of a wet scrubber would require extensive facility rearrangement and a retention pond for the waste water, in addition to the capital cost of the wet scrubber. Based on this, we do not consider the cost of a wet scrubber reasonable at this time.

The existing controls for SO_2 emissions at the facility limiting emissions to 200 ppm at 10% O2 for one hour average and a not to exceed of 176 tons per year were deemed adequate to meet reasonable progress.

Cost of compliance

Installing SCR NOx or SO_2 emission controls would require significant facility reconstruction. The Ash Grove facility brochure in [APPENDIX E] shows how congested the site is. To create room the emission devices would have to be elevated above the existing facility and would run into area height restrictions. The other option of raising existing plant equipment or positioning the emission control device above other equipment would require extensive structural work and would require that the facility shut down operations during construction and reconfigure the site. This would result in significant additional costs above capital expenditure and operational cost for the emission control equipment.

Ash Grove submitted a permit application for an SNCR system, and this indicates that the cost of SNCR installation is reasonable. Ecology is working with PSCAA and Ash Grove to optimize the proposed SNCR system so that the permitted system maximizes NOx emission reductions without excessive ammonia emissions.

Time necessary for compliance

Typical planning periods to design and then install SCR NO_X or SO_2 controls are two to three years. A tuning period after installation is required to understand the physical operation of the equipment. For the Ash Grove facility, the time required to plan and then install any equipment would increase by one to two years to allow for extensive facility modifications to accommodate any equipment.

With the base infrastructure of the SNCR system already in place at the facility, an analysis and subsequent optimization study would take six to twelve months. This time estimate comes from the actual time required to perform an optimization study at a coal-fired power plant in Washington. Most of the time involved in the optimization study is in setting the system parameters and then operating the facility under the parameters long enough to collect stabilized data.

Energy and non-air quality environmental impacts of compliance

SCR equipment would require preheating the exhaust stream before it enters the SCR. Preheaters burn fuel to generate heat and this would consume additional energy and create additional emissions.

The installation of a wet scrubber for SO_2 controls would require obtaining a water quality permit for use with the liquid in the wet scrubber. Depending on the permit requirements, the facility could need additional energy to treat the liquid from the wet scrubber before discharge off-site.

The SNCR system is already in place and the facility is working on obtaining a permit.

Remaining useful life of any potentially affected sources

Proper maintenance of this facility should allow it to continue operations well into the future.

Summary and preliminary recommendations

Ecology does not recommend installation of additional emission control equipment. The particulate matter controls at the site were recently upgraded. The cost for SCR NOx and wet scrubbing SO_2 equipment installation is also unreasonable due to the confined space at the site. The existing controls for particulate matter and SO_2 where used in the model to determine reasonable progress. The installation of a new SNCR system will be permitted by PSCAA identifying use requirements.

Cardinal Glass

Cardinal FG Company Winlock (Cardinal) operates a flat glass manufacturing plant in Winlock, near the intersection of Avery Road and Highway 603, in Lewis County, Washington. In 2019, Cardinal submitted a permit modification application to SWCAA to install an SCR emission control device and increase production of plate glass. The application also proposed removing the current emission control of limiting excess oxygen. SWCAA is working with the facility to issue a permit to add SCR to the existing plant.

Ecology identified Cardinal in the Q/d analysis as a facility to review under the RH program. On January 17, 2020, Cardinal FG Company submitted a four-factor analysis.

Four-factor analysis

Cardinal FG Company Winlock submitted an application to SWCAA to modify the facility's permit by:

- Installing an SCR system to control NO_X emissions from the glass furnace;
- Increasing rated furnace production from 650 tpd to 750 tpd;
- Removing an SCR from Emergency Generator #1;
- Installing a new emergency generator; and
- Establishing voluntary emission limits at levels below major source thresholds.

The use of the current emission control system will cease once the SCR system commences operation. The facility will also install a new supplemental heater between the Electrostatic Precipitator (ESP) and the SCR system. This heater will raise the exhaust stream temperatures to the range required for proper SCR operation.

Table 7-2 shows the emissions, by pollutant in tons, after the requested modification is complete. The table also shows the change in emissions from the current permit values to the requested modified permit values.

Table 7-2: Emissions summary

Pollutant	Facility-wide potential to emit after permit modification in tons per year (tpy)	Pollutant emissions change between current limits and permit modification limits in tons per year (tpy)
NOx	249.62	-583.05
CO	249.00	-522.48
VOC	57.79	1.92
SO_2	114.21	41.75
PM	141.96	16.84
PM_{10}	141.96	6.84
$PM_{2.5}$	141.96	16.84

Cost of compliance

Oxides of Nitrogen (NOx) – cost and cost/ton

Cardinal's permit modification application estimated a reduction of glass furnace annual NOx emissions from 828.05 to 245.0 tons per year (tpy). This is an annual reduction of 583.05 tpy. The estimated cost of the new SCR control system is $10 million. Based on 3.5 percent interest and 20-year life, the annual cost is $944,000 per year. Using the annualized cost and emissions reduction, the estimated cost effectiveness is $1,469 per ton of NOx. The actual cost will be higher since this does not include operating costs.

Ecology requested additional data needed to use the EPA Control Cost Manual from Cardinal to compare the EPA Control Cost Manual results to actual data for quality purposes. Ecology received the following unit specific information from Cardinal on June 15, 2020:

- Exhaust rate of 181,157 acfm @ 600 F
- SCR inlet NOx = 437.5 lbs/hr (above current emission limit)
- SCR outlet NOx = 49.1 lbs/hr
- Capital cost updated to $11 million (annualized cost not updated)

SO_2, PM – Temperature change – higher scrubber temperature and reheat - cost and cost/ton

The operating temperature of the new SCR system will require the existing spray dryer and electrostatic precipitator (ESP) to operate at higher temperatures, reducing their collection efficiency and requiring a reheat burner. This increased temperature results in a greater fuel consumption and SO_2 emissions. The SO_2 emissions limit will increase from 0.6 to 0.8 lbs of SO_2/ton of glass. The natural gas-fired reheat burner will have a capacity of 17 - Million British Thermal Units (MMBtu)/hr.

The permit modification application includes a production increase at the facility from 650 to 750 tons per day (TPD). This results in an increase of total annual PM emissions even though the total PM emission limits of 0.94 lbs/ton will not change.

Time necessary for compliance

Cardinal expects to have the proposed SCR installed and operational in 2021. The permit was issued by SWCAA to the facility on February 11, 2021, and the SCR should be operating by the end of 2021.

Energy and non-air quality environmental impacts of compliance

SCR - Ammonia and PM increases

The design of the SCR system at the facility assumes a 19 percent ammonia reagent usage of 816 lbs/hr. Appendix D of the permit modification application calculates ammonia emissions. SWCAA permit 20-3409 contains the permit modification application. Based on an ammonia slip limit of 10 parts per million (ppm), estimated ammonia emissions based on continuous operation will be 9.58 tpy.

The total particulate matter (PM) emission limits of 0.94 lbs PM/ton of glass will not change. Total PM emissions will increase, however, due to the facility increasing throughput capacity from 650 to 750 tpd of glass.

Appendix C of the permit modification application (in Appendix S) calculates PM emissions. The PM emissions from the glass furnace will increase from 111.0 to 127.84 tpy, for an increase of 16.84 tpy.

The SO_2 emissions limit will increase from 0.6 to 0.8 lbs/ton. SO_2 emission increases will occur due to the increase in capacity from 650 to 750 tpd of glass. Appendix C of the permit modification application calculates SO_2 emissions. The SO_2 emissions from the glass furnace will increase from 75.6 to 117.35 tpy, for an increase of 41.75 tpy.

SO_2/PM controls - additional fuel if needed – added emissions

The existing SO_2 and PM controls for the glass furnace do not use fuel.

Remaining useful life of any potentially affected sources

The Cardinal facility has operated since 2006. The new SCR system's design life will last at least 30 years if the facility performs proper maintenance.

Ecology's review

The RH program does not prohibit or limit construction of new stationary sources of emissions or modification of existing stationary sources of emissions. Cardinal submitted a permit modification application for increased glass production and a change in emission control devices. The NOx emission reductions resulting from the installation of the SCR are part of Ecology's long-term strategy for achieving reasonable progress goals in Class 1 Areas for this implementation period. Based on the above information and SWCAA's technical support document for the permit action, Ecology concludes:

- The new SCR will reduce NOx emissions. The permitted emissions will be reduced to 250 tpy. Ecology's independent review of the cost for installation of the SCR determined approximately $1,600/ton of NOx reduced. The facility's estimate was slightly higher as the company included the additional equipment (temporary stack and larger crane) to install the new system while the facility stays in operation. This could explain the higher actual cost when compared to the EPA Control Cost Manual when using a base reconstruction factor of 1.0.

- This cost is reasonable for NOx reductions. If the facility were not taking action on their own initiative to install a SCR system, Ecology would have pursued Cardinal Glass to install one. The permit modification with SWCAA is the only action needed for RH reductions.

Table 7-3: Cardinal cost vs Ecology using the EPA Control Cost Manual with June 15, 2020, updated exhaust flow and capital cost

Company	Actual cubic feet per minute	Capital costs ($)	Annualized costs ($)
Cardinal FG Winlock	181,157	11,000,000	944,000
EPA Model - R =1.0	181,157	10,899,998	750,225

Summary and preliminary recommendations

- The operating temperature of the new SCR system will require the existing spray dryer and ESP to operate at higher temperatures, reducing the collection efficiency and requiring a reheat burner. Ecology concluded that the resulting minor increase in PM and SO_2 is offset by the larger decrease in NOx.
- The facility is working to obtain local permits needed for the installation of the SCR.
- The new permit limit for ammonia of 10 ppm and 9.5 tpy is reasonable. New SCR systems will typically have actual ammonia emissions less than 2 ppm after tuning.

Coal-fired electrical generation unit

TransAlta Centralia Generation (TransAlta) is a coal-fired power plant located east of Centralia, WA. This is the largest source of NOx in Washington. TransAlta's large quantity of emissions and tall stacks create NOx impacts to all of the Class 1 areas within 300 km of the facility. TransAlta operates a two unit, pulverized coal-fired power plant. Each unit of the plant rates at 702.5-megawatt (MW) net output. Operation of a coal-fired power plant results in visibility impairing emissions of PM, SO_2, and NOx.

The Coal-Fired Electric Generation Facility Bill was signed in 2011, with an effective date of July 22, 2011. Washington's greenhouse gas emission performance standard for power plants codified at RCW 80.80.040determined the main environmental impacts of the bill. The requirements in RCW 80.80.040 have compliance dates for one boiler to cease coal-fired generation by December 31, 2020, and the other boiler to cease coal-fired generation by December 31, 2025. TransAlta has ceased coal-fired power generation on one boiler and plans to cease coal-fired power generation in the other boiler by December 31, 2025.

Ecology identified TransAlta as a best available retrofit technology (BART) eligible facility in the first implementation period of RH. Ecology issued a BART Order to TransAlta on June 18, 2010 (2010BARTtransalta). This BART Order required the installation of a SNCR emission control device. Ecology issued a revision to the BART Order on December 13, 2011. The revision incorporated an optimization study on urea volume injections for the SNCR. Ecology issued a second revision to the BART order on July 29, 2020. The second revision required the installation of automated controls on the combustion system, a lower NOx emission limit, and removal of specific urea injection volumes.

In the summer of 2019, TransAlta experienced emission opacity readings that would have exceeded the opacity limits if TransAlta had not reduced plant capacity to compensate. During a maintenance shutdown, the facility examined their ESPs. The ESPs had a visual fouling of all interior components, which dramatically reduced their efficiency. The facility analyzed the material in the ESPs and identified it as ammonia sulfate. The source of ammonia in the system was from the reactions of urea in the SNCR system.

In coordination with SWCAA and Ecology, TransAlta installed a computerized emission control system called a Combustion Optimization System with Neural Network program (Neural Net) to decrease the ammonia slip in the SNCR. SWCAA agreed to use enforcement discretion in 2019 on the urea injection rate mandated in the 2011 BART Order revision while TransAlta was tuning the Neural Net. TransAlta collected enough process data during tuning of the neural net to agree to a more stringent NOx emission standard of 0.18 lb/MMBtu, a decrease from the 0.21 lb/MMBtu allowed under the 2011 BART Order revision.

Because the Neural Net is able to maintain a more stringent emission standard, Ecology eliminated unnecessary requirements when issuing the second BART order revision. Specifically, the 2020 order:

- Removed the requirement of a specific urea injection rate to allow TransAlta to inject urea as required to meet the new emission standard.
- Removed the requirement to analyze and report nitrogen and sulfur coal content as the facility would have to meet NOx, SO_2, and PM emission standards regardless of the coal used.
- Changed the requirement for ammonia emission monitoring to require monitoring only when using a urea injection rate of greater than 1.5 gallons per minute.

The BART Order was submitted to EPA and approved into the Washington SIP on May 11, 2021.

Four factor analysis

The FFA of TransAlta reflects the Chapter 80.80 RCW and the Memorandum of Agreement (MOA) between TransAlta and the Governor of Washington that TransAlta will completely cease coal-fired power generation by December 31, 2025. It also discusses the second BART Order revision that reduces NOx emissions at the facility.

Cost of compliance

The agreement to cease coal-fired power generation greatly influences the compliance cost for installing any emission controls at TransAlta. The first unit ceased operation on December 31, 2020. This decreased by approximately half the plant emissions from coal-fired power generation. This emission reduction requires no capital cost. Operational costs to ensure that the unit will no longer be able to generate power from coal will occur, but all parties already considered this as part of the MOA.

The second BART Order revision includes the installation of the Neural Net to control combustion variables in one of the boilers. TransAlta proposed this installation and during optimization testing, the data confirmed that the controls could reduce NOx emissions. Ecology did not request the costs associated with installing, testing, and optimizing of the neural net as TransAlta proposed it and resulted in decreased NOx emissions for the remaining coal-fired power generation life of the facility.

Time necessary for compliance

TransAlta ceased coal-fired power generation on one of their units in December 2020. TransAlta will cease coal-fired power generation on their last unit by December 31, 2025. The Neural Net installation has already occurred and the more stringent emission limit applies to the facility until it ceases coal-fired power generation.

Energy and non-air quality environmental impacts of compliance

The energy required to meet compliance for ceasing coal-fired power operation is zero. We did not take non-air quality environmental impacts for the future of the facility into account for this analysis.

For the Neural Net, TransAlta is anticipating payback within a couple of years. This is because more efficient combustion controls reduce the amount of coal required to produce the same amount of heat.

Remaining useful life of any potentially affected sources

The facility useful life for coal-fired power generation is until December 31, 2025.

Summary and preliminary recommendations

TransAlta already has an agreement to cease coal-fired power generation by December 31, 2025. This will result in coal-related emissions from the facility going to zero. Ecology used the zero emission level in determining 2028 projected emissions and reasonable progress goals in Washington’s Class 1 Areas, as well as potential effects in Class 1 Areas of neighboring states. With the installation of the neural net, the facility will also have a reduced NOx emission standard for the remaining life of the facility. For these reasons, Ecology does not anticipate further emission reductions or emission control devices for Regional Haze purposes.

Primary aluminum production

Washington currently has two primary aluminum reduction facilities:

- Alcoa Primary Metals Wenatchee Works located in Wenatchee, Washington.
- Alcoa Primary Metals Intalco Works located in Ferndale, Washington

Alcoa curtailed the Wenatchee facility in 2015 and the Ferndale facility in 2020, while keeping both air permits active. Ecology did not include emission reductions from either facility when modeling on-the-books visibility projections for 2028 or determining reasonable progress goals in Washington's Class 1 Areas although future emissions inventories may show emission reductions resulting from curtailment.

In 2014, the emissions from the sites were as follows:

Table 7-4: Primary aluminum facility 2014 emissions

Facility	Tons $PM_{2.5}$	Tons SO_2	Tons NOx
Alcoa Intalco	637	4,794	227
Alcoa Wenatchee	457	2,935	70

Alcoa Wenatchee Works

The Wenatchee Works facility, curtailed since 2015, has very low emissions. The facility is performing all the requirements of their air permits and could restart at any time. Wenatchee Works would need time to expand their work force from the current curtailment level and additional physical activities would need to occur prior to returning to production.

The four-factor analysis of Wenatchee Works is complicated by the curtailment status. Annual emissions are very low while in curtailment and not typical of emissions during operation. In 2016-2018, annual emissions were less than 10 tpy for all pollutants. A facility in curtailment is also not generating revenue because the facility is not selling any aluminum.

Four-factor analysis

The primary haze-causing pollutant from the facility when it is operating is SO_2. A wet scrubber and associated liquid handling structures is often used for SO_2 emission control. The following FFA details how installation of a wet scrubber system is not reasonable when the facility is in curtailment.

Cost of compliance

The cost of compliance will always be unreasonable for a facility in curtailment since the analysis is based on cost/ton of actual emissions. The facility reported 10 tons of total annual emissions in 2016. Assuming the facility could install control equipment for the entire 10 tons, the cost per ton of emissions reduced will exceed $10,000 per ton of pollutants removed with only a $100,000 expenditure. A cost of $10,000 per ton is not a reasonable cost for primary aluminum facilities at this time.

Facilities with large emissions of SO_2, in tons per year, typically use wet scrubbers for emission control. Direct capital equipment costs for wet scrubbers are typically in the millions of dollars range and installing a wet scrubber would require spending at least $100,000 per ton of SO_2 removed based on current emissions, which is not reasonable.

Because the facility has the potential to restart at any time, emissions could potentially return to pre-curtailment levels. In this situation, an analysis of the facility could potentially result in reasonable emission control costs. Calculations of the cost of compliance would depend on numerous variables, from the number of pot lines brought back on line, amount of aluminum produced, regaining experienced operators for efficient operations, and other operational determinations.

We would need to determine numerous variables associated with a restart of the facility before performing a cost analysis. At the time of facility restart, we would need to do an analysis to determine the reasonableness of the cost of potential controls.

Time necessary for compliance

With the facility in curtailment and no emission control equipment deemed reasonable, the facility is already complying with reasonable emission control. If the facility comes out of curtailment, we would need a new FFA to determine time for compliance if we identify control equipment.

Energy and non-air environmental impacts

With the facility in curtailment and no emission control equipment deemed reasonable, the facility would not have any new non-air environmental impacts. If the facility comes out of curtailment, we would need a new four-factor analysis to determine non-air environmental impacts if we identify control equipment.

Remaining useful life

The facility is currently in curtailment and not operating. The facility is performing maintenance on equipment to keep the facility in position to restart in the future. The facility has permanently closed a pot line within the last five years.

Summary and preliminary recommendations

Wenatchee Works is currently in curtailment and installation of additional emission control devices is not reasonable at this time. With the potential of the facility to restart at any time, Ecology entered into an Agreed Order (AO #18100) (WenatcheeAORH) with the facility that requires the facility perform a FFA before restarting and provide the analysis to Ecology.

The AO conditions stipulate that Alcoa shall:

1. Prepare and submit a four-factor analysis to Ecology for review and approval at least 180 days prior to restarting any of the facility's potlines. Alcoa will base the analysis on the facility's permitted emission limits and will assess potential emission control measures against the following four statutory factors:
    - The cost of compliance,
    - Time necessary for compliance,
    - Energy and non-air quality impacts of compliance, and
    - Remaining useful life of the source.
2. Within 60 days of receipt of Ecology's comments on the four-factor analysis provide all additional information and/or documentation requested by Ecology, if any, and submit an updated four-factor analysis that adequately addresses Ecology's comments.
3. Install or otherwise implement and begin operating all emission control measures identified in the final four-factor analysis submitted within three years of Ecology's approval.

Alcoa Intalco

The Intalco facility near Ferndale is capable of making approximately 307,000 tons of aluminum metal each year. The facility is located in an area that had air monitor readings that were exceeding the one-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS). Ecology and Intalco entered into Agreed Order 16449 on July 25, 2019 (IntalcoAO16449). Intalco agreed in the AO to submit a complete Notice of Construction (NOC) application for the installation of a wet scrubber design and engineering report by October 31, 2020.

We anticipated using the information required under the terms of the AO to perform the FFA for our RH SIP. Ecology did not request the facility to perform a FFA as the AO obviated the need to perform one. On April 22, 2020, the Intalco facility announced that it was curtailing production. The AO contains a clause that "[n]ot withstanding anything else in this Order, in the event that Intalco announces the closure or curtailment of one of its three potlines (A, B, or C line, or any combination or equivalent measure thereof), then upon thirty days' prior written notice to Ecology, this Order and Intalco's obligations hereunder will become null and void."

With the curtailment and subsequent voiding of the wet scrubber AO Ecology cannot count potential emissions reductions from that control.

The Intalco facility is planning to perform all requirement of their permits and could restart at any time. Intalco would need time to expand their work force from the current curtailment level and additional physical activities would need to occur prior to returning to production.

The FFA of Intalco during curtailment is more complicated than on an operating facility. Annual emissions are very low while in curtailment and not typical of emissions during operation. Emissions should be comparable to the Wenatchee Work primary aluminum facility that is already in curtailment. The Wenatchee Works facility had annual emissions in 2016-2018 that were less than 10 tpy total for all pollutants. The Intalco facility in curtailment is also not generating revenue because the facility is not selling any aluminum.

Four-factor analysis

The primary haze-causing pollutant from the facility when it is operating is SO_2. A wet scrubber and associated liquid handling structures is often used for SO_2 emission control. The following FFA details how installation of a wet scrubber system is not reasonable when the facility is in curtailment.

Cost of compliance

The cost of compliance will always be unreasonable for a facility in curtailment since the analysis is based on cost/ton of actual emissions. If Intalco curtailed emissions are similar to the Wenatchee Works facility's reported 10 tons of total annual emissions in the 2016 EI, then Intalco will also have around 10 tons of annual emissions. Assuming the facility could install control equipment for the entire 10 tons, the cost per ton of emissions reduced will exceed $10,000 per ton of pollutants removed with only a $100,000 expenditure. A cost of $10,000 per ton is not a reasonable cost for primary aluminum facilities at this time.

Facilities with large emissions of SO_2, in tons per year, typically use wet scrubbers as emission control. Direct capital equipment costs for wet scrubbers are typically in the millions of dollars range and installing a wet scrubber would require spending at least $100,000 per ton of SO_2 removed based on current emissions, which is not reasonable.

Because the facility has the potential to restart at any time, emissions could potentially return to 2014 EI (2014EI) levels. In this situation, an analysis of the facility could potentially result in reasonable emission control costs. Calculations of the cost of compliance would depend on numerous variables from the number of pot lines brought back on line, amount of aluminum produced, regaining experienced operators for efficient operations, and other operational determinations.

Numerous variables associated with a restart of the facility need to be determined before performing a cost analysis. At the time of facility restart, we would need to do an analysis to determine the reasonableness of the cost of compliance.

Time necessary for compliance

With the facility in curtailment and no emission control equipment deemed reasonable, the facility is already complying with reasonable emission control. If the facility comes out of curtailment, we would need a new FFA to determine time for compliance if we identify control equipment.

Energy and non-air environmental impacts

With the facility in curtailment and no emission control equipment deemed reasonable, the facility would not have any new non-air environmental impacts. If the facility comes out of curtailment, we would need a new FFA to determine non-air environmental impacts if we identify control equipment.

Remaining useful life

The facility is currently in curtailment and not operating. The facility is performing maintenance on equipment to keep the facility in position to restart in the future. Because of the uncertainties, we cannot determine the remaining useful life of the facility at this time.

Summary and preliminary recommendations

Intalco is currently in curtailment and installation of additional emission control devices is not reasonable at this time. With the potential of the facility to restart at any time, Ecology entered into an Agreed Order (AO) with the facility that requires the facility perform a FFA before restarting and provide the analysis to Ecology.

The AO conditions stipulate that Intalco shall:

1. Prepare and submit a four-factor analysis to Ecology for review and approval at least 180 days prior to restarting any of the facility's potlines. Intalco will base the analysis on the facility's permitted emission limits and will assess potential emission control measures against the following four statutory factors:

    - The cost of compliance,
    - Time necessary for compliance,

    - Energy and non-air quality impacts of compliance, and
    - Remaining useful life of the source.
2. Within 60 days of receipt of Ecology's comments on the four-factor analysis provide all additional information and/or documentation requested by Ecology, if any, and submit an updated four-factor analysis that adequately addresses Ecology's comments.
3. Install or otherwise implement and begin operating all emission control measures identified in the final four-factor analysis submitted within three years of Ecology's approval.

7.5 Chemical pulp and paper mill four-factor analysis

The pulp and paper facilities include six sulfate (Kraft) and one sulfite chemical processing facilities. Cosmo Specialty Fiber is currently the only sulfite mill in Washington. The modeled 2028 reasonable progress goals did not include any emission reductions from any of the pulp and paper mills. Ecology has limited resources and is choosing to prioritize the sequence of implementation of reasonable controls. Ecology has identified potential cost-effective controls at a multitude of sources and is choosing to require reasonable controls at only a subset of those sources.

As discussed in EPA’s guidance:

> “Another potentially reasonable approach might be for a state that identifies cost-effective new controls at a multitude of sources to choose to require controls at only a subset of those sources that constitute the vast majority of the visibility benefit. In this case, the state could rely on visibility benefits to prioritize which sources would receive new controls.” [15]

Ecology is prioritizing implementation of potential new controls starting with refinery facilities because:

- The pulp and paper mills are not located as close to each other as the refineries so they do not have as great of a cumulative effect.
- One mill identified with potential reasonable cost controls, Packaging Corporation of America (PCA) Wallula, is located in a direction that is downwind from the nearest Class 1 Areas. This lessens, but does not remove, the influence the mill’s emissions have on Class 1 Areas.
- A potential reduction of 470 tons per year in regional haze emissions from the pulp and paper mills reasonable controls is vastly less than potential refinery emission reductions.

After we complete the reasonability analysis and determination for the refinery facilities, we plan to identify and implement any reasonable controls at pulp and paper facilities. Ecology will

[15] Peter Tsirigotis, Director, “Clarifications Regarding Regional Haze Second Implementation Plans for the Second Implementation Period,” memo, addressed to Regional Air Division Directors, Regions 1-10, July 8, 2021, Section 5.1, at page 12-13.

update the SIP if new emission controls are installed at pulp and paper facilities during this implementation period. In the interim, Ecology has determined that no additional controls are necessary for RP at this time or included in the LTS.

Four-factor request and initial review

On September 10, 2019, Ecology requested an FFA from the seven chemical pulp mills in Washington. Ecology received a combined FFA report from the six Kraft mills and a separate FFA from the sulfite mill (Cosmo) on December 5, 2019. After review, on January 13 2020, Ecology requested that six of the seven mills provide additional information to Ecology by February 28, 2020 [APPENDIX I].

Ecology did not request additional information from GP Camas because they are no longer a Kraft mill and facility emissions were reduced below the Q/d screening threshold. The 2019 Emission Inventory indicates regional haze causing emissions for the GP Camas facility reduced from 653 tons to 83.1 tons. The reduced emission mass changes the Q/d value from 23.1 to 1.8. With the new Q/d value being less than the threshold value of 10 for consideration, Ecology removed the facility from further analysis. If GP Camas pursues operation as a chemical pulp mill in the future, they will need to go through new source review.

On February 20, 2020, Cosmo requested a time extension for submitting additional information due to impacts of the coronavirus in China, where delivery of their product was delayed. Ecology agreed to a time extension to April 30, 2020.

Ecology received follow-up information from each of the mills in a timely manner. The FFAs and follow-up information from the pulp mills are in Appendix O. The FFA supplied from the mills all indicate that additional emission controls are unreasonable. Ecology evaluated and adjusted this information for NOx, SO_2, and PM control. Appendix J is a summary of Ecology's revised costs/ton for controls for NOx, SO_2, and PM, costs/ton, and estimated useful life at a 3.25 percent interest rate for the facilities.

Potentially reasonable controls at current chemical pulp mills

Ecology identified some potential reasonable controls at three Kraft mills and a sulfite mill. The Kraft mills are Nippon Dynawave Packaging Company Longview (Nippon), Packaging Corporation of America (PCA) Wallula, and WestRock PC, LLC Tacoma. The sulfite mill is Cosmo Specialty Fibers, Inc. (Cosmo) mill. Because Ecology has identified potential cost-effective controls at a multitude of sources, we are choosing to require any potential reasonable controls at only a subset of those sources. Ecology has chosen to perform a more extensive and in-depth engineering evaluation at refinery facilities first. This decision is based on the refineries having a greater potential amount of reductions to regional haze causing emissions than pulp and paper mills. The refineries are also geographically located such that they influence the same Class 1 Areas concurrently. The pulp and paper mills are more dispersed and have less of a combined influence on the Class 1 Areas.

For NOx control using a low-NOx burner, the following units have estimated cost/ton value less than the potential reasonableness threshold of $6,300/ton. Adding these controls could potentially reduce NO_X emissions by approximately 150 tpy.

- Nippon Boiler #9 ($2,754/ton) with approximately 97 tons potential reduction
- PCA boiler #1 ($5,893/ton); with approximately 26 tons potential reduction
- PCA boiler #2 ($4,834/ton) with approximately 30 tons potential reduction

For NOx control using an SCR or SNCR, the following units have a cost/ton value less than the potential reasonableness threshold of $6,250/ton. Adding one of these controls could potentially reduce NOx emissions by approximately 500 tpy to 1025 tpy.

- Nippon hog fuel (HF) boiler #11 ($5,413 for SNCR); ($5,466/ton for SCR); with approximately 329 tons or 848 tons potential reduction respectively.
- Nippon Boiler #9 ($6,041 for SCR) with approximately 175 tons potential reduction.
  - This unit was discussed above in the low-NOx burner section. Please note that only one of these options would be used.

For PM_{10} control, the following units have a cost/ton value less than the potential reasonableness threshold of $7,800/ton. Adding these controls could potentially reduce PM_{10}emissions by approximately 30 to 225 tpy depending whether Cosmo is included (see footnotes for Cosmo).

- WestRock Tacoma Lime Kiln #1 ($6,964/ton) with approximately 33 tons potential reduction.

For SO_2 control, Ecology did not receive recent cost incurred information from the pulp mills (the scrubber at WestRock Tacoma was for HCl control). The SO_2 control cost estimates that the pulp mills submitted to Ecology are greater than the potential cost threshold range of the other RH pollutant costs of $6,250 - $7,800.

Additional considerations

Ecology considered the following information as part of the reasonability analysis:

- GP Camas is no longer operating as a chemical pulp mill and the emissions will change. The facility would have to apply as a new source if it ever wanted to become a chemical pulp mill in the future. This would result in evaluation of emission controls requirements at that time.
- The Cosmo mill was in curtailment from May 10, 2020 until January 27, 2021. This shows the mills sensitivity to market conditions and impacts what the reasonable cost threshold for new emission equipment is.
- Currently, no one has practically demonstrated using SCRs for recovery furnaces (boilers), but they could potentially progress to a level of technical feasibility during a future implementation period. Since this is not shown to be technically feasible at this time, those controls will not be considered for analysis during this implementation period.

Conclusion

The pulp and paper mills identified no reasonable controls in their FFAs. Ecology will need to perform a more extensive and in-depth engineering evaluation on potential control to generate more accurate and defensible cost estimates. Ecology has limited resources and is choosing to prioritize the sequence of implementation of reasonable controls. Ecology has identified potential cost-effective controls at a multitude of sources and is choosing to require reasonable controls at only a subset of those sources at this time.

Pulp and paper mill sources are not the first priority for new control implementation. This decision is based on:

- The pulp and paper mills are not located as close to each other as the refineries so they do not have as great of a cumulative effect.
- One mill identified with potential reasonable cost controls, Packaging Corporation of America (PCA) Wallula, is located in a direction that is generally downwind from the nearest Class 1 Areas. This lessens, but does not remove, the influence the mill's emissions have on Class 1 Areas.
- The potential reduction of 450 tons per year in regional haze emissions from the pulp and paper mills reasonable controls is vastly less than potential refinery emission reductions (approximately 4,000 tons).

After we complete the reasonability analysis and determination for the refinery facilities, we plan to conduct a reasonability analysis at pulp and paper facilities. This will be included in a SIP revision or the next implementation period, depending on the timing.

7.6 Refineries

Five petroleum refineries are located in Washington. The refineries are Cherry Point refinery (BP Cherry Point), Shell Anacortes refinery (Shell), Marathon Anacortes refinery (Tesoro), Ferndale refinery (Phillips 66), and U.S. Oil refinery (U.S. Oil).

Refineries have extended timeframes for design, acquisition, and installation of equipment. Work at refineries must be scheduled during narrow time windows to coincide with other work during facility shutdowns. Performing work outside of these periods significantly increases cost if the facilities would shut down solely for the equipment installation. The next facility shutdowns may occur outside of this implementation period so no emission reductions were included in the modeled 2028 visibility projections.

The refineries in Washington are over 40 years old and the facilities have maintained the majority of the equipment in a manner that has not required updating emission controls to current standards. EPA national enforcement actions and the installation of new equipment have led to the updating of some equipment. All the refineries have made changes to accommodate the new fuel standards, lower sulfur requirements, and benzene content.

Table 7-5. General refinery information.

Refinery	Process Capacity (barrels/day)	Footprint (acres)	Year Built
BP	234,000	3,300	1971
Phillips 66	107,500	900	1954
Shell	149,000	800	1958
MPC	125,000	900	1955
U.S. Oil	42,000	136	1957

Each refinery has the same NAICS code, but are uniquely configured with different considerations for each. The major difference is in how they handle the heavy crude bottom fraction:

- BP Cherry Point uses hydrocracker and coker units.
- Phillips 66 uses a Fluidized Catalytic Cracking Unit (FCCU).
- Shell uses a FCCU and coker.
- Tesoro uses a FCCU.
- U.S. Oil produces asphalt or exports it to other refineries for further processing.

All the refineries have flexibility to send intermediate products to other refineries for final processing.

Table 7-6 shows how Washington refineries compare nationally based on NOx emissions per barrel of production capacity. The data is from the 2014 EPA emission data (2014 NEI Data, 2014) of 88 refineries located in nine states: AK, CA CO, IL, LA, MT, TX, WA, and WY. Table 7-6 only shows a subset of the 88 refineries and all Washington refineries are shown. The table is sorted from highest to lowest NOx emissions divided by production capacity. Washington refineries represent four of the top five facilities in the nine states in NOx emissions per 1,000 barrels produced per day. Three Washington refineries emit more oxides of nitrogen per barrel of production capacity than per year of any other refinery in the U.S.

Table 7-6: Washington refineries annual emissions and production capacity

State	Company	NOX tpy 2014	Ranking NOx tpy	1,000 BPD	NOx tpy/1,000 BPD
WA	Tesoro Northwest Company	1,918	3	119	16.12
WA	Shell Puget Sound Refinery	1,230	16	145	8.48
WA	BP Cherry Point Refinery	1,882	4	242	7.78
LA	Equilon Enterprises LLC - Shell Oil Products US Norco Refinery	1,626	11	225	7.23
WA	Phillips 66 Ferndale Refinery	723	31	105	6.89

State	Company	NOX tpy 2014	Ranking NOx tpy	1,000 BPD	NOx tpy/1,000 BPD
IL	Exxon Mobil Oil Corp	1,386	13	238	5.83
LA	Phillips 66 Co - Alliance Refinery	1,432	12	253	5.66
IL	ConocoPhillips Co	1,863	6	334	5.58
LA	Citgo Petroleum Corp - Lake Charles Manufacturing Complex	2,197	1	418	5.25
TX	Beaumont Refinery	1,868	5	365	5.12
LA	ExxonMobil Refinery & Supply Co - Baton Rouge Refinery	1,944	2	540	3.60
TX	Deer Park Plant	1,702	9	500	3.40
TX	Baytown Refinery	1,828	8	560	3.26
WA	U.S. Oil & Refining Co	133	68	41	3.24
TX	Port Arthur Refinery	1,858	7	603	3.08
TX	Galveston Bay Refinery	1,692	10	571	2.96
LA	Marathon Petroleum Co LP - LA Refining Division - Garyville Refinery	1,379	14	564	2.45

Refinery planning process

Ecology offered to enter into a cooperative AO with each refinery to achieve enforceable NOx emission reductions. We proposed to calculate the total amount of NOx reductions each refinery would achieve if they implemented Subpart Ja of the New Source Performance Standards (40 CFR 60 Subpart Ja). The Ja NOx total emission values would be used to calculate NOx emissions reductions that would need to occur over the remaining implementation periods prior to 2064. The refinery could meet the calculated NOx emission reductions through any NOx reduction work and not specifically tied to Ja requirements.

Ecology met with the refineries and the Western States Petroleum Association (WSPA) on September 17, 2019, to discuss this approach. At that meeting, Ecology also discussed not using the Subpart Ja option but doing a reasonability analysis at each facility. This would require a RACT determination for each facility based on their unique configurations. Ultimately, the refineries selected the reasonability analysis option over the AO approach.

On November 27, 2019, Ecology requested that the refineries perform a FFA review of equipment at the refineries. Ecology limited the scope of the FFA to equipment with large emissions of NOx. Ecology limited the scope to facilitate timely returns of the FFA to fit the timeline for RH SIP submittal. We requested the FFA for NOx emission reductions on specific pieces of equipment.

The refineries requested time extensions to the FFA request date and Ecology extended the final deadline to May 1, 2020. All of the refineries delivered their FFA's to Ecology prior to May 1, 2020.

Two refineries did not submit information on FCCU controls following criteria in Ecology's FFA request. Ecology agrees that the facilities did not need to submit a FFA on the units. Ecology subsequently decided to evaluate NOx controls using the EPA Control Cost Manual on the FCCUs since they are a large source of NOx emissions.

The refineries' FFAs indicated selective catalytic reduction (SCR) controls were not a cost-effective emissions control for any units analyzed. The refineries also indicated that low-NOx burners were either not a cost-effective emissions control or that more extensive and in-depth engineering evaluation would be required to establish costs on a unit-by-unit basis.

Ecology did a preliminary analysis using the EPA Control Cost Manual for SCR systems and worksheet model. Preliminary results indicate that SCR controls are cost-effective for the FCC units and various heaters and boilers. Ecology will perform a more extensive and in-depth engineering evaluation on each refinery to generate more accurate and defensible cost estimates. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable.

During formal consultation with the Federal Land Managers, Ecology received a request to include analysis of the calciner units at the Cherry Point Refinery. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable in regards to SO_2 emissions.

All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

Cherry Point Refinery (BP)

BP operations

BP has a total crude oil capacity of 250,000 barrels per calendar day. The refinery processes Canadian crude, domestic crude from North Dakota and Alaska North Slope and international crudes to manufacture gasoline, distillates, heavy fuel oil and propane. The refinery distributes products through pipeline-connected terminals, marine terminal via ships and barges. BP is the only refinery in the Pacific Northwest capable of manufacturing diesel made from biomass-based feed stocks. The refinery processes bio-mass feed stocks alongside conventional feed stocks in an existing ultra-low-sulfur diesel unit. Over the past decade, BP invested more than $1.5 billion in capital improvements at the refinery (BP, 2021).

PSD permit

Ecology issued a PSD permit to BP Cherry Point (BP) on May 23, 2017. During the PSD permit's public comment period, the National Park Service submitted comments regarding impacts to the Olympic National Park (NP).

Below is a summary of the Federal Land Manager's comments that directly pertain to RH and visibility:

- According to modeling performed by the NPS, the NPS believes that "emissions from the refinery are currently causing visibility impairment at Olympic NP and North Cascades NP and significantly contributing to excess nitrogen deposition at both parks." In addition, the NPS also believes that the Coker Replacement project itself "will significantly increase the impacts of visibility-impairing pollutants at Olympic NP and significantly increase nitrogen deposition at North Cascades NP."
- On October 14, 2016, the NPS provided helpful clarifications of their concerns in a document submitted to Ecology. The letter from NPS documented no dispute that the facility followed PSD regulations, or that the BP application was complete, but rather emphasized the different approaches used to address PSD regulatory applicability from approaches used to address project impacts on the Class 1 Areas Air Quality Related Values (AQRV).
- On December 25, 2016, the NPS sent a letter to Ecology stating that emissions from the Cherry Point refinery were adversely impacting air quality related values at North Cascades and Olympic National Parks.

Regional Haze, Four Factor Analysis 2020

BP submitted a FFA to Ecology in April 2020 and determined that it was not reasonable to install new emissions control equipment. Ecology used the EPA Control Cost Manual with a retrofit factor of one to generate baseline costs for installation of SCR controls. These costs indicate that it might be reasonable to install new SCR controls. The refineries and the Western States Petroleum Association (WSPA) contend that Ecology did not use the EPA Control Cost Manual for SCR systems appropriately.

Ecology's preliminary analysis using the EPA Control Cost Manual for SCR systems and worksheet model indicates that SCR controls are cost-effective for the FCC units and various heaters and boilers. Ecology will perform a more extensive and in-depth engineering evaluation on each refinery to generate more accurate and defensible cost estimates. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable.

All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

The following is Ecology's review of the FFA supplied by BP Cherry Point on selected equipment compared to the Cost Reports and Guidance for Air Pollution Regulations- Section 4 - NOx Controls spreadsheet[16]:

Table 7-7: BP Cherry Point equipment identified for RACT analysis

Company	Equipment	EPA Control Cost Manual $/Ton	Refinery $/Ton	TPY Reduced	Comment
BP	#1 Reformer heaters	3,101	24,378	304	
BP	Crude heater	2,051	24,378	393	
BP	Reforming furnace #1 (N H2 Plant)	6,161	78,065	262	Combined north and south stacks
BP	Reforming furnace #2 (S H2 Plant)				

Ecology reviewed the following equipment using the EPA Control Cost Manual:

Reformer Heaters

BP supplied a table with limited supporting data.

Table 7-8 shows the costs for the retrofit that BP supplied compared to the costs from the EPA Control Cost Manual (EPA, 2021). Ecology determined that a more detailed RACT analysis is justified to refine costs.

Table 7-8: Reformer heaters cost comparison

Costs	BP FFA costs	Ecology – EPA Control Cost Manual
Capital cost $	94,809,582	9,929,730
Maintenance $/yr	420,048	49,649
Reagent $/yr	284,001	57,895
Catalyst $/yr	180,467	33,548
Annualized cost $/yr	7,827,719	943,315
NOX tpy reduced	321	304
$/ton NOX reduced	24,378	3,101

[16] Cost Reports and Guidance for Air Pollution Regulations- Section 4 - NOx Controls spreadsheet: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution

Ecology used the EPA Control Cost Manual cost with 90 percent control efficiency. BP did not supply the data they used to scale their costs.

Crude Heater

BP supplied a table with limited supporting data. Table 7-9 shows the costs for the retrofit that BP supplied compared to the costs from the EPA Control Cost Manual (EPA, 2021). Ecology determined that a more detailed RACT analysis is justified to refine costs.

Table 7-9: Crude heater cost comparison

Costs	BP FFA costs	Ecology – EPA Control Cost Manual
Capital cost $	94,809,582	9,325,358
Maintenance $/yr	420,048	46,627
Reagent $/yr	284,001	51,515
Catalyst $/yr	180,467	29,852
Annualized cost $/yr	7,827,719	871,136
NOX tpy reduced	321	425
$/ton NOX reduced	24,378	2,051

The EPA Control Cost Manual (EPA, 2021) uses current cost with 90 percent controls. BP did not supply the cost data they used to scale their cost data.

Two Reforming Furnace #1 (H2 PLANT)

BP supplied a table with limited supporting data. Table 7-10 shows the costs for the retrofit that BP supplied compared to the costs from the EPA Control Cost Manual (EPA, 2021). Ecology determined that a more detailed RACT analysis is justified to refine costs.

Table 7-10: Two reforming furnace #1 (H2 Plant) cost comparison

Costs	BP FFA costs	Ecology – EPA Control Cost Manual
Capital cost $	143,325,183	9,325,358
Maintenance $/yr	479,126	46,627
Reagent $/yr	125,031	51,515
Catalyst $/yr	65,513	29,852
Annualized cost $/yr	11,038,382	871,136
NOx tpy reduced	141	141
$/ton NOx reduced	78,065	6,161

The EPA Control Cost Manual uses current cost with 90 percent controls. BP did not supply the data they used to scale their cost data.

Summary

Ecology's preliminary review of the industry supplied FFA data was inconclusive for determining reasonable controls. Therefore, Ecology is performing a detailed cost-analysis to ensure the most effective reasonable controls are identified. All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

Ecology's baseline and initial four-factor review using the EPA Control Cost Manual and a retrofit factor of one determined the following:

- Factor #1 – The costs of compliance
  - $2,100/ton to $6,200/ton
- Factor #2 – The time necessary for compliance.
  - Accommodation for the time necessary for design, and installation of the equipment during a planned shutdown is required to ensure reasonable costs.
- Factor #3 – The energy and non-air quality environmental impacts of compliance
  - The power needed to drive the exhaust fans is included in the analysis.
- Factor #4 – The remaining useful life on existing source subject to such requirement

BP Cherry Point did not indicate that any of the equipment had a limited lifetime.

Conclusion

Ecology will do a reasonability analysis to develop detailed cost-analysis to ensure the most effective reasonable controls are identified. Emission control equipment that is determined to be reasonable will then be required for installation at the facility. The RHR SIP will be amended to reflect any new control requirements. To allow for scheduling flexibility needed to maintain cost-effectiveness, installation of controls will likely occur in the next implementation period.

Phillips 66

Operations

The Phillips 66 refinery has an average annual processing rate of approximately 108,000 barrels of crude oil per day. Located outside of Ferndale in Whatcom County, this petroleum refinery uses crude oil as a feedstock that is processed into a variety of petroleum products including gasoline, diesel, fuel oil, liquefied petroleum gas (LPG), and butane. The refinery receives crude oil via marine vessels, railcars, and by pipeline (Phillips 66 Refinery, 2021).[17]

Regional Haze, Four Factor Analysis 2020

Phillips 66 submitted a FFA to Ecology in April 2020 and determined that it was not reasonable to install new emissions control equipment. Ecology used the EPA Control Cost Manual with a

[17] https://www.phillips66.com/refining/ferndale-refinery

retrofit factor of one to generate baseline costs for installation of a SCR controls. These costs indicate that it might be reasonable to install new SCR controls. The refineries and the Western States Petroleum Association (WSPA) contend Ecology's application of the EPA Control Cost Manual for SCR systems at refineries is not appropriate.

Ecology's preliminary analysis using the EPA Control Cost Manual for SCR systems and worksheet model indicates that SCR controls are cost-effective for the FCC units and various heaters and boilers. Ecology will perform a more extensive and in-depth engineering evaluation on each refinery to generate more accurate and defensible cost estimates. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable.

All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

As part of our analysis, Ecology compared cost data provided by Phillips 66 with corresponding costs from the EPA Control Cost Manual's SCR tools with the results shown in Table 7-11 below.

Table 7-11: Phillips 66 Equipment identified for RACT

Company	Equipment	EPA Control Cost Manual $/Ton	Refinery $/Ton	TPY Reduced	Comment
Phillips 66	Crude heater 1F-1	2,640	12,225	166	
Phillips 66	FCCU/CO Boiler/Wet Gas Scrubber 4F-100, 4F-101	3,954		247	NSCR is installed.

Ecology reviewed the following equipment using the EPA SCR Cost Model:

Crude heater 1F-1

Phillips 66 supplied a table with limited supporting data. Table 7-12 shows the costs for the retrofit that Phillips 66 supplied compared to the costs from the EPA Control Cost Manual. Ecology determined that a more detailed reasonableness is justified to refine costs.

Table 7-12: Crude heater 1F-1 cost comparison

Costs	Facility FFA costs	Ecology – EPA Control Cost Manual
Capital cost $	16,615,487	5,084,927
Maintenance $/yr	83,077	25,425
Reagent $/yr	17,691	20,677
Catalyst $/yr	18,680	11,982
Annualized cost $/yr	1,944,651	437,150
NOX tpy reduced	159	166
$/ton NOX reduced	12,225	2,640

Ecology used the EPA Control Cost Manual cost with 90 percent controls. Phillip 66 did not supply the data they used to scale their cost data.

FCCU/CO Boiler

In 2006, Phillips 66 modified the FCCU to include ESNCR for NOx controls and so was not required to submit a FFA for this unit. As FCC units are a large source of NOx emission at refineries that have them, Ecology decided to use the EPA Control Cost Manual anyway to review reasonableness of installing SCR systems on the FCCUs.

Table 7-13: FCCU/CO boiler cost

Costs	Ecology – EPA Control Cost Manual
Capital cost $	8,983,013
Maintenance $/yr	44,915
Reagent $/yr	49,624
Catalyst $/yr	27,183
Annualized cost $/yr	976,820
NOX tpy reduced	247
$/ton NOX reduced	3,954

Ecology used the EPA Control Cost Manual cost with 90 percent controls.

Summary

Ecology's preliminary review of the industry supplied FFA data was inconclusive for determining reasonable controls. Therefore, Ecology is performing a detailed cost-analysis to ensure the most effective reasonable controls are identified. All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

Ecology's baseline and initial four-factor review using the EPA Cost Control Manual and a retrofit factor of one determined the following:

- Factor #1 – The costs of compliance
  - $2,600/ton to $4,000/ton
- Factor #2 – The time necessary for compliance
  - Accommodation for the time necessary for design, and install the equipment during a planned shutdown is required to result in reasonable costs.
- Factor #3 – The energy and non-air quality environmental impacts of compliance
  - The power needed to drive the exhaust fans is included in the analysis.
- Factor #4 – The remaining useful life on existing source subject to such requirements.
  - Phillips 66 did not indicate that any of the equipment had a limited lifetime.

Conclusion

Ecology will do a reasonability analysis to develop detailed cost-analysis to ensure the most effective reasonable controls are identified. Emission control equipment that is determined to be reasonable will then be required for installation at the facility. The RHR SIP will be amended to reflect any new control requirements. To allow for scheduling flexibility needed to maintain cost-effectiveness, installation of controls will likely occur in the next implementation period.

Shell

Operations

The Shell refinery has an average annual processing rate of approximately 145,000 barrels (5.7 million gallons) of crude oil per day. When the refinery first began operating, most of its crude oil came from Canada via pipeline. Although it continues to receive crude from central and western Canada, feedstock also arrives by tanker from oilfields on Alaska's North Slope.

On an annual basis, the refinery produces multiple types of gasoline in addition to fuel oil, diesel fuel, propane, jet fuel, butane, and petroleum coke. It also produces two chemicals---nonene and tetramer---that industry uses in a variety of plastic products. Shell also owns and operates a cogeneration facility on the refinery site.[18]

The cogeneration facility was originally the March Point Cogeneration Company (MPCC), which Puget Sound Refinery (PSR) took possession of in February 2010. Air Liquide and Linde operate hydrogen plants on property owned by PSR and adjacent to the refinery. However, both Air Liquide and Linde are independent companies and permitted separately from Shell. This report does not address emission sources from Air Liquide and Linde in this report.

Regional Haze, Four-Factor Analysis 2020

Shell submitted a FFA to Ecology in April 2020 and determined that it was not reasonable to install new emissions control equipment. Ecology used the EPA Control Cost Manual with a retrofit factor at one to generate baseline costs for installation of a SCR controls. These costs indicate that it might be reasonable to install new SCR controls. The refineries and the Western States Petroleum Association (WSPA) contend the use of the EPA Control Cost Manual for SCR systems at refineries is not appropriate in how Ecology applied it.

Ecology’s preliminary analysis using the EPA Control Cost Manual for SCR systems and worksheet model indicates that SCR controls are cost-effective for the FCC units and various heaters and boilers. Ecology will perform a more extensive and in-depth engineering evaluation on each refinery to generate more accurate and defensible cost estimates. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable.

All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

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[18] https://www.shell.us/about-us/projects-and-locations/puget-sound-refinery/about-shell-puget-sound-refinery.html

Table 7-14: Shell equipment identified for RACT rule development

Company	Equipment	EPA Model $/Ton	Refinery $/Ton	TPY Reduced	Comment
Shell	Boiler #1 Erie City--31G-F1	2,441	12,511	179	8-yr life
Shell	Cogen turbine 1 MW	---	---	---	Current SCR controls – Study
Shell	Cogen turbine 2 MW	---	---	---	Current SCR controls – Study
Shell	Cogen turbine 3 MW	---	---	---	Current SCR controls – Study
Shell	FCCU Regenerator Unit	1,948	---	521	
Shell	CRU #2 HTR, INTERHTR--10H-101,102,103	6,346	10,813	69	

Ecology reviewed the following equipment using the EPA Control Cost Manual:

BOILER #1 ERIE CITY--31G-F1

Shell's FFA supplied a table with limited supporting data. Table 7-15 shows the costs for the retrofit that Shell supplied compared to the costs from the EPA Control Cost Manual. Ecology determined that a more detailed reasonableness analysis is justified to provide more credible and defensible costs.

Table 7-15: Boiler #1 Erie City--31G-F1 cost comparison

Costs	Shell	Ecology – EPA Control Cost Manual
Capital cost $	11,420,745	5,084,927
Maintenance $/yr	57,104	25,425
Reagent $/yr	17,221	20,677
Catalyst $/yr	39,340	11,982
Annualized cost $/yr	2,053,888	437,150
NOX tpy reduced	164	179
$/ton NOX reduced	12,511.00	2,441

Ecology used the EPA Control Cost Manual cost with 90 percent controls. Shell did not supply the cost data they used to scale their cost data and had only an eight-year life for the boiler. The limited eight-year lifetime of the boiler caused the cost/ton value to be significantly higher than a 25-year lifetime. With an eight-year lifetime, a requirement for the boiler to be retired after this period would be justified and the boiler should be required to decommission. Any new boiler brought in to replace it would need to go through the permitting process as a new source.

FCCU/CO Boiler

It was Shell's understanding that the addition of particulate matter and SO_2 controls on the FCCU in 2014 meant that they were not required to submit a NOx FFA. Current emissions limit on the FCCU is 1,380 tpy and 142.2 ppm NOx on a yearly average. As FCC units are a large source of NOx emission at refineries that have them, Ecology decided to use the EPA Control Cost Manual anyway to review reasonableness of installing SCR systems on the FCCUs.

Table 7-16: FCCU/CO boiler cost

Costs	Ecology – EPA Control Cost Manual
Capital cost $	10,680,913
Maintenance $/yr	53,405
Reagent $/yr	62,274
Catalyst $/yr	36,086
Annualized cost $/yr	1,014,677
NOX tpy reduced	521
$/ton NOX reduced	1,948

Ecology used the EPA Control Cost Manual cost with 90 percent controls.

CRU #2

Shell supplied a table with limited supporting data. Table 7-17 shows the costs for the retrofit that Shell supplied compared to the costs from the EPA Control Cost Manual. Ecology determined that a more detailed reasonableness analysis is justified to provide more credible and defensible costs.

Table 7-17: CRU #2 cost comparison

Costs	Facility FFA costs	Ecology – EPA Control Cost Manual
Capital cost $	5,939,772	5,084,927
Maintenance $/yr	29,699	25,425
Reagent $/yr	6,165	20,677
Catalyst $/yr	13,454	11,982
Annualized cost $/yr	635,480	437,150
NOX tpy reduced	59	77
$/ton NOX reduced	10,813	6,346

Ecology used the EPA Control Cost Manual cost with 90 percent controls. Shell's cost was similar but they used a lower emission reduction.

Three turbines have SCR installed on the units. The current emission limit is 74 tpy at 9 ppm NO_X. Actual emissions vary from 46-64 tpy (5.6-7.8 ppm) with less than 2 tpy (less than 0.5 ppm) ammonia. As part of the reasonableness analysis an engineering optimization study to minimize NOx emissions is needed to see if emissions can match similar new units permitted below 2 ppm NOx.

Summary

Ecology's preliminary review of the industry supplied FFA data was inconclusive for determining reasonable controls. Therefore, Ecology is performing a detailed cost-analysis to ensure the most effective reasonable controls are identified. All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

Ecology's four-factor review has determined the following:

- Factor #1 – The costs of compliance
    - $1,900/ton to $ 6,300/ton
- Factor #2 – The time necessary for compliance
    - Accommodation for the time necessary for design, and installation of the equipment during a planned shutdown is required to validate reasonable costs.
- Factor #3 – The energy and non-air quality environmental impacts of compliance
    - The power needed to drive the exhaust fans is included in the analysis.
- Factor #4 – The remaining useful life on existing source subject to such requirements
    - Shell indicates that the BOILER #1 ERIE CITY--31G-F1 had a limited lifetime of 8 years. Ecology will work with NWCAA to have a regulatory order on the boiler to shut the unit down by January of 2028.

Conclusion

Ecology will do a reasonability analysis to develop detailed cost-analysis to ensure the most effective reasonable controls are identified. Emission control equipment that is determined to be reasonable will then be required for installation at the facility. The RHR SIP will be amended to reflect any new control requirements. To allow for scheduling flexibility needed to maintain cost-effectiveness, installation of controls will likely occur in the next implementation period.

Marathon Petroleum Company

Process

Marathon Petroleum Company (MPC) is the current owner of the Anacortes refinery. Located in Anacortes, the refinery has a total crude oil capacity of 119,000 barrels per calendar day.

The refinery processes Canadian crude, domestic crude from North Dakota and Alaska North Slope, and international crudes to manufacture gasoline, distillates, heavy fuel oil, and propane.

The refinery distributes products through pipeline-connected terminals and MPC's marine terminal via ships and barges.[19]

Table 7-18: MPC emission rates pre - and post - best available retrofit technology (BART)

Pollutant	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/PM_{10}	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

2010 regional haze best available retrofit technology

During the first regional haze implementation period the MPC facility was operated by Tesoro. Tesoro had a BART determination and Federal Implementation Plan for Tesoro (MPC) found that four of the BART-eligible sources contribute approximately 93 percent of the NOx emissions from the 14 combustion sources: F-103, F-304, F-6650, and F-6651. Tesoro (MPC) identified that it was cost effective to add NOx controls on these four units. The cost was found unreasonable if the facility needed to have a special outage just for the NOx controls. These outages usually occur every five to six years.

PSD permit

On July 18, 2017, Ecology issued a PSD permit to Tesoro (MPC). During the public comment period, the Federal Land Managers made comments regarding the impacts to the Olympic Class 1 area. These comments are contained in the PSD technical support document, https://fortress.wa.gov/ecy/ezshare/AQ/PSD/PSD_PDFS/Tesoro_Anacortes_TSD.pdf

Federal Land Manager's comments 4-6, pages 45-51 indicated the major issues with the issued PSD permit were:

- Tesoro (MPC) should be reviewed in the next RH period
- Supported the installation of SCR on the new boiler and control of vapors from loading marine vessels

Regional Haze

Ecology's preliminary analysis using the EPA Control Cost Manual for SCR systems and worksheet model indicates that SCR controls are cost-effective for the FCC units and various heaters and boilers. Ecology will perform a more extensive and in-depth engineering evaluation on each refinery to generate more accurate and defensible cost estimates. Ecology will perform a detailed reasonability analysis to determine what controls are reasonable.

[19] https://www.marathonpetroleum.com/Operations/Refining/Anacortes-Refinery/

All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

The following is Ecology's review of the four-factor analysis supplied by MPC on selected equipment compared to BART and the EPA Control Cost Manual:

Table 7-19: Tesoro equipment identified for RACT rule development

Company	Equipment	EPA Model 2020 $/Ton	MPC 2020 $/Ton	BART 2008 $/Ton	TPY reduced
Tesoro	FCCU	1,159	14,381	4,592	843.3
Tesoro	F 102 Crude Heater	2,962	16,086	---	147.6
Tesoro	F 201 Vacuum Flasher Heater	7,589	35,279	---	57.6
Tesoro	F 6650 CAT Reformer Heater	3,736	21,196	3,349	117
Tesoro	F 6651 CAT Reformer Heater	3,520	21,196	3,349	124.2
Tesoro	F 751 Main Boiler	2,159	10,060	---	202.5
Tesoro	F 752 Main Boiler	2,570	10,513	---	170.1

Ecology reviewed the following equipment using the EPA SCR Cost Model:

FCCU

MPC supplied a table with limited supporting data. Table 7-20 shows the costs for the retrofit that MPC supplied compared to the costs from the EPA Control Cost Manual. Ecology determined that a more detailed reasonableness analysis is justified to provide more credible and defensible costs.

Table 7-20: FCCU cost comparison

Cost	MPC	Ecology EPA Control Cost Manual
Capital cost $	114,030,975	10,286,436
Maintenance $/yr	570,155	51,432
Reagent $/yr	1,340,590	59,974
Catalyst $/yr	116,845	34,754
Annualized cost $/yr	10,747,992	977,202
$/ton NOX reduced	14,381	1,159

Ecology used the EPA Control Cost Manual cost with 90 percent controls. MPC did not supply the cost data they used to scale their cost data. The MPC data is based on SNCR controls at about 60 percent controls, which account for the higher $/ton cost.

F 102 Crude Heater

Both MPC and Ecology used the EPA Control Cost Manual with different results. To reconcile the difference a more detailed reasonableness analysis is justified to provide more credible and defensible costs:

Table 7-21: Crude heater cost comparison

Costs	MPC EPA Control Cost Manual	Ecology EPA Control Cost Manual
Ft3/min-MMBtu/hr	55,577	484
Ammonia $/gal	3.513	0.293
acfm	6,381,721	115,784
Vspace	19,760.72	112
Catalyst Ft2	6,648	121
Capital cost $	20,876,000	5,084,927
Maintenance $/yr	104,380	25,425
Reagent $/yr	315,021	20,677
Catalyst $/yr	3,548	11,982
Annualized cost $/yr	2,021,692	437,150
$/ton NOX reduced	16,086	2,962

MPC incorrectly changed the default value in the model for the ft^3/min-MMBtu/hr input. Ecology used the default value and determined the minimum cost of $439,065/yr.

Other equipment

We used the default cost of $437,150/yr for the other equipment. MPC incorrectly changed the default value for the Ft^3/min-MMBtu/hr input to the EPA Control Cost Manual for all their determinations other than the FCCU.

Summary

Ecology's preliminary review of the industry supplied FFA data was inconclusive for determining reasonable controls. Therefore, Ecology is performing a detailed cost-analysis to ensure the most effective reasonable controls are identified. All controls identified as reasonable in the reasonability analysis will be installed and operated as an enforceable requirement consistent with the RHR. The results of the analysis and determinations from the analysis will be included in a RHR SIP supplement.

- Factor #1 – The costs of compliance
    - $1,200/ton to $7,600/ton
- Factor #2 – The time necessary for compliance
    - Accommodation for the time necessary for design, and installation of the equipment during a planned shutdown is required to validate reasonable costs.
- Factor #3 – The energy and non-air quality environmental impacts of compliance
    - The power needed to drive the exhaust fans is included in the analysis.
- Factor #4 – The remaining useful life on existing source subject to such requirements
    - MPC did not indicate that any of the equipment had a limited lifetime.

Conclusion

Ecology will do a reasonability analysis to develop detailed cost-analysis to ensure the most effective reasonable controls are identified. Emission control equipment that is determined to be reasonable will then be required for installation at the facility. The RHR SIP will be amended to reflect any new control requirements. To allow for scheduling flexibility needed to maintain cost-effectiveness, installation of controls will likely occur in the next implementation period.

U.S. Oil

Operations

The U.S. Oil refinery has an average daily processing rate of approximately 41,000 barrels of crude oil per day. It uses crude oil as a feedstock processed into a variety of petroleum products including gasoline, diesel, fuel oil, and asphalt.[20]

Regional Haze State Implementation Plan, Final December 2010

During the first implementation period, BART was not triggered for U.S. Oil based on their emissions.

Regional Haze four-factor analysis 2020

U.S. Oil submitted a FFA to Ecology in April 2020 and concluded that additional emission control devices were not reasonable. Ecology analyzed the data and concluded that U.S. Oil based the analysis on the EPA Control Cost Manual and the results were similar to Ecology’s analysis using the EPA Control Cost Manual. The emissions were only 28 tpy for the largest unit and the cost effectiveness was over $15,000/ton of NO_X reductions.

[20] http://usor.com/about/about

The following is Ecology's review of the four-factor analysis supplied by U.S. Oil on selected equipment compared to the EPA Control Cost Manual:

HEATER H11

The facility supplied a table with the limited supporting data.

Table 7-22: Heater H11 cost comparison

Cost	Facility	Ecology EPA Control Cost Manual
Capital cost $	4,894,235	5,084,927
Maintenance $/yr	24,471	25,425
Reagent $/yr	2,979	20,677
Catalyst $/yr	9,862	11,982
Annualized cost $/yr	522,175	437,150
NOx tpy reduced	28	28
$/ton NOx reduced	18,649	15,612

Ecology and U.S. Oil used the EPA Control Cost Manual with minor differences.

Summary and preliminary recommendations

Ecology's review indicates that additional controls are likely not cost reasonable, but recommends a more detailed and defensible cost reasonableness analysis to verify this initial review. Any reasonable emission control equipment from the analysis will result in a determination of equipment to install with federally-enforceable conditions.

- Factor #1 – The costs of compliance
  - Over $15,000/ton for SCR controls
- Factor #2 – The time necessary for compliance
  - Accommodation for the time necessary for design, and installation of the equipment during a planned shutdown is required to validate reasonable costs.
- Factor #3 – The energy and non-air quality environmental impacts of compliance
  - The power needed to drive the exhaust fans is included in the analysis.
- Factor #4 – The remaining useful life on existing source subject to such requirements
  - U.S. Oil did not indicate that any of the equipment had a limited lifetime

Conclusion

Ecology will do a reasonability analysis to develop more robust and defensible cost data. Emission control equipment that is determined to be reasonable will then be required for installation at the facility. The RHR SIP will be amended. Installation of any reasonable emission controls for implementation may occur in the next implementation period to be reasonable.

7.7 Summary

Ecology performed a four-factor analysis on sources selected using the EPA approved Q/d screening process. Ecology focused on major point sources that had a Q/d of 10 or greater. We selected sources emitting approximately 80 percent of all haze-causing emissions in the entire emission inventory for a four-factor analysis.

The selected sources included:

- a flat glass facility,
- five petroleum refineries,
- six pulp and paper facilities,
- a coal-fired power plant,
- a cement plant
- two aluminum smelters

Two facilities have enforceable emission reductions that were used in on-the-books emission projections. The power plant is ceasing coal-fired power production by the end of 2025 and the flat glass facility is changing their emission controls to a SCR system.

The aluminum facilities are currently in curtailment and their actual emissions are essentially zero. An Agreed Order with the two facilities was issued to have the facilities perform a FFA if and when they restart. This will provide an accurate evaluation of the facilities' impacts on regional haze using actual restart operating conditions.

Ecology has preliminarily identified potential cost-effective controls at a multitude of sources and is choosing to require reasonable controls at only a subset of those sources.[21] Ecology is prioritizing the sequence of implementation of reasonable controls. The first priority is to identify reasonable controls at the refinery facilities. A number of factors supports the selection of refineries as the first priority:

- Four of the five refinery facilities are located in the Puget trough, west of several Class 1 Areas. Their cumulative regional haze causing emissions influence the same Class 1 Areas.
- Predominant winds direct the emissions from the refineries toward several Class 1 Areas.
- The refineries' potential emission reductions of 4,200 tons per year account for the vast amount of potential emission reductions.

Our second priority is to identify and implement reasonable controls at pulp and paper facilities after the refinery facilities. Pulp and paper mills are a subset of sources that are lower priority than refineries because:

- The pulp and paper mills are not located as close to each other as the refineries so they do not have as great of a cumulative effect.

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[21] Peter Tsirigotis, Director, "Clarifications Regarding Regional Haze Second Implementation Plans for the Second Implementation Period," memo, addressed to Regional Air Division Directors, Regions 1-10, July 8, 2021.

- One mill identified with potential reasonable cost controls, Packaging Corporation of America (PCA) Wallula, is located in a direction that is downwind from the nearest Class 1 Areas. This lessens, but does not remove, the influence the mill's emissions have on Class 1 Areas.
- The potential reduction of 450 tons per year in regional haze emissions from the pulp and paper mills reasonable controls is vastly less than potential refinery emission reductions.

Ecology will supplement the SIP when new controls are determined to be reasonable and scheduled for implementation.

Chapter 8. Long-term Strategy for Visibility Improvement

8.1 Introduction

Section 169A(b)(2) of the federal Clean Air Act requires each state to submit a Regional Haze (RH) State Implementation Plan (SIP) revision about every 10 years. The SIP revision includes a long-term strategy (LTS) for making reasonable progress toward the national visibility goal, which is to remedy any existing visibility impairment in Class 1 Areas resulting from human-caused air pollution and to prevent future visibility impairment.

Washington's LTS for visibility improvement is a set of "enforceable emissions limitations, compliance schedules, and other measures that are necessary to make reasonable progress, as determined pursuant to [40 CFR 51.308](f)(2)(i) through (iv)" (40 CFR 51.308(f)(2)). Specifically:

(i) The state must evaluate and determine the emission reduction measures that are necessary to make reasonable progress by considering the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected anthropogenic source of visibility impairment.

(ii) The state must consult with those states that have emissions that are reasonably anticipated to contribute to visibility impairment in the mandatory Class 1 federal area to develop coordinated emission management strategies containing the emission reductions necessary to make reasonable progress.

(iii) The state must document the technical basis, including modeling, monitoring, cost, engineering, and emissions information, on which the state is relying to determine the emission reduction measures that are necessary to make reasonable progress in each mandatory Class 1 federal area it affects.

(iv) The state must consider the following additional factors in developing its long-term strategy:

- (A) Emission reductions due to ongoing air pollution control programs, including measures to address reasonably attributable visibility impairment;
- (B) Measures to mitigate the impacts of construction activities;
- (C) Source retirement and replacement schedules;
- (D) Basic smoke management practices for prescribed fire used for agricultural and wildland vegetation management purposes and smoke management programs; and
- (E) The anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the period addressed by the long-term strategy.

Washington's LTS protects Class 1 Areas within and outside Washington. It includes controls Ecology determined to be reasonable when we considered the four statutory factors, as well as federal, state, and local controls on haze-causing emissions.

Ecology relied on the Western Regional Air Partnership (WRAP) for air quality modeling and other analytical tools to identify pollutants, the sources of those pollutants, and to predict future levels of visibility impairment. WRAP 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 (Appendix K).

The LTS covers a 10-year period from 2018 - 2028 and focuses both on existing regulatory mechanisms and those needed in the future to control and reduce visibility-impairing emissions. The administrative rules the EPA promulgated to implement the federal Clean Air Act's LTS requirements are in 40 CFR 51.308(f)(2)(i). In establishing its LTS for the 2018–2028 implementation period, Ecology evaluated the feasibility of implementing new controls at major and minor stationary sources, mobile sources, and non-point sources (40 CFR 51.308(f)(2)(i)). A detailed summary of that evaluation and the methods used for source selection are in Chapter 7.

Ecology designed the LTS to include the enforceable emissions limitations, compliance schedules, and other measures that are necessary to make reasonable progress, as determined pursuant to (f)(2)(i) through (iv). The reasonable progress goals (RPGs) reflect the emissions reductions achieved through implementation of the LTS in each of Washington's Class 1 Areas during this implementation period (2018 – 2028). The reasonable progress goals (RPGs) serve as benchmarks for progress toward meeting the national visibility goal by 2064. The description of RPGs for Washington's Class 1 Areas are in Chapter 9 in detail. We measure the success of our LTS by evaluating the resulting RPGs to improvements in visibility on the most impaired days (MID). Chapter 3 has more information about the MID metric.

8.2 Washington's approach to long-term strategy

We identified three categories of pollutants that contribute significantly to the MIDs, which we need to reduce during this second implementation period. Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data shows that sulfates (primarily), nitrates (secondarily), and organic mass are the dominant pollution species affecting visibility in the Class 1 Areas during the MIDs. We identified sources of these pollutants from within and outside Washington. Chapter 7 describes the source selection and evaluation process that we used to identify potential pollution controls on selected point sources within Washington.

In order to calculate anticipated progress and set toward the RPGs, Ecology incorporated the results of federally-mandated controls applicable to out-of-state sources of emissions that contribute to visibility impairment in Washington's Class 1 areas. However, Ecology's emissions control authority only applies to sources and pollutants within Washington's regulatory jurisdiction. Emission sources that contribute to visibility impairment in Washington, but are outside of Ecology's regulatory jurisdiction include wildfires, prescribed burns, marine vessels, and both stationary and mobile sources that are located offshore, in other states, or in other countries.

We also identified federal, state and local rules, permits, and standards that limit haze-causing emissions that are already in place, or put in place during this implementation period. We rely in part on these existing emission controls to decrease emissions during and beyond this implementation period of 2018 - 2028.

Federal fuel and engine rules are of special importance to our progress toward RPGs because they have resulted in large reductions in mobile source air pollution during the last 30 years. Improvements in vehicle and engine design, and cleaner, higher-quality fuels have substantially reduced mobile source emissions and we expect the progress to continue, even with more miles driven and more power equipment used every year. We also expect on-going efforts to increase electrification of cars and trucks to reduce mobile source pollution in this second implementation period.

For example, President Biden signed an executive order in August of 2021 that establishes a goal for new cars and trucks sold in the U.S. in 2030 – specifically, that 50 percent be electric vehicles, including battery electric, plug-in hybrid electric or fuel-cell electric vehicles. Although this goal is non-binding, its inclusion in an executive order is likely to drive technological innovation. President Biden also called on EPA and the U.S. Department of Transportation to begin working on rules for:

- new fuel economy standards for passenger cars and light trucks for model year (MY) 2027 through at least MY 2030,
- new fuel economy standards for HD pickup trucks and vans for MY 2028 through at least MY 2030, and
- new fuel economy standards for medium- and HD-engines and vehicles to begin as soon as MY 2030.

In addition to these developments on federal fuel and engines standards, Washington is currently engaged in rulemaking to reduce mobile source emissions by adopting California's more protective vehicle emission standards for new vehicles sold in Washington, starting with model year 2025 (Chapter 173-423 WAC, Low Emission Vehicles). Ecology expects to finalize this rule by December 30, 2021. In addition, in May 2021, Governor Inslee signed into law the Transportation Fuels-Clean Fuels Program (E3SHB 1091[22], codified at RCW Chapter 70A.535), which requires Ecology to adopt a rule establishing a clean fuels standard to reduce the carbon intensity of transportation fuels used in Washington. The intent of the clean fuels standard is to reduce emissions of not only greenhouse gases but also "conventional air pollutants from diesel and gasoline." (RCW 70A.535.005(3)(a)). Ecology is currently preparing to begin this rulemaking and expects to finalize the rule by December 30, 2022.

[22] https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session Laws/House/1091-S3.SL.pdf?q=20210929134724

8.3 Development of Washington's long-term strategy

The Regional Haze Rule (RHR) requires consultation between states on the development of coordinated emission management strategies. Appendix R is a record of our inter-state consultation. (40 CFR 51.308(f)(2)(ii)). This requirement applies both to Class 1 Areas within Washington and to Class 1 Areas outside of Washington where we reasonably anticipate emissions from sources in Washington to contribute to visibility impairment. The RHR also requires that states consider five additional factors in developing their LTS (40 CFR 51.308(f)(2)(iv)). We discuss those five factors later in this chapter.

Through WRAP technical collaborations, the western states agreed upon the RPGs for 2028 (the end of the second implementation period) and a regionally consistent approach to addressing visibility impairment in the west.

8.4 Major visibility-impairing pollutants

Ecology's evaluation of potential controls focused primarily on reduction of sulfates and nitrates during the 2018 - 2028 implementation period. The first (or foundational) RH SIP that covered 2005 - 2018 dealt with both regional haze and reasonably attributable visibility impairment (RAVI). RAVI is visibility impairment clearly attributed to individual sources instead of collective effects from multiple sources over a large area.

IMPROVE monitoring data shows that sulfates (primarily), nitrates (secondarily), and organic mass are the dominant pollution species affecting visibility in the Class 1 Areas during the MIDs. See Chapter 3 for more information on monitoring.

Sulfates

Sulfates are the primary pollutant contributing to total light extinction (including Rayleigh scattering) for the MIDs in 2014 - 2018. Sulfates range from 35 to 50 percent of the total light extinction. In the 2028 projections, sulfates range from 37 to 53 percent of total light extinction and remain the primary pollutant contributing to total light extinction at all of the IMPROVE sites. The 2028 projections show a reduction in sulfate emissions largely due to cessation of coal-fired operation at TransAlta by 2025 and large reductions in marine fuel sulfate levels.

Nitrates

The 2014 – 2018 five-year average of MIDs in Class 1 Areas shows that nitrates contribute 9 to 26 percent of species contribution to light extinction. In the 2028 projections, nitrate contribution to the total light extinction ranges from 5 to 19 percent. The 2028 projections show a reduction in nitrate emissions primarily due to decreases in on-road and non-road mobile source emissions.

Organic mass

Organic mass contributes approximately 21 to 32 percent of total light extinction at IMPROVE sites in Washington in the 2014 – 2018 period. In the 2028 projections, organic mass contributes a similar amount of 21 to 33 percent of total light extinction. Organic mass from fire is an important contributor to light extinction. Several Class 1 Areas see large contributions to visibility impairment due to smoke from fire; it is the highest in the Pasayten Wilderness. Organic mass is composed of either primary organic aerosols or secondary organic compounds. Primary organic aerosols are particulates directly emitted from combustion processes due to natural and anthropogenic causes. Secondary organic aerosols form particulates from condensation or photo-oxidization of volatile organic compounds from biogenic or anthropogenic sources.

Volatile organic compounds

Non-point sources are the largest human-generated source category of volatile organic compounds in 2018. Emissions from solvent use and residential wood combustion dominate these contributions. Both of these reflect the impact population growth has on the total amount of emissions.

8.5 State, federal, and local rules and controls that limit emissions of visibility-impairing pollutants

Washington's LTS to achieve reasonable progress goals relies on federal, state, and local controls on sources of visibility-impairing pollutants. WRAP identified all existing (adopted) rules and upcoming rules and limits, and incorporated the data into the calculations of expected reductions and improvements in visibility in 2028 (WRAP 2028 modeling). The modeling used the following regulations that limit emissions.

Adopted rules, programs, and permits

Federal fuel and engine rules for on-road and nonroad engines are of special importance. These result in large projected percent decreases in visibility-impairing emissions in Washington by 2028.

- Mobile source controls:
  - Heavy Duty Diesel (2007 and later model year) Engine Standard (40 CFR 86.007-11)
  - Tier 3 Tailpipe Standards (79 Fed. Reg. 23414 (Apr. 28, 2014)). Starting in 2017, these reduced both tailpipe and evaporative emissions from passenger cars, light-duty trucks, medium duty passenger vehicles, and some heavy-duty vehicles. The gasoline sulfur standard will enable more stringent vehicle emissions standards and make emissions control systems more effective.
  - Large Spark Ignition and Recreational Engines and Vehicle Rule (67 Fed. Reg. 68242 (Nov. 8, 2002))
  - Tier 4 Nonroad Diesel Engines and Fuel Rule (40 CFR Part 1039)
  - Low sulfur fuel requirements for gasoline engines, on-road diesel engines, nonroad diesel engines, and locomotives (40 CFR 80 Subpart I)
  - Ultra-low sulfur diesel fuel for highway, nonroad, locomotive, and marine diesel necessary for new advanced emission control technologies. This contributes to particulate matter reductions in the existing fleet of nonroad engines and equipment (40 CFR 80.500).

- Maximum Achievable Control Technology (MACT) emission standards (40 CFR Part 63): Combustion Turbines (Subpart YYYY), Industrial Boilers and Process Heaters (Subpart DDDDD), and Reciprocating Internal Combustion Engines (RICE) (Subpart ZZZZ).
- Permits and state/EPA consent agreements.
- Ozone and Coarse Particulate Matter (PM_{10}) SIPs in place in the WRAP region.
- State oil and gas emissions control programs.

Additional federal and international rules leading to emission reductions and visibility improvement:

- MACT emission standards (40 CFR Part 63):
    - Petroleum Refineries (Subparts CC and UUU)
    - Boilers (area sources) (Subpart 6J)
    - Revised Utility Boilers (Subpart UUUUU)
    - Various area source MACTs
- Stationary Spark Ignition Internal Combustion Engine Rules (40 CFR 60 Subpart JJJJ)
- Locomotive and Marine Diesel Emission Standards for engines with a cylinder displacement of less than 30 liters (73 Fed. Reg. 37096 (June 30, 2008))
- Corresponding EPA rules for Category 3 Marine Diesel Engines with a cylinder displacement equal to or greater than 30 liters (75 Fed. Reg. 22896 (Apr. 30, 2010))
- International Maritime Organization (IMO) rules reducing NO_2 and SO_2 emissions from commercial marine vessels

8.6 Controls on visibility-impairing pollutants not in previous RH SIP

Since approval of Washington's 2010 RH SIP, Ecology, EPA, and other federal agencies, have adopted or implemented the following programs to reduce emissions from stationary and mobile sources.

Table 8-1. Control Strategies not in previous RH SIP.

Regulatory Program	Affected Sources	Affected Visibility Impairing Air Pollutants
North American Maritime Emission Control Area (ECA) and Maritime Pollution (MARPOL) Annex VI	Marine vessels operating within 200 nautical miles of United States and Canada's Pacific and Atlantic Ocean coast lines	SOx, NOx, $PM_{2.5}$
40 CFR Part 94 Marine Engine Requirements	Marine vessels operating in US Waters	NOx, SOx, $PM_{2.5}$
Motor Vehicle CAFE/GHG standards	Light and medium duty on-road vehicles	NOx, $PM_{2.5}$
On-road Tier 3 diesel standards	Diesel fueled engines, especially on road vehicles	SOx, $PM_{2.5}$

Regulatory Program	Affected Sources	Affected Visibility Impairing Air Pollutants
Utility Boiler MACT	Coal fired boilers at electric generating stations	$PM_{2.5}$, SOx
Large and Area Source Boiler MACTs	All commercial/industrial boilers	NOx, $PM_{2.5}$, SOx
Commercial and Industrial Solid Waste Incineration Units (CISWI) New Source Performance Standards (NSPS)	Industrial/commercial boilers burning designated solid wastes	NOx, $PM_{2.5}$, SOx
SSI NSPS	Sewage sludge incinerators	NOx, $PM_{2.5}$
Revised Petroleum Refinery NSPS and MACT requirements	Petroleum refineries, very large petroleum storage tanks	VOC, $PM_{2.5}$

The most current emission inventory reflects the effects of many of these rules. Specific marine programs not included in the previous inventory that have significant impacts on Washington air quality include the North American Maritime Emission Control Area (ECA) regulations, the MARPOL VI annex, and the Marine Engine Requirements (40 CFR Part 94).

Starting in August 2012, the ECA required marine vessels within 200 nautical miles of the North American coast to use fuels with no more than 1 percent sulfur content, which decreased to 0.1 percent in 2015. EPA and the U.S. Coast Guard share implementation responsibilities for these requirements and have allowed some shipping companies delayed compliance dates for these requirements. Together, these programs require marine vessels to reduce SO_2 emissions by the equivalent of changing from 3.5–5 percent sulfur by weight fuel to 0.1 percent sulfur by weight fuel. We expect a 70–90 percent reduction in SOx emissions from marine vessels in the ECA area. According to the EPA, ships complying with the ECA will reduce annual emissions of NOx, SOx and $PM_{2.5}$ by 23 percent, 74 percent and 86 percent, respectively, below the predicted levels without the ECA by 2020 (EPA Fact sheet 420-F-10-105, March 2010).

MARPOL (the International Convention for the Prevention of Pollution from Ships) Annex VI addresses air pollution from ocean-going ships. The MARPOL VI set limits on NOx emissions and has required the use of fuel with lower sulfur content since June of 2011.

40 CFR Part 94 marine engine requirements phase in NOx reductions as manufacturers build new vessels or install new replacement engines. Part 94 requires that new engines meet Tier 2 requirements in 2011 (equal to the MARPOL requirement) and Tier 3 requirements starting in 2016. EPA estimates that these NOx requirements will reduce national marine vessel NOx by 80 percent from 2009 levels.

The effects of the marine vessel fuel sulfur requirements are reflected in the IMPROVE data, though the effects of the ECA are not fully reflected in the data due to the long lead time for the phase-in of the MARPOL requirements and the relatively recent date (2013) for vessels to meet the first stage requirements.

Washington emission limits and shutdowns

The following emission limits and shutdown schedules have gone into effect since the last implementation period or will occur prior to the end of the second implementation period and are part of Washington's LTS.

- TransAlta Centralia Generation, LLC Power Plant: best available retrofit technology (BART) Order revision and shutdown of coal-fired boilers. TransAlta is the only coal-fired power generation facility in Washington. The facility ceased coal-fired operation in one boiler in December 2020 and will completely cease coal-fired operation by the end of 2025. Ecology updated the TransAlta BART Order in 2020, and EPA approved its incorporation into the SIP in June 2021 (86 Fed. Reg. 24502). This revised BART Order established lower NOx emissions limits from the remaining coal-fired boiler until the facility ceases coal-fired operation by the end of 2025.
- Cardinal Glass, a flat glass facility, submitted a permit modification application to Southwest Clean Air Agency (SWCAA) to install a selective catalytic reduction (SCR) emission control device and increase production of plate glass. The application also proposed removing the permit's emission controls of limiting excess oxygen. SWCAA issued the permit to the facility on February 11, 2021, and the SCR should be installed and operating in 2022. Ecology is submitting this permit as part of the LTS in our SIP.
- Ash Grove consent decree: The Ash Grove Cement Company entered into a consent decree with EPA, Ecology, the Puget Sound Clean Air Agency (PSCAA), and other state agencies in 2013 (Appendix E). The consent decree required the Seattle facility to submit an optimization protocol for the Seattle Kiln to optimize the operation of this unit to reduce NOx emissions to the maximum extent practicable. On August 25, 2016, EPA, in consultation with affected state agencies, approved the new limit of 5.1 pounds of NOx per ton of clinker on a 30-day rolling average. Ecology is submitting this consent decree as part of the LTS in our SIP.

Non-regulatory factors can also result in decreased emissions. Economic and market conditions can drive business decisions that may result in decreased or curtailed production. In Washington, two aluminum smelters are currently in curtailment due to market conditions, one since 2014 and the second one since 2020. Ecology worked with these facilities to develop Agreed Orders (AOs 18100 and 18216 in Appendix Q) that require them to complete a four-factor analysis to evaluate emission controls prior to start-up, should they decide to resume operations. The four-factor analysis developed by the smelters will be subject to Ecology's approval, and any controls identified as necessary to make reasonable process must be installed and operational within three years of start-up. In addition, one of the smelters is in an area that EPA designated as being in nonattainment for the 2010 1-hour SO_2 NAAQS, effective April 31, 2021. Nonattainment is a separate and distinct regulatory program of the Clean Air Act, but the emission controls required for purposes of attainment will have visibility benefits. The SO_2 attainment plan will describe any emission controls required to bring the area back into attainment, such as installation of new control equipment and/or new emission limits. Future RH SIP analyses will incorporate the effects of the RH Agreed Orders and the attainment plan on visibility for new controls installed at the smelters as a result. Chapter 7 discusses these facilities in more detail. Ecology is submitting Agreed Orders AO 18100 and AO 18216 in Appendix Q as part of the LTS in our SIP.

Non-point and mobile sources

The RHR requires that states identify all anthropogenic sources of visibility impairment considered by the state when developing its LTS, including stationary, mobile, and non-point sources (40 CFR 51.308(f)(2)(i)). We discuss stationary sources in the previous section and in Chapter 6 (Source Apportionment) and Chapter 7 (four-factor Analysis).

Wood stoves

Wood stove smoke contributes to visibility impairment in Washington. However, since 2007, Washington has decreased emissions from wood stoves by supporting a wood stove buy-back and exchange program (Chapter 173-433 WAC). This program provides grant funding to local clean air agencies and Ecology's regional offices to use in programs that replace older wood stoves with new, cleaner burning wood stoves or cleaner heat sources such as heat pumps, gas stoves, or furnaces. Some of these grant recipients have also run wood stove recycling programs where they buy back and destroy older stoves to remove them from use. Ecology estimates that in the past 13 years, state and local government agencies have bought back or exchanged more than 8,000 stoves for an estimated total reduction of 194 tons of $PM_{2.5}$. Since 2007, Ecology and the local clean air agencies have provided grants to replace 6,068 old wood stoves with cleaner sources of heat and incentives to recycle 2,472 wood stoves that did not meet current emission standards. This has reduced $PM_{2.5}$ emissions by over 200 tons.

Recent federal actions also contribute to the reduction of wood stove emissions. EPA's 2015 NSPS for new wood stoves established "Step 2" emission standards that went into effect in May 2020, limiting $PM_{2.5}$ emissions to 2.0 grams per hour if using crib wood (has standard characteristics) or 2.5 grams per hour if the manufacturer choses to use cord wood for performance testing (40 CFR 60 Subpart AAA). Before May 2020, Washington law was more stringent than the applicable NSPS, limiting $PM_{2.5}$ emissions to 2.5 grams per hour for catalytic devices and 4.5 grams per hour for all other devices (RCW 70A.15.3530). Because the federal standards are now more stringent, Ecology is using its delegated CAA authority to enforce the disNSPS Step 2 standards.

Mobile sources

Although Ecology does not directly regulate emissions from mobile sources, we actively participate in programs that reduce mobile source emissions and manage grants that result in reduced emissions and higher fuel economy.

Mobile sources are the largest contributors to NOx emissions in Washington. Population growth has contributed to increased mobile source emissions. Factors that have decreased mobile source emissions include fleet turnover to more fuel efficient or electric vehicles, low sulfur fuel requirements, and adoption of California's low emission vehicle standards.

Motor Vehicle Emission Inspection program retirement

Another program that has contributed to emission reductions from mobile sources was Washington's vehicle emission testing program. The program required vehicles registered in Washington to meet state emission limits as a condition of vehicle registration. The combination of the vehicle emission testing program and advances in vehicle technology led to reduced mobile source emissions. The legislature phased the emission testing program out starting in 2005 based on Ecology's prediction that more fuel efficient and electric vehicles would replace the need for it by 2020 (RCW 70A.25.030). The program ended on January 1, 2020.

New state laws and regulations

Washington has also pursued mobile source emission reductions through the technology of zero emission vehicles (ZEV) and low-emission vehicles (LEV). Special provisions in the federal Clean Air Act (Section 177) allow states to adopt California's standards instead of the federal motor vehicle emission standards. California's standards contain both LEV and ZEV requirements.

In 2005, the Washington Legislature adopted the California vehicle emission standards for passenger cars, light duty trucks, and medium duty passenger vehicles (ESHB 1397). However, the law did not adopt the ZEV standards or the LEV standards for medium duty trucks (trucks generally weighing between 8,500 and 14,000 pounds). The 2020 Legislature expanded Washington's program to include the entire California program and directed Ecology to adopt rules to implement the ZEV program (SB 5811). We are currently in the process of adopting rules to reflect our expanded statutory authority.

In addition, Ecology submitted a SIP revision to EPA in 2019 to adopt by reference California's LEV program. The purpose of the SIP revision was to implement programs to reduce vehicle emissions that contribute to formation of ground level ozone and fine particulate matter ($PM_{2.5}$). The precursors to ground level ozone and $PM_{2.5}$ also contribute to regional haze. EPA is currently proposing to approve this revision to the Washington SIP (86 FR 46169).

State grant programs

Ecology has also pursued grant opportunities that result in decreased emissions from mobile sources. Volkswagen (VW) violated federal and state clean air laws by installing illegal emissions software on some diesel vehicles. In January 2016, the U.S. Department of Justice filed a lawsuit on behalf of EPA against VW. After admitting fault, VW reached multiple settlements with EPA and Ecology. Ecology is managing $140 million in settlement funds used to reduce air pollution from transportation. As of February 2020 we have committed $91 million statewide to projects that decrease diesel emissions such as electrification of school buses, transit buses, ferries, state agency fleet vehicles, port drayage trucks, shore power, and installing light duty electric vehicle charging stations.

Factors required for the long-term strategy

In addition to the FFA, the RHR requires states to consider the following five factors in developing a LTS (40 CFR 51.308(f)(2)(iv)).

Emission reductions due to ongoing air pollution control programs, including measures to address reasonably attributable visibility impairment (40 CFR 51.308(f)(2)(iv)(A)).

In addition to the ongoing air pollution control programs described above, current state and federal rules and state and local air agency permits limit visibility-impairing emissions from point, non-point, and mobile sources. The projected 2028 emissions inventory reflects the emission reductions from most rules and permits in existence in 2018.

To obtain a permit, 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. Major New Source Review (NSR) permits include requirements to meet Air Quality Related Values (AQRV) protection criteria established by EPA for Class 1 Areas.

Ecology and local air pollution control authorities work to reduce emissions from existing emission producing units and to minimize new emissions through Ecology's NSR program. This program requires BACT emission reductions for all new sources and modifications that result in an increase of emissions.

State law (RCW 70A.15.2220) requires that when a source 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 reasonably available control technology (RACT) level of emissions control at a minimum.

Measures to mitigate the impacts of construction activities (40 CFR 51.308(f)(2)(iv)(B)).

Ecology or a local air quality agency regulates construction activities as a source of air pollution. The following Washington air quality rules (WAC 173-400-040(3) and (9)) address air emissions associated with construction activities.

- WAC 173-400-040(3) (Fallout)
- WAC 173-400-040(4) (Fugitive emissions)
- WAC 173-303-040(9) (Fugitive dust)

Local clean air agencies and local governments have additional rules and policies governing mitigation of air pollution from construction activities. We describe types of construction permits in Washington below. These are all part of a federally-enforceable permitting program.

A prevention of significant deterioration (PSD) permit applies to new large facilities or major changes at existing large facilities that could increase air pollution in an area that meets air quality standards. The intent is to prevent that area's air quality from getting worse.

A notice of construction (NOC) approval order is required before installing a new source of air pollution or modifying an existing source of air pollution.

Regulators issue a general order for similar sources of air pollution, instead of a series of individual NOC permits.

An air operating permit (AOP) combines all applicable rules and requirements for operation and procedures, emission standards, monitoring, recordkeeping, and reporting. An AOP is required for major sources that emit or have the potential to emit more than 100 tons per year of any air pollutant, 10 tons per year or more of any hazardous air pollutant, or more than 25 tons per year of a combination of hazardous air pollutants.

Source retirement and replacement schedules (40 CFR 51.308(f)(2)(iv)(C)).

TransAlta's Centralia Power Plant boiler number one ceased coal-fired energy production in December of 2020. The remaining boiler (boiler number two), and thus the entire facility, is required to cease coal-fired operation by the end of 2025. A 2020 revised BART Order requires reduced NOx levels until coal-fired production ceases in 2025.

Basic smoke management practices for prescribed fire used for agricultural and wildland vegetation management purposes and smoke management programs (40 CFR 51.308(f)(2)(iv)(D)).

As part of the regional haze LTS, states are required to consider basic smoke management practices for prescribed fire used for agricultural and wildland vegetation (silvicultural) management purposes and smoke management programs (40 CFR Section 51.308(f)(2)(iv)(D)). Under Washington law, Ecology and the local air agencies regulate agricultural burning (Chapter 173-430 WAC). Ecology has established controls required for agricultural burning to minimize adverse health and environmental impacts. Ecology works with a variety of stakeholders including agricultural burners, agricultural interest groups, and air quality interest groups to encourage development, research, and use of alternatives to burning.

The Washington Department of Natural Resources (DNR) issues silvicultural burning permits in Washington according to the regulatory direction provided in the SIP-approved 1998 Washington Department of Natural Resources Smoke Management Plan.[23][24] The goal of the plan is to coordinate and facilitate statewide regulation of silvicultural burning on lands under DNR jurisdiction, and on unimproved federally managed forestlands and participating tribal lands. The strategy of DNR's Smoke Management Plan is to balance the protection of public health and visibility with the need for silvicultural burning to improve ecosystem health and reduce the damaging effects of catastrophic wildfires. Prescribed silvicultural burning is a non-point source and prescribed burn plumes can have significant impacts on visibility. Washington proactively addressed this source in its RAVI SIP. Washington incorporated DNR's Smoke Management Plan into the September 1999 revisions to the RAVI SIP and EPA approved the Smoke Management Plan's incorporation into the SIP in 2003. DNR is currently revising and preparing to update the Smoke Management Plan in the SIP. Ecology will provide status of the RAVI SIP in the 2025 RH Progress Report.

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[23] https://www.epa.gov/sips-wa/epa-approved-nonregulatory-provisions-and-quasi-regulatory-measures-washington-sip

[24] http://file.dnr.wa.gov/publications/rp_burn_smptoc.pdf

The anticipated net effect on visibility due to projected changes in point, non-point, and mobile source emissions over the period addressed by the long-term strategy (40 CFR 51.308(f)(2)(iv)(E)).

Ecology used the WRAP modeled inventory for this RH SIP to determine the expected net effect of projected changes to visibility due to emission changes over the control period for the second RH SIP ending in 2028. The modeled effects reflect the implementation of controls on the books.

Table 8-2 below presents the net effects of emission changes on visibility. The net effect for the MID was considered in establishing RPGs for Washington’s mandatory Class 1 Areas. The modeling results show that we meet the goal of no degradation of visibility for the clearest days.

Table 8-2: Anticipated net effect on visibility of emission reductions over the second control period for MID, in deciviews (dv)

Class 1 Area	2014 to 2018 (dv)	2028 projected visibility (dv)	Improvement (dv)
Olympic National Park	11.9	11.5	0.4
North Cascades National Park and Glacier Peak Wilderness	10	9.8	0.2
Alpine Lakes Wilderness	12.7	12.0	0.7
Mount Rainier National Park	12.7	12.0	0.7
Goat Rocks Wilderness and Mount Adams Wilderness	8	7.6	0.4
Pasayten Wilderness	9.5	9.2	0.3

Table 8-3: Anticipated net effect on visibility of emission reductions over the second control period for clearest days, (dv)

Class 1 Area	2014 to 2018 (dv)	2028 projected visibility (dv)	Improvement (dv)
Olympic National Park	3.6	3.4	0.2
North Cascades National Park and Glacier Peak Wilderness	2.5	2.4	0.1
Alpine Lakes Wilderness	3.3	3.1	0.2
Mount Rainier National Park	3.9	3.7	0.2
Goat Rocks Wilderness and Mount Adams Wilderness	1.0	0.9	0.1
Pasayten Wilderness	1.6	1.5	0.1

8.7 Summary

Washington's LTS for visibility improvement reduces haze-causing emissions that contribute to visibility impairment in Washington's Class 1 Areas and in Class 1 Areas outside of Washington, where we reasonably anticipate Washington emissions contribute to visibility impairment.

The LTS for this second RH SIP includes the following key elements:

- Existing federal and state laws and regulations, including federal fuel and engine rules for on-road and non-road vehicles, are important for making reasonable progress by 2028.
- Additional reductions from mobile sources due to state legislation, rulemaking, and grants will continue to decrease vehicle emissions.
- New emission controls to reduce NOx emissions, including the cessation of all coal-fired energy generation in Washington by 2025 (and reductions in NOx at the coal-fired facility until 2025), and SCR operation at Cardinal Glass.
- Organic mass emissions resulting primarily from fire are an important contributor to total light extinction in Washington's Class 1 Areas.
- Regional contributions beyond the direct control of Ecology, from Canada and Pacific offshore sources and wildfires, play a significant role in visibility impairment in Washington's Class 1 Areas.
- Washington's LTS prioritizes improvement to visibility on the MID.

Chapter 9. Reasonable Progress Goals

9.1 Introduction

The Regional Haze Rule requires states to establish reasonable progress goals (RPGs) for mandatory Class 1 Areas within the state. The RPGs, expressed in deciviews (dv), reflect projected visibility improvements achieved by the end of the current implementation period (2018 to 2028) for the most impaired days (MID) and ensure no degradation in visibility on the clearest days. The RPGs are based on the long-term strategy that addresses visibility impairment for each Class 1 Area (see Chapter 8). The long-term strategy includes the measures that are necessary to make reasonable progress during this implementation period.

In the establishment of RPGs, the Regional Haze Rule requires states to consider both:

- The uniform rate of progress (URP) needed to attain natural conditions by 2064 (shown as a glidepath), and
- The four statutory factors required by the federal Clean Air Act to use in determining what measures are necessary to make reasonable progress.

Ecology's calculation of RPGs relies on technical data and analysis developed by the Western Regional Air Partnership (WRAP). Data are available on WRAP's Technical Support System (TSS2) website.[25]

WRAP determined the RPGs for each Class 1 Area using the guidance "Procedures for Making Visibility Projections and Adjusting Glidepaths using the WRAP-WAQS 2014 Modeling Platform" (Appendix D). Projected 2028 emissions for mobile sources and major facilities were obtained by WRAP from EPA and states, representing existing and expected controls. The modeled baseline and projections were used to calculate relative response factors (RRFs), which were applied to the measured baseline period concentrations at the IMPROVE sites, thus providing 2028 RPG visibility projections (see Chapter 5 for more information on modeling). The RPGs for Washington's Class 1 Areas are shown in Table 9-1.

Table 9-1: Washington's Class 1 Areas and their 2028 reasonable progress goals in deciviews (dv)

Class 1 Area	Reasonable progress goal
Olympic National Park	11.5 dv
North Cascades National Park	9.8 dv
Glacier Peak Wilderness Area	9.8 dv
Alpine Lakes Wilderness Area	12.0 dv
Mount Rainier National Park	12.0 dv
Goat Rocks Wilderness Area	7.6 dv
Mount Adams Wilderness Area	7.6 dv
Pasayten Wilderness Area	9.2 dv

[25] http://views.cira.colostate.edu/tssv2/

Uniform rate of progress glidepath adjustment

The charts in this chapter illustrate the regional haze glidepath as defined by EPA guidance and an alternative glidepath with a 2064 endpoint adjustment. The adjusted endpoint of the glidepath and thus the associated slope is consistent with methods described in the EPA's September 2019 regional haze modeling Technical Support Document. Per the Regional Haze Rule, a state can select the default glidepath slope or propose to use endpoint adjustment options for international sources and prescribed fire contributions to visibility at each Class 1 Area (40 CFR 51.308(f)(1)(vi)).

Washington's Class 1 Areas are all affected by international anthropogenic contributions that Washington cannot control. Source apportionment results (Chapter 6) show that sulfates from international anthropogenic sources are expected to impact visibility more than in-state sources at all Washington Class 1 Areas. Source apportionment results also show that nitrates from international anthropogenic sources are expected to impact visibility more than in-state sources at most Washington Class 1 Areas, with the exception of Alpine Lakes Wilderness Area and Mount Rainier National Park. We propose to use the international adjustment added to the EPA estimated natural conditions endpoint, calculated using the 2028 modeling results normalized to the monitored visibility.

Four-factor analysis

The RHR requires states to perform a four factor analysis (FFA) to determine whether the installation of new emission controls at certain facilities is necessary for the state to make reasonable progress toward the national visibility goal. 40 CFR 51.308(f)(2)(i) requires the state to consider the following four statutory factors in determining which emission reductions measures are necessary to make reasonable progress:

- Costs of compliance,
- The time necessary for compliance,
- The energy and non-air quality environmental impacts of compliance, and
- The remaining useful life of any potentially affected sources.

Ecology selected point sources with the largest "Q/d" to undergo a FFA, where the annual emissions (Q) is divided by the distance to the nearest Class 1 Area (d). The Q/d point-source screening is discussed in Chapter 7, while the long-term strategies for non-point and mobile sources are discussed in Chapter 8. Ecology requested a FFA from facilities chosen in the source-selection process. Ecology reviewed the FFA information submitted by the sources. The conclusions from this review are described in Chapter 7 and summarized here.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data show that sulfate (SO_4) and nitrate (NO_3) are two of the most significant pollutants impairing visibility in Washington's Class 1 Areas. SO_2 and NOx emissions are precursors of SO_4 and NO_3, respectively. The WRAP visibility projections show that SO_4 and NO_3, which are mostly anthropogenic in origin, are expected to continue impairing visibility in 2028 more than the other monitored pollutant species. The majority of SO_4 impairment at Class 1 Areas from in-state sources is attributed to non-EGU (electric generating units) point sources, as discussed in

Chapter 6. The majority of NO_3 impairment at Class 1 Areas from in-state sources is attributed to mobile vehicles.

Ecology is focusing on SO_2 and NOx emission reductions from major point sources for this implementation period (2018 – 2028) because major point sources contribute the majority of the haze-causing emissions that Washington can potentially control. SO_2 and NOx make up the majority of the haze-causing emissions from the major sources. NOx emissions from mobile sources decreased significantly prior to 2018 due to the vehicle and engine provisions of Title II of the Clean Air Act and other regulations (40 C. F. R. Parts 85, 86, 88 through 94, 600, and 1033 through 1068), and are expected to continue decreasing each year due to fleet turnover and recent legislation requiring Ecology to adopt California's low emission vehicle standards (SB 5811, 2020)[26] and to establish a clean transportation fuels standard (E3SHB 1091, 2021)[27].

Ecology evaluated projected 2028 emissions of SO_2 and NOx from specific emission processes as defined by Source Classification Codes (SCCs). We identified the SCCs projected to have the largest SO_2 and NOx emissions from in-state point sources. The resulting three groups were industrial processes, external combustion boilers, and internal combustion engines. Emissions of SO_2 and NOx from specific industries and emission source categories vary greatly across these three groups.

Ecology calculated the total emissions of SO_2, NOx, PM_{10}, and NH_3 from each major facility to inform source-selection. The majority of sources selected for FFA are located in the Puget Sound lowlands in western Washington, and may contribute to visibility impairment at multiple Class 1 Areas. Seven of Washington's eight Class 1 Areas are directly to the east of the Puget Sound lowlands, in the Cascade Mountains. The eighth Class 1 Area is located directly to the west of the Puget Sound lowlands on the Olympic Peninsula. See Chapter 7 for details about the process used and the final list of sources selected for FFA.

Based on the FFAs, we concluded that there is potential for SO_2 and NOx emission reductions from a number of emission points, principally boilers, process heaters, and fluidized catalytic cracking unit/carbon monoxide boiler systems.

Reasonably available control technology

As discussed in Chapter 7, in Washington, RCW 70A.15.2230 (the "RACT statute") is the legal mechanism that Ecology can use to require existing sources to install new emission controls that are determined to be reasonable. Because the analysis performed under the RACT process is equivalent to the RHR's FFA, Ecology will use the RACT process to require the installation of reasonable emission controls for purposes of compliance with the RHR.

After the RACT analysis is complete, Ecology will make a determination of what constitutes reasonable emission control(s) for each selected source. The determination will result in an

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[26] https://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bills/Session Laws/Senate/5811.SL.pdf?cite=2020%20c%20143%20%C2%A7%201

[27] https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session Laws/House/1091-S3.SL.pdf?q=20210929134724

enforceable requirement to install and operate the controls identified in the analysis. The results of the analysis and the subsequent determinations will be included in a supplement to our Regional Haze SIP revision. Development of controls is discussed more as part of Washington's long-term strategy in Chapter 6 (Source Apportionment) and Chapter 7 (FFA).

Progress in reducing visibility impairing pollutants

As discussed in Chapter 4, projected 2028 emissions and the resulting RPGs reflect controls "on-the-books" (OTB) throughout the WRAP region. OTB controls are existing, legally adopted controls that will reduce visibility impairing pollutants during the second implementation period of 2018 to 2028. Large statewide reductions in NOx (50 percent) are expected by 2028 as a result of engine and fuel rules that reduce vehicle emissions. Significant reductions in NOx and SO_2 are also expected after the full cessation of coal-burning at TransAlta Centralia Generation facility in 2025. Additionally, recent emission reductions measures for TransAlta and Cardinal Glass were included in the long-term strategy and the 2028 modeled emission projections for determining reasonable progress goals. For the purpose of the WRAP modeling and this document these recent emission reduction measures were included in the "2028 OTB projection" because the TransAlta reduction measures were approved by the EPA in the SIP on May 7, 2021 (86 FR 24502) and the revised Cardinal Glass permit was issued by SWCAA to the facility on February 11, 2021 for inclusion in the LTS. These and other controls are discussed in Chapter 8 (long-term strategy).

9.2 Olympic National Park

Most impaired days

Baseline, adjusted glidepath, and projected visibility

Visibility conditions at Olympic National Park are monitored at the IMPROVE site OLYM1. The monitored 2000-2004 baseline visibility at this site on the most impaired days (MID) is 14.9 dv. The calculated natural conditions for the adjusted glidepath are 8.9 dv, a difference of 6 dv and a rate of 0.1 dv per year (6 dv divided by 60 years). This is the rate that needs to be maintained to reach natural visibility conditions in the park by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 1.4 dv. The 2028 RPG is projected to be 11.5 dv, which is a visibility improvement of 3.4 dv from the baseline.

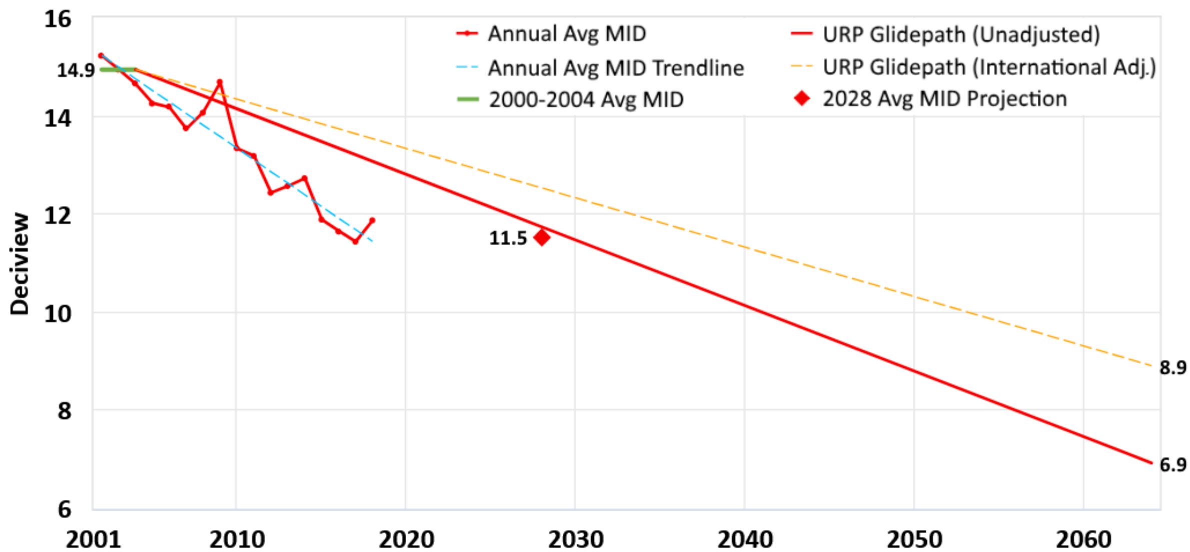

Figure 9-1: Projected 2028 visibility conditions on the MID in Olympic National Park.

Progress in reducing visibility impairing pollutants

Table 9-2: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in Olympic National Park.

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	10.0	4.3	4.6	1.2	1.3	0.2	0.8
2028 OTB projection	10.0	3.3	4.5	1.0	1.3	0.2	0.8
Percent change	0%	-23%	-3%	-14%	0%	-1%	0%

Summary*:* Ecology concludes from this analysis that progress is being made in reducing visibility impairing pollutants impacting Olympic National Park. The 2028 RPG for Olympic National Park is 11.5 dv assuming emission controls that are on the books.

Clearest days

The monitored 2000-2004 baseline conditions at OLYM1 on the Clearest Days are 6 dv. This second SIP covers the 2018 - 2028 period. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 3.37 dv for the clearest days is below the baseline for the clearest days.

9.3 North Cascades National Park and Glacier Peak Wilderness

Most impaired days

Baseline, adjusted glidepath, 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 visibility at this site on the most impaired days (MID) is 12.6 dv. The calculated natural conditions for the adjusted glidepath are 8.2 dv, a difference of 4.4 dv and a rate of 0.07 dv per year (4.4 dv divided by 60 years). This is the average rate that needs to be maintained to reach natural visibility conditions in these Class 1 Areas by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 1.8 dv. The 2028 RPG is projected to be 9.8 dv, which is a visibility improvement of 2.8 dv from the baseline and 0.2 dv below the 2014 to 2018 average.

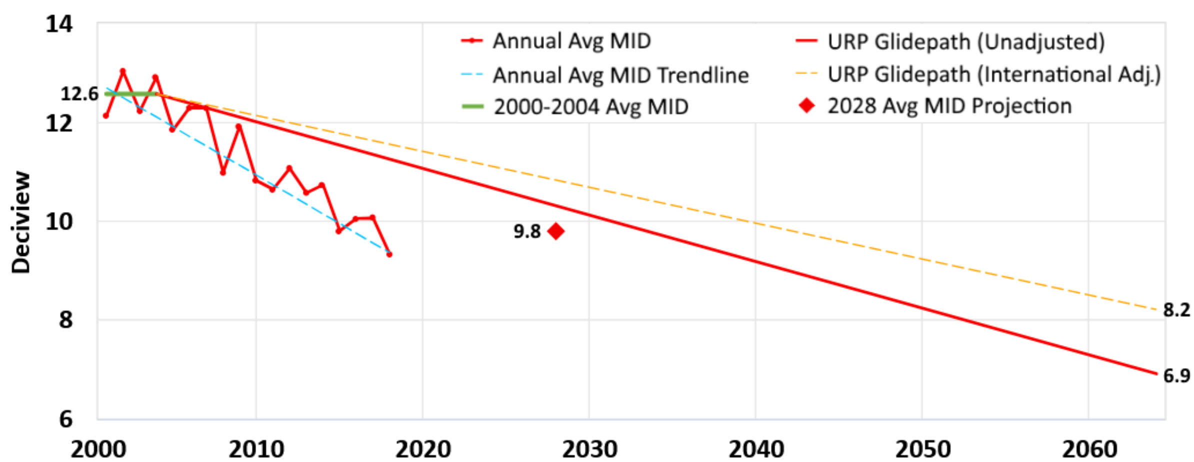

Figure 9-2: Projected 2028 visibility conditions on the MID in North Cascades National Park and Glacier Peak Wilderness

Progress in reducing visibility impairing pollutants

Table 9-3: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in North Cascades National Park and Glacier Peak Wilderness.

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	8.1	1.7	4.0	0.9	1.3	0.2	0.3
2028 OTB projection	8.2	1.2	4.0	0.9	1.3	0.2	0.3
Percent change	0%	-28%	-1%	-4%	0%	-1%	0%

Summary*:* Ecology concludes from this analysis that progress is being made in reducing visibility impairing pollutants that impact the North Cascades National Park and Glacier Peak Wilderness. The 2028 RPG is 9.8 dv assuming emission controls that are on the books.

Clearest days

The monitored 2000-2004 baseline conditions at NOCA1 on the clearest days are 3.4 dv. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 2.38 dv for the clearest days is below the clearest days baseline.

9.4 Alpine Lakes Wilderness

Most impaired days

Baseline, adjusted glidepath, and projected visibility

Visibility conditions at Alpine Lakes Wilderness are monitored at the IMPROVE site SNPA1. The monitored 2000-2004 baseline visibility at this site on the most impaired days (MID) is 15.4 dv. The calculated natural conditions for the adjusted glidepath are 8.2 dv, a difference of 7.2 dv and a rate of 0.1 dv per year (7.2 dv divided by 60 years). This is the average rate that needs to be maintained to reach natural visibility conditions in the park by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 2.9 dv. The 2028 RPG is projected to be 12.0 dv, which is a visibility improvement of 3.4 dv from the baseline and 0.7 dv below the 2014 to 2018 average.

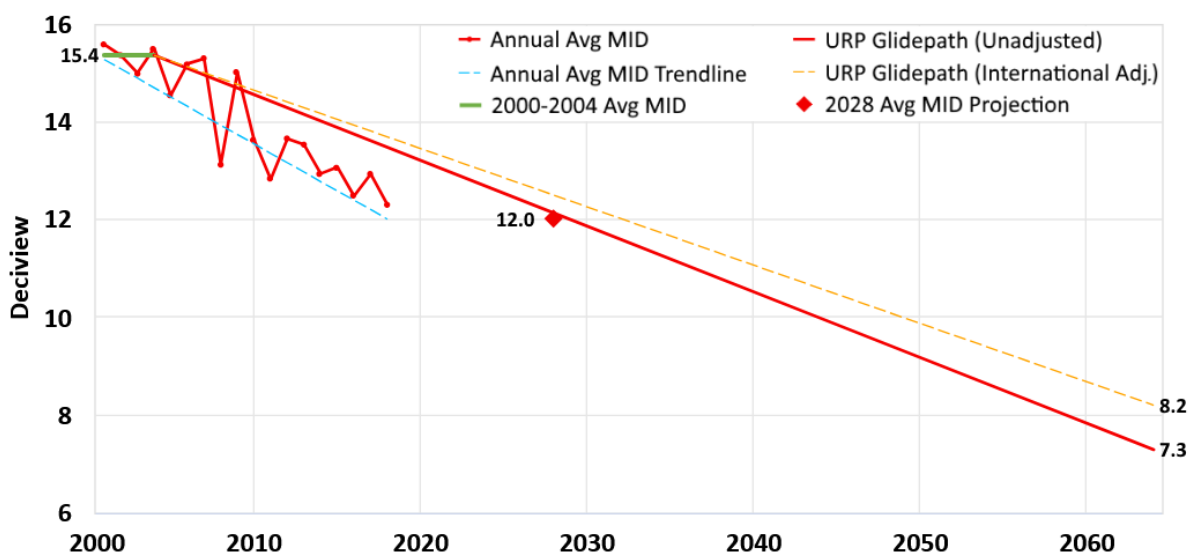

Figure 9-3: Projected 2028 visibility conditions on the MID in Alpine Lakes Wilderness

Progress in reducing visibility impairing pollutants

Table 9-4: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in the Alpine Lake Wilderness.

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	8.8	6.7	6.4	1.8	1.1	0.2	0.3
2028 OTB projection	8.8	4.3	6.3	1.8	1.1	0.2	0.3
Percent change	-1%	-37%	-1%	-4%	0%	-1%	-1%

Summary*:* Ecology concludes from this analysis that Washington is making progress in reducing visibility impairing pollutants impacting Alpine Lakes Wilderness. The 2028 RPG is 12.0 dv assuming emission controls that are on the books.

Clearest days

The monitored 2000-2004 baseline conditions at SNPA1 on the clearest days are 5.5 dv. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 3.0 dv is below the clearest days baseline.

9.5 Mount Rainier National Park

Most impaired days

Baseline, adjusted glidepath, and projected visibility

Visibility conditions at Mount Rainier National Park are monitored at the IMPROVE site MORA1. The monitored 2000-2004 baseline visibility at this site on the most impaired days (MID) is 16.5 dv. The calculated natural conditions for the adjusted glidepath are 8.9 dv, a difference of 7.6 dv and a rate of 0.1 dv per year (7.6 dv divided by 60 years). This is the average rate that needs to be maintained to reach natural visibility conditions in the park by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 3.0 dv. The 2028 RPG is projected to be 12.0 dv, which is a visibility improvement of 4.5 dv from the baseline and 0.7 below the 2014 to 2018 average.

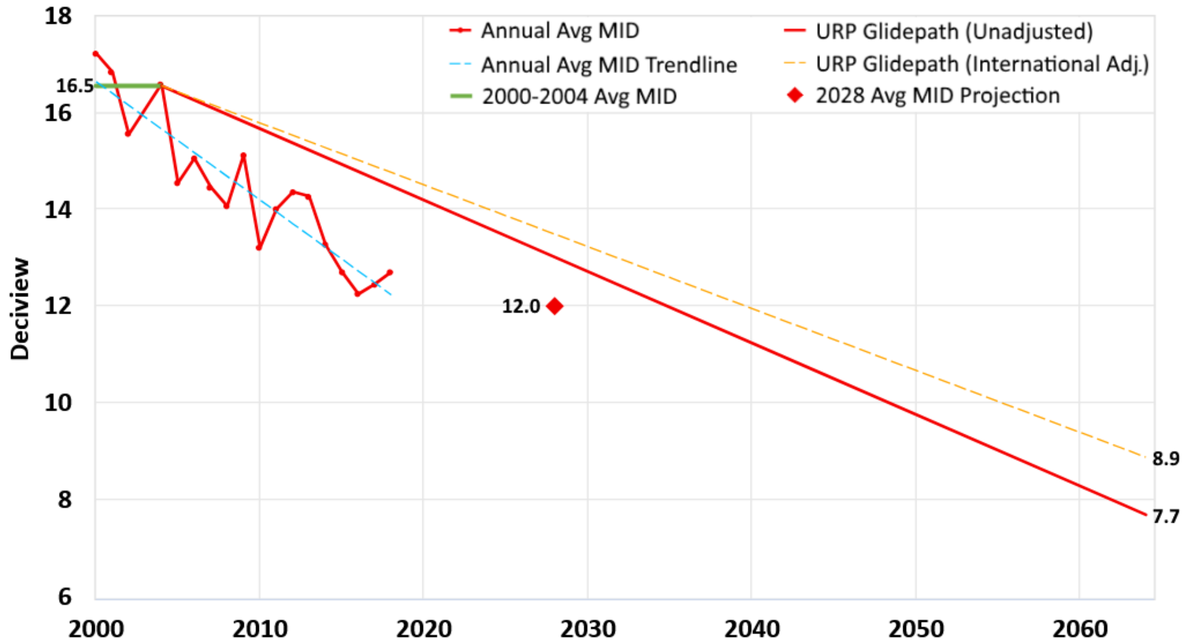

Figure 9-4: Projected 2028 visibility conditions on the MID in Mount Rainier National Park

Progress in reducing visibility impairing pollutants

Table 9-5: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in Mount Rainier National Park.

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	10.1	2.3	7.8	2.3	1.9	0.2	0.3
2028 OTB projection	9.7	1.1	7.4	1.9	1.9	0.2	0.3
Percent change	-4%	-50%	-5%	-16%	+1%	-3%	0%

Sulfate*:*

Statewide emissions of SO_2 are projected to decline almost 40% between the 2000-2004 baseline period and 2028. 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.

Summary*:* Ecology concludes from this analysis that overall Washington is making progress in reducing visibility impairing pollutants impacting Mount Rainier National Park. The 2028 RPG is 12.0 dv assuming emission controls that are on the books.

Clearest days

The monitored 2000-2004 baseline conditions at MORA on the clearest days are 5.5 dv. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 3.68 dv is below the clearest days baseline.

9.6 Goat Rocks Wilderness and Mount Adams Wilderness

Most impaired days

Baseline, adjusted glidepath, 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 visibility at this site on the most impaired days (MID) is 10.5 dv. The calculated natural conditions for the adjusted glidepath are 8.1 dv, a difference of 2.4 dv and a rate of 0.04 dv per year (2.4 dv divided by 60 years). This is the average rate that needs to be maintained to reach natural visibility conditions in the park by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 0.96 dv. The 2028 RPG is projected to be 7.6 dv, which is a visibility improvement of 2.9 dv from the baseline and 0.4 dv below the 2014 to 2018 average. Natural conditions have been reached at these Class 1 Areas and air quality is projected to continue to be better than natural conditions by 2028. However, we anticipate that there may be additional visibility improvements with improved air quality in Washington over the remaining implementation periods.

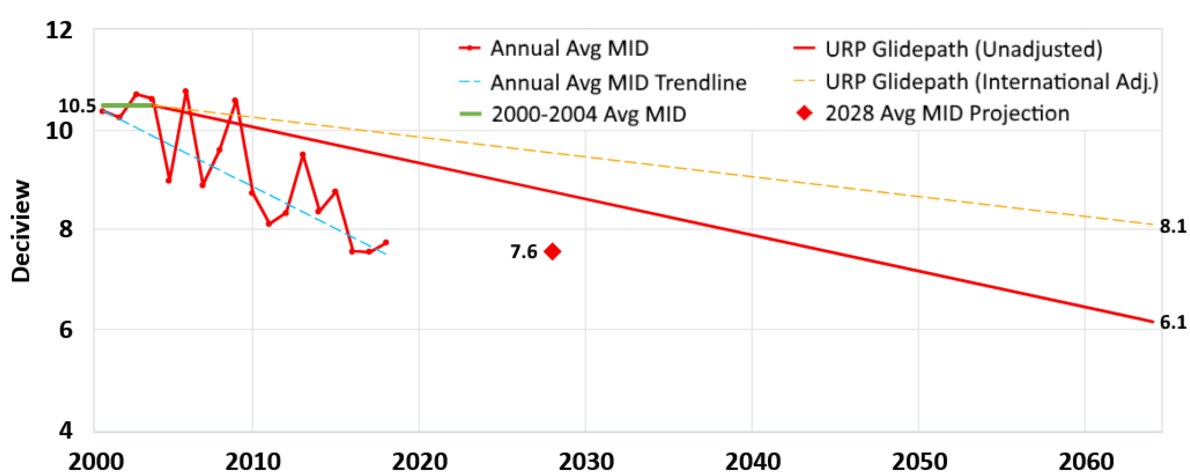

Figure 9-5: Projected 2028 Visibility Conditions on the MID in Goat Rocks Wilderness and Mount Adams Wilderness

Progress in reducing visibility impairing pollutants

Table 9-6: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in Mount Adams Wilderness and Goat Rocks Wilderness

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	6.4	1.5	2.8	0.7	0.9	0.3	0.2
2028 OTB Projection	6.3	1.0	2.6	0.5	0.9	0.3	0.2
Percent Change	-1%	-36%	-7%	-21%	0%	-3%	-1%

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 2028 RPG is 7.5 dv assuming emission controls that are on the books. This is less than projected natural conditions of 8.1 with the glidepath adjusted endpoint.

Clearest days

The monitored 2000-2004 baseline conditions at WHPA1 on the clearest days are 1.7 dv. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 0.91 dv is below the clearest days baseline.

9.7 Pasayten Wilderness

Most impaired days

Baseline, adjusted glidepath, and projected visibility

Visibility conditions at Pasayten Wilderness are monitored at the IMPROVE site PASA1 The monitored 2000-2004 baseline visibility at this site on the most impaired days (MID) is 10.4 dv. The calculated natural conditions for the adjusted glidepath are 8.0 dv, a difference of 2.4 dv and a rate of 0.04 dv per year (2.4 dv divided by 60 years). This is the average rate that needs to be maintained to reach natural visibility conditions in the park by 2064. The amount of visibility improvement from the baseline to 2028 required to stay below the 2028 URP adjusted glidepath for MID is 0.96 dv. The 2028 RPG is projected to be 9.2 dv, which is a visibility improvement of 1.2 dv from the baseline and 0.3 dv below the 2014 to 2018 average.

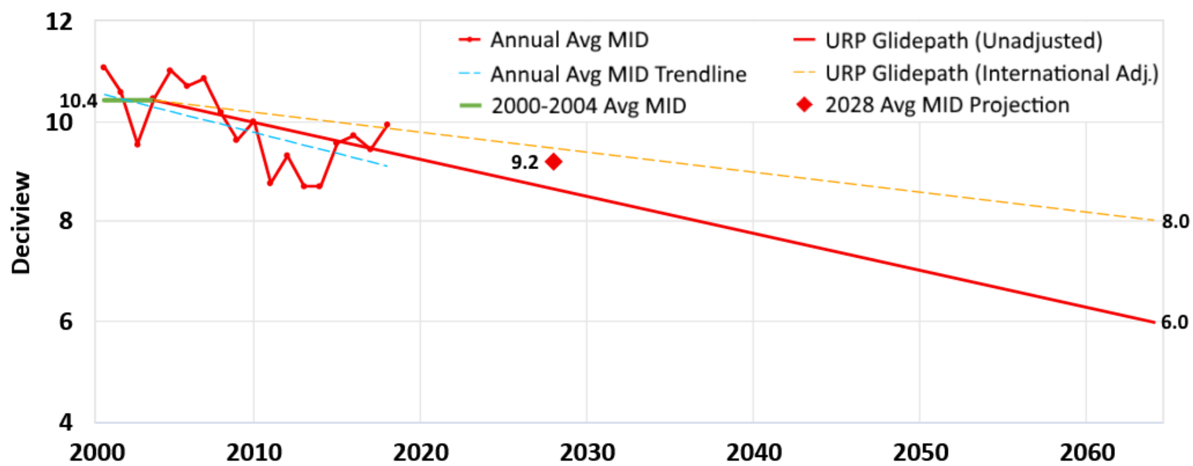

Figure 9-6: Projected 2028 visibility conditions on the MID in Pasayten Wilderness

Progress in reducing visibility impairing pollutants

Table 9-7: Projected changes in light extinction (Mm^{-1}) from 2014 – 2018 baseline to 2028 in Pasayten Wilderness

	Ammonium sulfate	Ammonium nitrate	Organic mass	Elemental carbon	Coarse mass	Fine soil	Sea salt
IMPROVE 2014-2018 average	5.8	2.3	5.4	1.1	1.3	0.4	0.1
2028 OTB projection	5.8	1.8	5.2	1.0	1.3	0.4	0.1
Percent change	0%	-23%	-2%	-9%	0%	-1%	-1%

Summary*:* Ecology concludes from the analysis provided above that Washington is making progress in reducing visibility impairing pollutants impacting Pasayten Wilderness. The 2028 RPG is 9.2 dv assuming emission controls that are on the books.

Clearest days

The monitored 2000-2004 baseline conditions at PASA1 on the clearest days are 2.7 dv. WRAP modeling projects no degradation on the clearest days because the 2028 visibility of 1.46 dv is below the clearest days baseline.

9.8 Summary

Ecology established RPGs, in deciviews, for the MID and the clearest days as required by the Regional Haze Rule. These are summarized in Table 9-8 and Table 9.9. It is projected that Washington will continue to make progress during this implementation period and the 2028 MID RPGs are below the URP adjusted glidepath. The 2028 RPGs for the clearest days are projected to stay below the baseline and therefore show no degradation in visibility.

Table 9-8: 2028 reasonable progress goals in deciviews (dv) for the MID

Mandatory Class 1 Areas	Baseline conditions 2000-2004	Five-year average 2014 to 2018	MID reasonable progress goal 2028	Unadjusted glidepath 2028	Adjusted glidepath 2028
Olympic National Park	14.9	11.9	11.5	11.7	12.5
North Cascades National Park & Glacier Peak Wilderness	12.6	10	9.8	10.3	10.8
Alpine Lakes Wilderness	15.4	12.7	12.0	12.1	12.5
Mount Rainier National Park	16.5	12.7	12.0	13	13.9
Goat Rocks Wilderness & Mount Adams Wilderness	10.5	8.0	7.6	8.7	9.5
Pasayten Wilderness	10.4	9.5	9.2	8.6	9.4

Table 9-9: 2028 projections in deciviews (dv) for the clearest days

Mandatory Class 1 Areas	2000-2004 Baseline Conditions	2028 projection
Olympic National Park	6	3.37
North Cascades National Park and Glacier Peak Wilderness	3.4	2.38
Alpine Lakes Wilderness	5.5	3.03
Mount Rainier National Park	5.5	3.68
Goat Rocks Wilderness and Mount Adams Wilderness	1.7	0.91
Pasayten Wilderness	2.7	1.46

International anthropogenic emissions contribute to visibility impairment in all of Washington's Class 1 Areas. International emissions include emissions from Canada, Asia, international commercial marine vessels from outside and inside the Emissions Control Areas, and all other non-US anthropogenic emission sources from outside and inside the modeling domain. Thus, Washington is adding the international contributions to the endpoint (natural conditions) of the glidepaths for all Washington's Class 1 Areas since those emissions are significant and are not controllable by Washington. If prescribed fire has a significant influence on regional haze in the future, natural conditions may need to be adjusted further, as allowed by the Regional Haze Rule.

Under the Regional Haze Rule, RPGs for the clearest days are required to ensure no degradation of visibility from baseline visibility conditions. WRAP's modeling analysis indicates these goals will be met. Washington's average decrease in dv (visibility improvement) is summarized in Table 9-10. The required average decrease in dv per year from 2004–2064 to achieve natural conditions is listed in the second column. For both 2004–2018 and 2004–2028, Washington's visibility improvement per year exceeds the average per year rate needed to achieve natural conditions by 2064.

Table 9-10: Average visibility improvement in deciviews (dv) on MIDs at Washington's Class 1 Areas

Monitor	2004 to 2064 dv average needed per year to stay on track to meet 2064 natural conditions	Actual dv decrease per year 2004 to 2018	Projected 2004 to 2028 RPG dv decrease per year
MORA1	0.13	0.27	0.19
WHPA1	0.04	0.18	0.12
SNPA1	0.12	0.19	0.14
NOCA1	0.07	0.19	0.12
PASA1	0.04	0.06	0.05
OLYM1	0.10	0.21	0.14

Chapter 10. Future Planning Process and Summary

10.1 Future planning process

The Regional Haze Rule 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 Regional Haze Rule also includes other requirements regarding periodic progress reports, State Implementation Plan (SIP) revisions, and continuing consultation. These future planning requirements are:

- Submitting a monitoring strategy with the SIP
- Including a commitment to update the statewide emissions inventory of visibility impairing pollutants
- Submitting periodic reports describing progress toward the reasonable progress goals
- Determining the adequacy of the existing SIP
- Revising the SIP every ten years
- Continuing interstate coordination and consultation
- Continuing consultation with the Federal Land Managers (FLMs)

Monitoring strategy

Ecology will continue to work in collaboration with the Western Regional Air Partnership (WRAP) and rely upon their adequate technical support to meet its commitment to conduct the analyses necessary to meet the requirements of the Regional Haze Rule.

Ecology 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 Regional Haze Rule. The Regional Haze Rule is a long-term tracking program with an implementation period set for 60 years and states expect the IMPROVE program will provide data based on the following goals:

- Maintain a stable configuration of the individual monitors and sampling sites, and stability in network
- Continue operations for the purpose of continuity in tracking reasonable progress trends
- Assure sufficient data capture at each site of all visibility-impairing species
- Comply with EPA's quality control and assurance requirements
- Prepare and disseminate periodic reports on IMPROVE program operations

Ecology is relying on the IMPROVE program 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 Regional Haze Rule baseline period. Ecology based the technical analyses and reasonable progress goals in this implementation plan on data from these sites.

Federal agencies provide the human resources to operate these monitors. Ecology will collaborate with the EPA, FLMs, other states, tribes, and the IMPROVE committee to ensure adequate and representative data collection and reporting by the IMPROVE program.

Ecology will use data reported by the IMPROVE program as part of the regional technical support analysis tools found at the Technical Support System (TSS2), as well as other analysis tools and efforts sponsored by WRAP. Ecology will participate in the ongoing regional analysis activities of WRAP to collectively assess and verify the progress toward reasonable progress goals and natural conditions. We will also support interstate consultation as the Regional Haze Rule is implemented, and collaborate with WRAP members to ensure the continued operation of these technical support analysis tools and systems. Ecology may conduct additional analyses as needed.

Statewide emissions inventory updates

Ecology has prepared a statewide inventory of emissions that we reasonably expect to cause or contribute to visibility impairment in Class 1 Areas. Chapter 4 of this plan summarizes the emissions by pollutant and source category.

Ecology will update statewide emissions and will use the data for tracking emission changes and trends. We will update the inventories every three years on the same schedule as the three-year reporting required by EPA's Consolidated Emissions Reporting Rule.

Ecology is a member of WRAP and will continue to use WRAP to store and access emission inventory data for the region. Ecology will also depend on and participate in additional periodic emissions inventory efforts by the WRAP. Further, Ecology 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.

Periodic progress reports

The Regional Haze Rule requires states to submit a progress report to EPA every five years evaluating progress toward the reasonable progress goals. The requirements for the progress report are in the Regional Haze Rule (40 CFR 51.308(g)) and are discussed in Chapter 1 of this document.

Washington commits to submitting a report on reasonable progress to EPA every five years. The reasonable progress report will evaluate progress made toward the reasonable progress goals for each mandatory Class 1 Area. Ecology's review will address each of the required elements listed above. Ecology will also evaluate the monitoring strategy adequacy in assessing reasonable progress goals.

Determination of State Implementation Plan Adequacy

The Regional Haze Rule requires states to make a determination of the adequacy of the implementation plan as part of its five-year progress report. Based on the findings of the five-year progress report, Ecology finds that no further substantive SIP revisions of the existing plan are required in order to meet established visibility goals at this time.

Future State Implementation Plan Revisions

In addition to a SIP revision made for plan inadequacy, the Regional Haze Rule requires states to revise and submit a comprehensive regional haze implementation plan revision to EPA every ten years. Future SIP revisions must evaluate and reassess all of the elements required under40

CFR 51.308(f) and specifically address the items listed in 40 CFR 51.308(f)(1-3). 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 Regional Haze Rule requirements for future plans follows:

Approximately every 10 years, Washington commits to completing and submitting a comprehensive regional haze SIP revision to EPA, evaluating and reassessing all of the elements required under 40 CFR 51.308(f). In evaluating and reassessing these elements, Washington commits to:

- Determine 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 toward natural conditions.
- Determine the effectiveness of the long-term strategy for achieving the reasonable progress goals for the prior SIP period as well as include enforceable emission limitations and compliance schedules.
- Affirm or revise the current reasonable progress goals based on assessment of new or updated information, improved technologies and on-going legislation. If the reasonable progress goals are insufficient to attain natural conditions by 2064, Washington will analyze whether there are additional or new control measures to adopt to achieve the degree of visibility improvement projected by the analysis contained in the SIP.

Continuing Interstate Coordination and Consultation

In accordance with 40 CFR 51.308(f)(2)(ii), 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 1 Areas. Washington will also continue consultation with any state for reasonably anticipated Washington's emissions that cause or contribute to visibility impairment in those states' mandatory Class 1 Areas.

Should disagreement arise between another state, or group of states and Washington, Washington will describe the actions taken to resolve the disagreement in its regional haze SIP submittal for EPA's consideration. Washington commits to coordinate its emission management strategies with affected states and will continue to include in its future regional haze SIP revisions all measures necessary to obtain its share of emissions reductions for meeting other states' reasonable progress goals.

Washington commits to continued participation in the WRAP, to the extent possible, and to coordinating future plan revisions with other WRAP member states in addressing regional haze.

Continuing Consultation with the Federal Land Managers

Section 51.308(i)(2) of the Regional Haze Rule 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 accordance with 40 CFR 51.308(i)(2).

The designated visibility protection program coordinators for the National Park Service and the U.S. Forest Service will coordinate the consultation.

Tribal Communication

Ecology will continue outreach and communication with WA Tribes and tribes in neighboring states to provide the opportunity for engagement with the tribes regarding the regional haze program.

10.2 Amendments to the 2021 regional haze SIP revision

The RHR requires states to perform a Four-Factor Analysis (FFA) to determine whether the installation of new emission controls at certain facilities is necessary for the state to make reasonable progress toward the national visibility goal. In Washington, RCW 70A.15.2230 (the "RACT statute") is the legal mechanism that Ecology can use to require existing sources to install new emission controls that are determined to be reasonable. Because the analysis performed under Washington's RACT process is equivalent to the RHR's FFA, Ecology will use the RACT process to require the installation of reasonable emission controls for purposes of compliance with the RHR.

40 CFR 51.308(f) requires the state's long-term strategy to include all measures that are "necessary to make reasonable progress, as determined pursuant to [40 CFR 51.308](f)(2)(i) through (iv)." In turn, 40 CFR 51.308(f)(2)(i) requires the state to consider the following four statutory factors in determining which emission reductions measures are necessary to make reasonable progress:

- the costs of compliance,
- the time necessary for compliance,
- the energy and non-air quality environmental impacts of compliance, and
- the remaining useful life of any potentially affected anthropogenic source of visibility impairment.

Pursuant to RCW 70A.15.1030(20) and 70A.15.2230(5), the RACT evaluation of new emission controls at existing stationary sources requires Ecology to consider the following:

- the impact of the source upon air quality,
- the availability of additional controls,
- the emission reduction to be achieved by additional controls,
- the impact of additional controls on air quality,
- and the capital and operating costs of the additional controls.

The costs of compliance

Under the RACT analysis, Ecology characterizes and considers the cost of compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. The cost of compliance factor in 40 CFR 51.308(f)(2)(i) directly correlates to the RACT analysis consideration of capital and operating costs of the additional controls. The capital and operating costs in RACT are for purchase, installation, and operation of all equipment. These costs include the actual emission control equipment, any non-air quality equipment, and the energy costs to operate the equipment.

The time necessary for compliance

Under the RACT analysis, Ecology characterizes and considers the time necessary for compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Under the RACT analysis requirements, Ecology determines the time necessary for compliance as part of considering the capital and operating costs of the additional controls and impact of the source upon air quality. Specifically, a shorter amount of time for compliance would involve costs distributed over a shorter time and thus have a larger annualized cost. The impact of the source on air quality is also a consideration in the time for compliance. The longer it takes to install and operate the control equipment the greater the negative impact on air quality.

The energy and non-air quality environmental impacts of compliance

Under the RACT analysis, Ecology characterizes and considers the energy and non-air quality environmental impacts of compliance consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Ecology considers the energy and non-air quality environmental impacts of compliance factor as part of analyzing the capital and operating costs of the additional controls in the RACT analysis. The RACT analysis includes costs for equipment directly related to the emissions and all indirectly required equipment needed to install and operate the new controls. The operating cost requirement in the RACT analysis also covers the energy impacts of the controls and supporting equipment.

The remaining useful life of any potentially affected anthropogenic source of visibility impairment

Under the RACT analysis, Ecology characterizes and considers the remaining useful life of any potentially affected anthropogenic source of visibility impairment consistent with 40 CFR 51.308(f)(2)(i) and EPA guidance. Ecology considers the remaining useful life of an emissions control system as part of calculating the capital and operating costs of the system. Specifically, the annualized costs of the emissions control system are affected by the remaining useful life. The shorter the useful life, the larger the annual costs associated with control equipment.

Additionally, RACT requires consideration of the impact of the source upon air quality.' This is consistent with the CAA, RHR, and EPA guidance. While the four statutory factors must be considered in determining what is necessary to make reasonable progress, they are not the only factors that states may consider in this evaluation. As explained by EPA in its 2019 guidance, states have the flexibility to consider other factors, including visibility benefits, when determining the emission reduction measures that are necessary to make reasonable progress:

> "Section 51.308(f)(2)(i) of the Regional Haze Rule requires consideration of the four factors listed in CAA section 169A(g)(1) and does not mention visibility benefits. However, neither the CAA nor the Rule suggest that only the listed factors may be considered. Because the goal of the regional haze program is to improve visibility, it is reasonable for a state to consider whether and by how much an emission control measure would help achieve that goal. Likewise, it is reasonable that such information

on visibility benefits be considered in light of other factors that may weigh for or against the control at issue. Such a balancing of outcomes is consistent with CAA section 169A(b)(2), which states that SIPs must contain elements as may be necessary to make reasonable progress toward meeting the national visibility goal. Thus, EPA interprets the CAA and the Regional Haze Rule to allow a state reasonable discretion to consider the anticipated visibility benefits of an emission control measure along with the other factors when determining whether a measure is necessary to make reasonable progress."[28]

Washington received four-factor analyses from the refineries that indicated there were no reasonable controls at the refineries. Ecology then conducted preliminary analyses using emission inventory data and the EPA Control Cost Manual. The results from the four-factor analyses and the preliminary control cost model were vastly different. This indicated the need for a more robust analysis to determine reasonableness of controls. Therefore, Ecology will use the RACT process to (1) evaluate and determine the emissions reduction measures that are necessary to make reasonable progress and (2) incorporate these measures into its long-term strategy and Regional Haze SIP in a manner that is enforceable as a legal and practical matter.

Ecology will supplement this plan with the results of the reasonableness analysis. The analysis will include an implementation schedule that will be coordinated with scheduled maintenance shutdowns at the refineries when necessary to maintain costs at a reasonable level. These shutdowns occur approximately every two to six years. Emission reductions from refineries were not included in the 2028 projected emissions for the second implementation period, so this does not affect the modeled 2028 reasonable progress goals.

10.3 Summary

National Visibility Goal

In 1977, Congress amended the Clean Air Act and declared a national visibility goal:

"The prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class 1 federal areas which impairment results from manmade air pollution." (CAA § 169A).

The objectives of the Regional Haze Rule are to improve existing visibility in all 156 mandatory Class 1 Areas, prevent future impairment of visibility by human-caused sources, and meet the national goal of natural visibility conditions by 2064. Emissions from numerous sources that are often mixed and transported long distances cause visibility impairment related to regional haze.

Washington's State Implementation Plan

There are planning phases from 2005 to 2064; each planning phase covers approximately 10 years. The first regional haze state implementation plan (regional haze SIP) revision covered the

[28] EPA-457/B-10-003, *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period*, Section II.B.5.

initial planning period from 2005 to 2018. It provided the basis for future SIPs to continue reducing visibility-impairing emissions and meet the national visibility goal by 2064.

This second regional haze SIP sets reasonable progress goals for each of the eight mandatory Class 1 Areas in Washington. The reasonable progress goals reflect already adopted controls for sources that cause or contribute to visibility impairment. Ecology will supplement this second SIP revision with reasonable controls that we determine during the next phase of this implementation period.

Washington developed a long-term strategy that addresses reasonably attributable visibility impairment and regional haze. The long-term strategy applies to mandatory Class 1 Areas both within Washington and outside Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment. We designed the coordinated strategy to achieve the reasonable progress goals for mandatory Class 1 Areas inside Washington and the reasonable progress goals established by other states for mandatory Class 1 Areas outside of Washington where emissions from Washington are reasonably anticipated to contribute to visibility impairment.

Long-Term Challenges and Issues

Under the Regional Haze Rule, Washington is responsible for doing its share of visibility improvement to achieve the national goal for mandatory Class 1 Areas within Washington and Class 1 Areas outside of Washington that it may affect. The Western Regional Air Partnership (WRAP) has provided a technical framework for understanding and dealing with the source regions and sources of visibility impairment. The WRAP analysis 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 1 Areas:

- Emissions from outside the modeling domain, Pacific offshore, and Canada significantly impact visibility. These are all beyond Washington's control. In this regional haze SIP, we have proposed an adjustment to the glidepath endpoint to compensate for these international contributions.
- It will be difficult to achieve natural conditions, at some Class 1 Areas, unless we can either reduce the contribution of organic mass from fire to visibility impairment or not include it in the most impaired days metric. The most impaired days (MID) metric as it is currently calculated is insufficient to remove the effect of all wildfire smoke in Washington. With an increase in catastrophic fire in the Pacific Northwest, this will continue to be a challenge and requires an acceptable method to adjust the MID metric within each state as needed.

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
- Reconsideration of natural conditions especially in light of the expectation that prescribed 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 these challenges and dealing with the issues presented by our changing environment will ultimately enable Washington to achieve natural conditions within Washington and contribute to meeting natural conditions in Class 1 Areas outside Washington.

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