TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
AGENDA ITEM REQUEST
for Proposed State Implementation Plan Revision

AGENDA REQUESTED: October 7, 2020

DATE OF REQUEST: September 18, 2020

INDIVIDUAL TO CONTACT REGARDING CHANGES TO THIS REQUEST, IF NEEDED: Jamie Zech, (512) 239-3935

CAPTION: Docket No. 2020-0924-SIP. Consideration for publication of, and hearing on, the proposed state implementation plan (SIP) revision to address the regional haze requirements of Federal Clean Air Act, §169A. The proposed SIP revision addresses regional haze in Big Bend and Guadalupe National Parks and Federal Class I areas located outside Texas that may be affected by emissions from within the state. The proposed SIP revision contains the core federal Regional Haze Rule (40 Code of Federal Regulations §51.308) requirements, including: calculations of baseline; current and natural visibility conditions; progress-to-date and the uniform rate of progress; a long-term strategy for regional haze; reasonable progress goals; a monitoring strategy; and a statewide emissions inventory. (Margaret Earnest, John Minter) (Non-Rule Project No. 2019-112-SIP-NR)

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Copy to CCC Secretary? NO X YES

Texas Commission on Environmental Quality

Interoffice Memorandum

To: Commissioners **Date:** September 18, 2020

Thru: Bridget C. Bohac, Chief Clerk
Toby Baker, Executive Director

From: Tonya, Deputy Director
Office of Air

Docket No.: 2020-0924-SIP

Subject: Commission Approval for Proposed 2021 Regional Haze State Implementation Plan (SIP) Revision for the Second Planning Period

2021 Regional Haze SIP Revision
Non-Rule Project No. 2019-112-SIP-NR

Background and reason(s) for the SIP revision:
Federal Clean Air Act (FCAA), §§169A and B require the United States Environmental Protection Agency (EPA) to adopt regulations to reduce visibility impairment resulting from anthropogenic air pollution in 156 mandatory Class I Federal areas (Class I areas). Big Bend and Guadalupe Mountains National Parks are the two Class I areas in Texas. States are required to submit periodic plans demonstrating how they made, and will continue to make, progress towards achieving their visibility improvement goals. The 2021 Regional Haze SIP Revision examines the need to implement measures to reduce Texas' visibility impacts in Class I areas in and around Texas.

Model simulations were conducted to estimate visibility conditions at the end of the second planning period in 2028. The Regional Haze Rule includes a provision that allows states to propose an adjustment to the glidepath to account for impacts from anthropogenic sources outside the United States. Both Big Bend and Guadalupe Mountains National Parks are projected to be below the adjusted glidepath at the end of the second planning period.

The FCAA and the Regional Haze Rule require states to consider four factors when evaluating control measures for selected sources: 1) cost of compliance; 2) time necessary for compliance; 3) energy and non-air quality environmental impacts of compliance; and 4) remaining useful life. A two-pronged screening analysis that combined sulfate and nitrate weighted residence times (known as areas of influence) with emissions over distance (Q/d) was used to select sources for evaluation under these four factors. The screening analysis resulted in a list of 18 sources for evaluation. A cost threshold of $5,000 per ton for nitrogen oxides (NO_x) and sulfur dioxide (SO_2) emissions reduced was used to further refine source selection. The four-factor analysis identified potential additional emission controls for the sources with a total annualized control costs over $200 million. A sensitivity analysis of the potential additional controls showed a maximum visibility benefit of 0.56 deciviews at one Class I area, the Caney Creek Wilderness Area in Arkansas. The TCEQ determined that it is not reasonable to implement new additional measures to improve visibility to a degree that is imperceptible to the human eye at the costs described above. Therefore, no new additional emission control measures for the 18 identified sources are included with this SIP revision.

Re: Docket No. 2020-0924-SIP

Scope of the SIP revision:

A.) Summary of what the SIP revision would do:
The SIP revision would address the regional haze requirements of FCAA, §169A for Big Bend and Guadalupe Mountains National Parks and Class I areas located outside of Texas that may be affected by emissions from Texas. The proposed SIP revision contains the core federal Regional Haze Rule (40 Code of Federal Regulations (CFR) §51.308) requirements, including: calculations of baseline; current and natural visibility conditions; progress-to-date and the uniform rate of progress; a long-term strategy for regional haze; reasonable progress goals; a monitoring strategy; and a statewide emissions inventory.

This SIP revision covers a 10-year period from 2019 through 2028 showing that Texas' two Class I areas, when adjusted for international transport, will both be under the uniform rate of progress for 2028. Analysis shows only one Class I area that Texas impacts, Salt Creek in New Mexico, is expected to not meet the 2028 goals.

B.) Scope required by federal regulations or state statutes:
This SIP revision would address the regional haze requirements of FCAA, §169A and the core federal Regional Haze Rule requirements in 40 CFR §51.308.

C.) Additional staff recommendations that are not required by federal rule or state statute:
None.

Statutory authority:
The authority to propose SIP revisions is derived from the Texas Water Code (TWC), §5.102, General Powers, TWC, §5.103, Rules, and TWC, §5.105, General Policy, which provide the commission with the general powers to carry out its duties and authorize the commission to adopt rules necessary to carry out its powers and duties under the TWC; and TWC, §5.013, General Jurisdiction of Commission, which states the commission's authority over various statutory programs. This SIP revisions is also proposed under Texas Health & Safety Code (THSC), §382.002, Policy and Purpose, which establishes the commission's purpose to safeguard the state's air resources consistent with the protection of public health, general welfare, and physical property; THSC, §382.011, General Powers and Duties, which authorizes the commission to control the quality of the state's air; and THSC, §382.012, State Air Control Plan, which authorizes the commission to develop a general, comprehensive plan for the control of the state's air.

Effect on the:

A.) Regulated community:
None.

B.) Public:
The analysis included in this proposed SIP revision shows that visitors will continue to experience improved visibility conditions at Big Bend and Guadalupe Mountains National Parks.

C.) Agency programs:
This SIP revision would have no new effect on agency programs.

Stakeholder meetings:
The TCEQ hosted meetings in March 2020 via calls and webinars presenting an air quality planning update, an introduction to photochemical modeling, and discussion on the four-actor analysis. Attendees included representatives from the selected industry sources. Consultation calls and webinars with Arkansas, New Mexico, and Oklahoma were held in 2020 to share modeling results, the method for selecting sources for four-factor analysis, and the sources selected. This information was also shared with federal land managers in a separate webinar. Consultation with other states and the FLMs is ongoing and because other states are at different stages of development of their regional haze SIP revisions, this proposal does not include a complete record of consultation. Documentation of additional consultation after July 31, 2020 will be included at adoption.

If the proposed SIP revision is approved by the commission for public comment and public hearing, a formal public comment period would be opened, and a public hearing would be offered.

Potential controversial concerns and legislative interest:
Texas is under a Best Available Retrofit Technology (BART) federal implementation plan (FIP) and a Reasonable Progress Goals (RPG) FIP for the first planning period. The RPG FIP has been challenged by the state in federal court. The RPG FIP was stayed by the court and the EPA has taken a voluntary remand of the FIP for further consideration.

Would this SIP revision affect any current policies or require development of new policies?
No.

What are the consequences if this SIP revision does not go forward? Are there alternatives to this SIP revision?
The TCEQ could choose not to comply with the requirements to develop and submit this SIP revision to the EPA by the required July 31, 2021 deadline. However, if a regional haze SIP revision is not submitted to the EPA, the EPA could issue a finding of failure to submit, requiring that the TCEQ submit, and EPA approve, the required SIP revision to avoid imposition of a FIP. The EPA would be required to promulgate a FIP any time within two years after finding the TCEQ failed to make the required submission. Sanctions, including loss of highway funding, could be imposed as a result of a failure to submit the SIP revision; however, sanctions are not mandatory.

Key points in the proposal SIP revision schedule:
Anticipated proposal date: October 7, 2020
Anticipated public hearing date (if any): December 8, 2020
Anticipated public comment period: October 9, 2020 through December 9, 2020
Anticipated adoption date: June 9, 2021

Re: Docket No. 2020-0924-SIP

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REVISIONS TO THE STATE OF TEXAS AIR QUALITY IMPLEMENTATION PLAN FOR THE CONTROL OF REGIONAL HAZE

2021 REGIONAL HAZE STATE IMPLEMENTATION PLAN REVISION FOR THE SECOND PLANNING PERIOD

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
P.O. BOX 13087
AUSTIN, TEXAS 78711-3087

2021 REGIONAL HAZE STATE IMPLEMENTATION PLAN REVISION

PROJECT NUMBER 2019-112-SIP-NR

Proposal
October 7, 2020

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EXECUTIVE SUMMARY

The Federal Clean Air Act (FCAA), §§169A and B require the United States Environmental Protection Agency (EPA) to adopt regulations to reduce visibility impairment resulting from anthropogenic air pollution in 156 mandatory Class I Federal areas (Class I areas). Big Bend and Guadalupe Mountains National Parks are the two Class I areas in Texas. States are required to submit periodic plans demonstrating how they made, and will continue to make, progress towards achieving their visibility improvement goals. The 2021 Regional Haze State Implementation Plan (SIP) Revision examines the need to implement measures to reduce Texas' visibility impacts in Class I areas in and around Texas. Information contained in this SIP revision for the second planning period, including the four-factor analysis, supplements the information provided in the SIP revision for the first planning period, adopted by the commission on February 27, 2009 (Project Number 2007-016-SIP-NR).

Figure ES-1:Big Bend National Park at the Chisos Mountains

Source: NPS Photo/Blake Trester (https://www.nps.gov/bibe/planyourvisit/basicinfo.htm)

Model simulations were conducted to estimate visibility conditions at the end of the second planning period in 2028. The Regional Haze Rule with amendments includes a provision that allows states to propose an adjustment to the glidepath to account for impacts from anthropogenic sources outside the United States. Both Big Bend and Guadalupe Mountains National Parks are projected to be below the adjusted glidepath at the end of the second planning period.

To determine which sources would be evaluated for controls to meet the Regional Haze Rule reasonable progress requirements, a screening analysis was conducted for point sources by pairing emissions over distance with ammonium sulfate and ammonium nitrate extinction-weighted residence times (EWRT). For both electric generating units (EGU) and non-EGU point sources, 2028 future year nitrogen oxides (NO_X) and sulfur dioxide (SO_2) emissions were estimated from 2016 reported emissions. Selected sources were those within the identified areas of influence (based on EWRT) and an emissions-over-distance equal to or greater than five for either NO_X or SO_2. Using this approach, 18 sources were identified for additional analysis.

The Regional Haze Rule requires states to consider four criteria when evaluating control measures for selected sources: 1) cost of compliance; 2) time necessary for compliance; 3) energy and non-air quality environmental impacts of compliance; and 4) remaining useful life. A cost threshold of $5,000 per ton for NO_X and SO_2 emissions reduced was used to further refine source selection. This allows for identification of sources to which potential control measures could be applied in a cost-effective manner. Using a $5,000 per ton cost threshold, a total annualized cost of over $200 million was estimated. The EPA's August 2019 Regional Haze guidance allows for the consideration of visibility impacts on Class I areas as part of the evaluation of controls (EPA, 2019a). The Texas Commission on Environmental Quality (TCEQ) performed a sensitivity analysis to evaluate the impact of potential controls meeting the $5,000 per ton cost threshold on visibility at Class I areas in Texas and surrounding states. The results of this analysis indicate a maximum visibility impact from SO_2 controls at Caney Creek Wilderness Area of 0.56 deciviews and a minimal incremental impact from NO_X controls (<0.01 deciviews).

States are required to consult with other states and Federal Land Managers (FLM) as part of the regional haze SIP development process. States are required to share information with other states that have Class I areas that are reasonably anticipated to be impacted by emissions from Texas. States are also required to evaluate, though not necessarily implement, control measures requested by other states and document actions taken to resolve disagreements. Only three neighboring states met the impact criteria that the TCEQ selected using the screening analysis described previously. The TCEQ held consultation webinars with Arkansas, New Mexico, and Oklahoma to share modeling results, the method for selecting sources for four-factor analysis, and the sources selected. The TCEQ also shared this information with FLMs in a separate webinar.

Modeling of 2028 visibility conditions for Class I areas in and around Texas indicates that all areas except Salt Creek in New Mexico are expected to meet the 2028 planning goals (i.e., the adjusted glidepath point in 2028). Sensitivity analysis shows a maximum visibility improvement of just over half a deciview from the identified SO_2 controls at a total annualized cost of over $200 million. Minimal incremental benefit of less than 0.01 deciviews is expected in visibility impacts from NO_X controls when added to the SO_2 controls. This proposed SIP revision describes and documents rules, regulations, and additional measures that are included in the long-term strategy. However, based on the sensitivity analysis, the TCEQ determined that it is not cost effective nor reasonable to implement additional measures to only improve visibility to a degree that is imperceptible to the human eye.

SECTION V-A: LEGAL AUTHORITY

<u>General</u>

The Texas Commission on Environmental Quality (TCEQ) has the legal authority to implement, maintain, and enforce the National Ambient Air Quality Standards (NAAQS) and to control the quality of the state's air, including maintaining adequate visibility.

The first air pollution control act, known as the Clean Air Act of Texas, was passed by the Texas Legislature in 1965. In 1967, the Clean Air Act of Texas was superseded by a more comprehensive statute, the Texas Clean Air Act (TCAA), found in Article 4477-5, Vernon's Texas Civil Statutes. The legislature amended the TCAA in 1969, 1971, 1973, 1979, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, and 2019. In 1989, the TCAA was codified as Chapter 382 of the Texas Health and Safety Code.

Originally, the TCAA stated that the Texas Air Control Board (TACB) was the state air pollution control agency and was the principal authority in the state on matters relating to the quality of air resources. In 1991, the legislature abolished the TACB effective September 1, 1993, and its powers, duties, responsibilities, and functions were transferred to the Texas Natural Resource Conservation Commission (TNRCC). In 2001, the 77th Texas Legislature continued the existence of the TNRCC until September 1, 2013 and changed the name of the TNRCC to the TCEQ. In 2009, the 81st Texas Legislature, during a special session, amended section 5.014 of the Texas Water Code, changing the expiration date of the TCEQ to September 1, 2011, unless continued in existence by the Texas Sunset Act. In 2011, the 82nd Texas Legislature continued the existence of the TCEQ until 2023. With the creation of the TNRCC (and its successor the TCEQ), the authority over air quality is found in both the Texas Water Code and the TCAA. Specifically, the authority of the TCEQ is found in Chapters 5 and 7. Chapter 5, Subchapters A - F, H - J, and L, include the general provisions, organization, and general powers and duties of the TCEQ, and the responsibilities and authority of the executive director. Chapter 5 also authorizes the TCEQ to implement action when emergency conditions arise and to conduct hearings. Chapter 7 gives the TCEQ enforcement authority.

The TCAA specifically authorizes the TCEQ to establish the level of quality to be maintained in the state's air and to control the quality of the state's air by preparing and developing a general, comprehensive plan. The TCAA, Subchapters A - D, also authorize the TCEQ to collect information to enable the commission to develop an inventory of emissions; to conduct research and investigations; to enter property and examine records; to prescribe monitoring requirements; to institute enforcement proceedings; to enter into contracts and execute instruments; to formulate rules; to issue orders taking into consideration factors bearing upon health, welfare, social and economic factors, and practicability and reasonableness; to conduct hearings; to establish air quality control regions; to encourage cooperation with citizens' groups and other agencies and political subdivisions of the state as well as with industries and the federal government; and to establish and operate a system of permits for construction or modification of facilities.

Local government authority is found in Subchapter E of the TCAA. Local governments have the same power as the TCEQ to enter property and make inspections. They also may make recommendations to the commission concerning any action of the TCEQ that affects their territorial jurisdiction, may bring enforcement actions, and may execute cooperative agreements with the TCEQ or other local governments. In addition, a city or town may enact and enforce ordinances for the control and abatement of air pollution not inconsistent with the provisions of the TCAA and the rules or orders of the commission.

Subchapters G and H of the TCAA authorize the TCEQ to establish vehicle inspection and maintenance programs in certain areas of the state, consistent with the requirements of the Federal Clean Air Act; coordinate with federal, state, and local transportation planning agencies to develop and implement transportation programs and measures necessary to attain and maintain the NAAQS; establish gasoline volatility and low emission diesel standards; and fund and authorize participating counties to implement vehicle repair assistance, retrofit, and accelerated vehicle retirement programs.

<u>Applicable Law</u>
The following statutes and rules provide necessary authority to adopt and implement the state implementation plan (SIP). The rules listed below have previously been submitted as part of the SIP.

<u>Statutes</u>
All sections of each subchapter are included, unless otherwise noted.

TEXAS HEALTH & SAFETY CODE, Chapter 382	September 1, 2019
TEXAS WATER CODE	September 1, 2019

Chapter 5: Texas Natural Resource Conservation Commission
- Subchapter A: General Provisions
- Subchapter B: Organization of the Texas Natural Resource Conservation Commission
- Subchapter C: Texas Natural Resource Conservation Commission
- Subchapter D: General Powers and Duties of the Commission
- Subchapter E: Administrative Provisions for Commission
- Subchapter F: Executive Director (except §§5.225, 5.226, 5.227, 5.2275, 5.231, 5.232, and 5.236)
- Subchapter H: Delegation of Hearings
- Subchapter I: Judicial Review
- Subchapter J: Consolidated Permit Processing
- Subchapter L: Emergency and Temporary Orders (§§5.514, 5.5145, and 5.515 only)
- Subchapter M: Environmental Permitting Procedures (§5.558 only)

Chapter 7: Enforcement
- Subchapter A: General Provisions (§§7.001, 7.002, 7.0025, 7.004, and 7.005 only)
- Subchapter B: Corrective Action and Injunctive Relief (§7.032 only)
- Subchapter C: Administrative Penalties
- Subchapter D: Civil Penalties (except §7.109)
- Subchapter E: Criminal Offenses and Penalties: §§7.177, 7.179-7.183

Rules

All of the following rules are found in 30 Texas Administrative Code, as of the following latest effective dates:

Chapter 7: Memoranda of Understanding, §§7.110 and 7.119
December 13, 1996 and May 2, 2002

Chapter 19: Electronic Reporting — March 15, 2007

Chapter 35: Emergency and Temporary Orders and Permits; Temporary Suspension or Amendment of Permit Conditions
- Subchapter A: Purpose, Applicability, and Definitions — December 10, 1998
- Subchapter B: Authority of Executive Director — December 10, 1998
- Subchapter C: General Provisions — March 24, 2016
- Subchapter K: Air Orders — July 20, 2006

Chapter 39: Public Notice
- Subchapter H: Applicability and General Provisions, §§39.402(a)(1) - (6), (8), and (10) - (12), 39.405(f)(3) and (g), (h)(1)(A) - (4), (6), (8) - (11), (i) and (j), 39.407, 39.409, 39.411(a), (e)(1) - (4)(A)(i) and (iii), (4)(B), (5)(A) and (B), and (6) - (10), (11)(A)(i) and (iii) and (iv), (11)(B) - (F), (13) and (15), and (f)(1) - (8), (g) and (h), 39.418(a), (b)(2)(A), (b)(3), and (c), 39.419(e), 39.420 (c)(1)(A) - (D)(i)(I) and (II), (D)(ii), (c)(2), (d) - (e), and (h), and Subchapter K: Public Notice of Air Quality Permit Applications, §§39.601 - 39.605 — May 14, 2020

Chapter 55: Requests for Reconsideration and Contested Case Hearings; Public Comment, all of the chapter, except §55.125(a)(5) and (6) — May 14, 2020

Chapter 101: General Air Quality Rules — May 14, 2020

Chapter 106: Permits by Rule, Subchapter A — April 17, 2014

Chapter 111: Control of Air Pollution from Visible Emissions and Particulate Matter — August 3, 2017

Chapter 112: Control of Air Pollution from Sulfur Compounds — July 16, 1997

Chapter 113: Standards of Performance for Hazardous Air Pollutants and for Designated Facilities and Pollutants — May 14, 2009

Chapter 114: Control of Air Pollution from Motor Vehicles — April 26, 2018

Chapter 115: Control of Air Pollution from Volatile Organic Compounds — March 26, 2020

Chapter 116: Control of Air Pollution by Permits for New Construction or Modification — May 14, 2020

Chapter 117: Control of Air Pollution from Nitrogen Compounds	March 26, 2020
Chapter 118: Control of Air Pollution Episodes	March 5, 2000
Chapter 122: §122.122: Potential to Emit	February 23, 2017
Chapter 122: §122.215: Minor Permit Revisions	June 3, 2001
Chapter 122: §122.216: Applications for Minor Permit Revisions	June 3, 2001
Chapter 122: §122.217: Procedures for Minor Permit Revisions	December 11, 2002
Chapter 122: §122.218: Minor Permit Revision Procedures for Permit Revisions Involving the Use of Economic Incentives, Marketable Permits, and Emissions Trading	June 3, 2001

SECTION VI: CONTROL STRATEGY

A. Introduction (No change)
B. Ozone (No change)
C. Particulate Matter (No change)
D. Carbon Monoxide (No change)
E. Lead (No change)
F. Oxides of Nitrogen (No change)
G. Sulfur Dioxide (No change)
H. Conformity with the National Ambient Air Quality Standards (No change)
I. Site Specific (No change)
J. Mobile Sources Strategies (No change)
K. Clean Air Interstate Rule (No change)
L. Transport (No change)
M. Regional Haze (Revised)

TABLE OF CONTENTS

LIST OF ACRONYMS

AEDT	Aviation Environmental Design Tool
AEO	Annual Energy Outlook
AMPD	Air Markets Program Database
AOI	Area of Influence
APU	auxiliary power unit
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
BC	boundary conditions
BEIS	Biogenic Emission Inventory System
Bext	light extinction or beta extinction, expressed in inverse megameters
BIBE	Big Bend National Park
BOAP	Bosque del Apache Wilderness Area
BOEM	U.S. Bureau of Ocean Energy Management
BPA	Beaumont-Port Arthur
CACR	Caney Creek Wilderness Area
CAIR	Clean Air Interstate Rule
CALPUFF	California Puff Model
CAMx	Comprehensive Air Quality Model with Extensions
CEMS	continuous emissions monitoring system
CenRAP	Central Regional Air Planning Association
CenSARA	Central States Air Resource Agencies
CF	coarse/fine
CFR	Code of Federal Regulations
CH_4	methane
CM	coarse mass
CMV	commercial marine vessel
CONUS	Continental United States
CO	carbon monoxide
CSAPR	Cross-State Air Pollution Rule
CST	Central Standard Time
DERI	Diesel Emissions Reduction Incentive program
DFW	Dallas-Fort Worth
dv	deciview
EC	elemental carbon
EGF	electric generating facility
EGU	electric generating unit
EI	emissions inventory
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
EPS3	Emissions Processing System
ERCOT	Electric Reliability Council of Texas
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
ESL	Energy Systems Laboratory
EWRT	extinction-weighted residence times
FAA	Federal Aviation Administration
FB	fractional bias

FE	fractional error
FCAA	Federal Clean Air Act
FINN	Fire Inventory of National Center for Atmospheric Research
FIP	federal implementation plan
FLM	Federal Land Manager
FR	*Federal Register*
FS	United States Forest Service
FWS	United States Fish and Wildlife Service
GCVTC	Grand Canyon Visibility Transport Commission
GEOS	Goddard Earth Observing System
GRSA	Great Sand Dunes Wilderness Area
GSE	ground support equipment
GUMO	Guadalupe Mountains National Park
GW	gigawatts
GWEI	Gulfwide Emissions Inventory
I/M	inspection and maintenance
HB	House Bill
HECT	Highly Reactive Volatile Organic Compounds Emissions Cap and Trade
HEGL	Hercules-Glades Wilderness Area
HGB	Houston-Galveston-Brazoria
HNO_3	nitric acid
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IC	initial conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometer
Kv	vertical diffusivity
LADCO	Lake Michigan Air Directors Consortium
LCC	Lambert Conformal Conic
LTS	long-term strategy
m AGL	meters above ground level
MANE-VU	Mid-Atlantic-Northeast Visibility Union
MDA8	maximum daily average eight-hour ozone
MECT	Mass Emissions Cap and Trade
MING	Mingo Wilderness Area
Mm^{-1}	inverse megameters
MMBtu	one million British thermal units
MOVES	Motor Vehicle Emissions Simulator
MPE	model performance evaluation
MW	megawatt
MWh	megawatt-hour
NAAQS	National Ambient Air Quality Standard
NASA	National Aeronautics and Space Administration
NEI	National Emissions Inventory
NEIC	National Emissions Inventory Collaborative
NERC	North American Electric Reliability Corporation
NH_3	ammonia
NH_4	ammonium
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_3	nitrate

NO_2	nitrogen dioxide
NO_X	nitrogen oxides
non-EGU	non-electrical generating units
NPS	National Park Service
NSR	New Source Review
OC	organic carbon
PM	particulate matter
$PM_{2.5}$	particulate matter with aerodynamic diameters less than 2.5 microns
PM_{10}	particulate matter with aerodynamic diameters less than 10 microns
PBL	planetary boundary layer
PiG	Plume-in-Grid
POA	primary organic aerosol
ppm	parts per million
PPM	Piecewise-Parabolic Method
PSAT	Particulate Matter Source Apportionment Technology
Q/d	emissions over distance (to Class I area) (tpy/km)
RH	Relative Humidity
RPG	reasonable progress goal
RPO	Regional Planning Organization
RRF	relative response factor
SACR	Salt Creek Wilderness Area
SESARM	Southeastern States Air Resource Managers
SIP	state implementation plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	sulfur dioxide
SO_4	sulfate
SOA	secondary organic aerosol
SECO	State Energy Conservation Office
SPRY	Seaport and Rail Yard Areas Emissions Reduction Program
STARS	State of Texas Air Reporting System
TAC	Texas Administrative Code
TACB	Texas Air Control Board
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality (commission)
TCFP	Texas Clean Fleet Program
TDM	travel demand model
TERP	Texas Emissions Reduction Plan
TexN2	Texas NONROAD model
TFS	Texas Forest Service
THSC	Texas Health and Safety Code
TNGVGP	Texas Natural Gas Vehicle Grant Program
TNRCC	Texas Natural Resource Conservation Commission
TOMS	Total Ozone Mapping Spectrometer
tpd	tons per day
tpy	tons per year
TSD	technical support document
TTI	Texas Transportation Institute
TUV	Tropospheric Ultraviolet and Visible (Radiation Model)
TxLED	Texas Low Emission Diesel
U.S.	United States

UPBU	Upper Buffalo Wilderness Area
URP	uniform rate of progress
VIEWS	Visibility Information Exchange Web System
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
VMT	vehicle miles traveled
VOC	volatile organic compounds
WHIT	White Mountain Wilderness Area
WHPE	Wheeler Peak Wilderness Area
WIMO	Wichita Mountains Wilderness
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting
ZROW	zero out the rest of the world

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1: GENERAL

1.1 BACKGROUND

In amendments to the Federal Clean Air Act (FCAA) in 1977, Congress added §169A [42 United States Code (U.S.C.) 7491] setting the national visibility goal of restoring pristine conditions in national parks and wilderness areas:

"Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution."

When the FCAA was amended in 1990, Congress added §169B (42 U.S.C. 7492), authorizing further research and regular assessments of the progress to improve visibility in the mandatory Class I Federal areas (Class I areas). Figure 1-1: *Map of 156 Mandatory Class I Federal Areas* shows the location of the Class I areas of concern and the Federal Land Manager (FLM) responsible for each area around the nation. For Texas and surrounding states, the three FLMs are the National Park Service (NPS), the United States (U.S.) Fish and Wildlife Service (FWS), and the U.S. Forest Service (FS).

Note: NPS – National Park Service, FWS –Fish and Wildlife Service, FS – Forest Service

Figure 1-1: Map of 156 Mandatory Class I Federal Areas

1.1.1 Texas State Implementation Plan

Information on the Texas State Implementation Plan (SIP), a list of SIP revisions, and other air quality plans adopted by the commission are available on the Texas State Implementation Plan webpage (http://www.tceq.texas.gov/airquality/sip) on the Texas Commission on Environmental Quality's (TCEQ) website (http://www.tceq.texas.gov/).

1.2 VISIBILITY IMPAIRING EMISSIONS

Regional haze is visibility impairment that is produced by a multitude of sources and activities. These emission sources and activities are located across a broad geographical area and consist of fine particles and their precursors. Visibility impairment caused by air pollution occurs at most Class I visibility protected national park and wilderness area monitoring stations (IMPROVE, 2020). A significant factor in visibility impairment is regional transport of fine particles that contribute to elevated particulate matter (PM) levels.

Haze-forming pollution comes from both human and natural sources. Windblown dust and soot from wildfires contribute to haze, as do motor vehicles, electric generating facilities, industrial fuel burning, and manufacturing operations. PM and PM precursor emissions are the major cause of reduced visibility or haze in the U.S. and at many of the national parks and wilderness areas. Some haze-forming particles are directly emitted into the air. The usual term for directly emitted particles is primary particles. Secondary particles, created when emitted gases form particles downwind of the emission sources, are usually the primary cause of regional haze. Nitrates and sulfates, which result from nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) Haze is measured in deciviews (dv), which is a unit of visibility proportional to the logarithm of the atmospheric light extinction. Figure 1-2: *Comparison of Extinction, Deciviews and Visual Range* compares extinction (measured in inverse megameters or Mm^{-1}) to deciviews to visual range (measured in kilometers or km). One mile is equal to approximately 1.6 kilometers. A deciview is a unit of visibility impairment proportional to the logarithm of the atmospheric light extinction. One deciview is approximately the minimum amount of change in visibility that a human observer can detect.

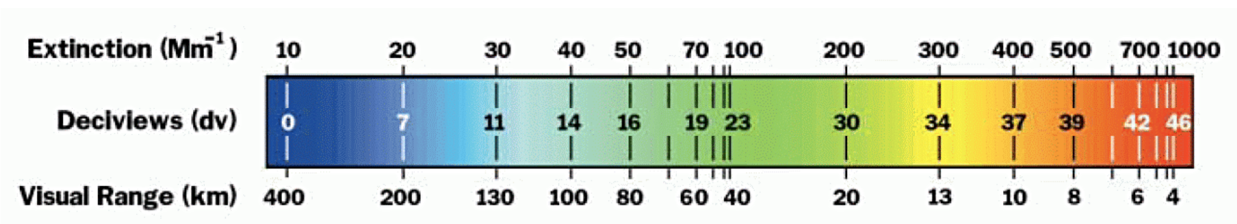

Figure 1-2: Comparison of Extinction, Deciviews and Visual Range

Source: William Malm, Introduction to Visibility, 1999.

Data analysis and modeling conducted by the TCEQ shows several types of emissions reduce visibility, including SO_2, nitrogen oxides (NO_X), and PM. Table 1-1: *Visibility-Impairing Pollutants* lists some of the different molecule variations in the atmosphere and various emission sources. Unlike pollutants like ozone, visibility is not a measurable concentration for which a standard like the NAAQS could be set. Instead, the Regional Haze Rule sets procedures states must follow to determine how much emissions reductions are reasonable to move toward the national goal Congress established under the FCAA: returning Class I areas to natural visibility conditions. The U.S. Environmental Protection Agency (EPA) has set 2064 as the target date to meet Congress' goal to reach natural conditions at all Class I areas. To accomplish this goal, a state must first determine what "natural conditions" are and then plan how to reach those conditions.

Table 1-1: Visibility-Impairing Pollutants

Major Components of Particles	Symbol	Directly Emitted?	Formed in the Air?	Formed From	In which Size Range? (µm)	Major Sources
Sulfates	SO_4	Yes*	Yes	SO_2	$PM_{2.5}$	Coal-fired power plants, oil fields and refineries, paper mills
Nitrates	NO_3	No*	Yes	NO_2	$PM_{2.5}$	All combustion
Secondary Organic Carbon	OC	No	Yes	VOC**	$PM_{2.5}$	Gasoline, organic solvents, biogenics
Primary Organic Carbon	OC	Yes	No	--	$PM_{2.5}$	Incomplete combustion
Elemental Carbon (i.e., black carbon)	EC	Yes	No	--	$PM_{2.5}$	Incomplete combustion
Fine Soil Dust	FS	Yes	No	--	$PM_{2.5}$	Wind blowing over loose soil, motor vehicle usage
Coarse Mass, which is normally ~ 100% Coarse Soil Dust	CM	Yes	No	--	PM_{COARSE}, i.e. $PM_{10-2.5}$	Wind blowing over loose soil, motor vehicle usage

Notes: *There are few significant, direct sulfate sources; direct nitrate sources are rare.
**Volatile organic compounds

1.3 HISTORY OF FEDERAL REGIONAL HAZE RULE

In addition to authorizing the creation of visibility transport commissions and setting forth their duties, FCAA, §169B(f) specifically mandated the creation of the Grand Canyon Visibility Transport Commission (GCVTC) to make recommendations to the EPA for the region affecting visibility in Grand Canyon National Park. After four years of research and policy development, the GCVTC submitted its report to the EPA in June 1996 (GCVTC, 1996). This report, as well as other research reports prepared by the GCVTC, contributed information to the EPA's development of the Federal Regional Haze Rule.

The EPA promulgated the1999 Regional Haze Rule on July 1, 1999 (64 *Federal Register* (FR) 35714).[1] The federal rule's objective is to achieve the national visibility goal of

[1] EPA, 1999. Regional Haze Regulations, 64 FR 35714, https://www.govinfo.gov/content/pkg/FR-1999-07-01/pdf/99-13941.pdf, July 1, 1999.

restoring natural visibility conditions to Class I areas by 2064. Chapter 4: *Assessment of Baseline and Current Conditions and Estimate of Natural Conditions in Class I Areas* discusses natural conditions in more detail. The rulemaking addresses the combined visibility effects of sources over a broad geographic region, and all states must participate in haze reduction efforts, including those without Class I areas.

On January 10, 2017, the EPA published the 2017 Regional Haze Rule amendments (82 FR 3078)[2] to update aspects of the reasonably available visibility impairment (RAVI) and regional haze programs including: strengthening the FLM consultation requirements; extending the RAVI requirements so that all states must address situations where a single source or small number of sources is affecting visibility at a Class I area; and extending the SIP submittal deadline for the second planning period from July 31, 2018 to July 31, 2021 to allow states to consider planning for other federal standards like the 2010 one-hour SO_2 NAAQS and the 2012 annual $PM_{2.5}$ NAAQS. Additionally, the 2017 rule adjusts the interim progress report submission deadlines so that second progress reports will be due by January 31, 2025.

1.4 CLASS I AREAS

Texas has two Class I areas within its borders located in west Texas. Big Bend National Park (Big Bend) is in Brewster County and borders the Rio Grande and Mexico. Guadalupe Mountains National Park (Guadalupe Mountains) is in Culberson County and borders New Mexico. Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals* addresses Texas' impacts and long-term strategies for Class I areas outside of Texas.

1.4.1 Big Bend National Park

Big Bend was authorized as a national park on June 20, 1935 and established and signed into law on June 12, 1944 as the nation's 27th national park. The park gets its name from the course of the Rio Grande, which makes a great bend from a southeasterly to a northerly direction in the western portion of Texas [NPS, 2020 (https://www.nps.gov/bibe/index.htm)].

Big Bend has national significance as the largest protected area of Chihuahuan Desert in the continental U.S. The park contains river, desert, and mountain environments. Figure 1-3: *Big Bend 2020 Webcam View from Park Headquarters* shows a view of the mountains in miles from park headquarters. On a clear day, distant peaks over 80 miles away are clearly visible.

[2] EPA, 2017b. Protection of Visibility: Amendments to Requirements for State Plans, 82 FR 3078, https://www.govinfo.gov/content/pkg/FR-2017-01-10/pdf/2017-00268.pdf, January 10, 2017.

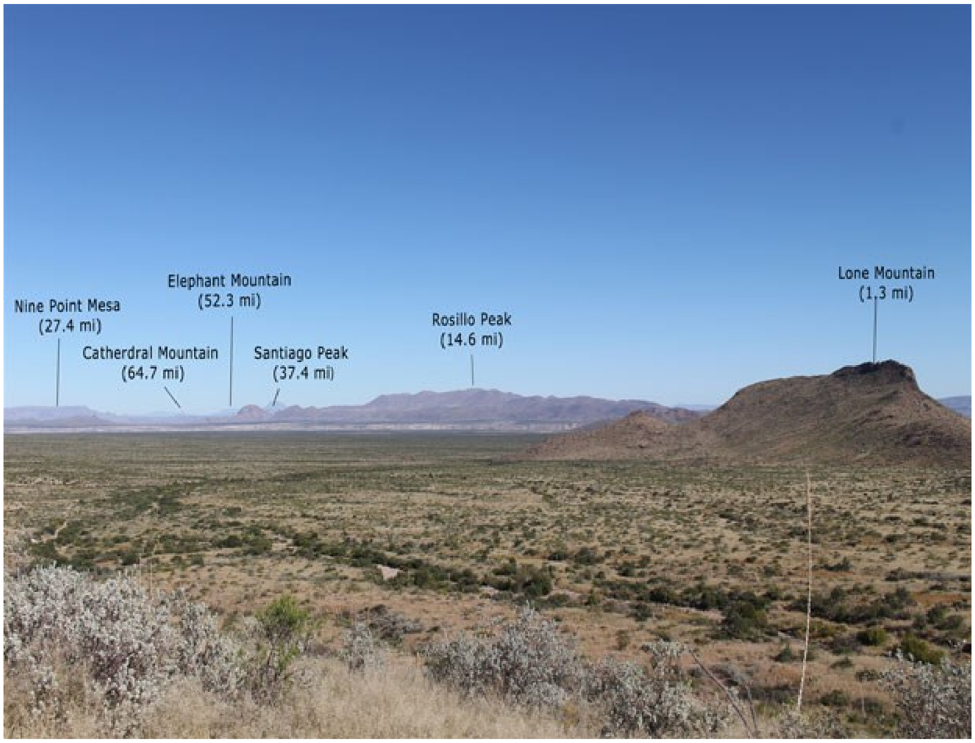

Figure 1-3: Big Bend 2020 Webcam View from Park Headquarters

1.4.2 Guadalupe Mountains National Park

Guadalupe Mountains was established as a national park on September 30, 1972 and contains Guadalupe Peak, the highest point in Texas at 8,749 feet. The park covers more than 86,000 acres and is in the same mountain range as Carlsbad Caverns National Park, which is located about 40 miles to the northeast in New Mexico. Carlsbad Caverns and Guadalupe Mountains share the same IMPROVE monitor, which helps measure visibility for the program.

The Guadalupe Mountains and Big Bend National Parks are in the Chihuahuan Desert (see Figure 1-4: *The Chihuahuan Desert in North America*). The Chihuahuan Desert is just one of the three deserts in the arid southwestern U.S.; the Sonoran and Mojave Deserts are west and adjacent to the Chihuahuan Desert.

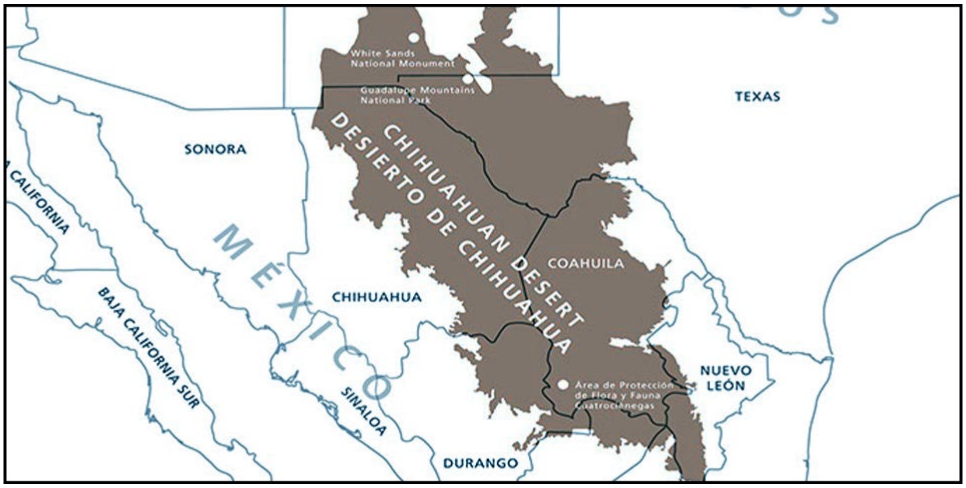

Figure 1-4: The Chihuahuan Desert in North America

Source: NPS, 2020 (https://www.nps.gov/im/chdn/ecoregion.htm)

1.5 GENERAL PLANNING PROVISIONS

In accordance with the federal Regional Haze Rule (40 Code of Federal Regulations (CFR) §51.308), the TCEQ submits this state implementation plan (SIP) revision to address the core requirements of 40 CFR §51.308(f) – (i). This SIP revision addresses coordination with regional planning groups, states and tribes, FLMs, and the EPA. The TCEQ also commits to plan revisions and adequacy determinations as outlined in this SIP revision.

1.6 PUBLIC HEARING AND COMMENT INFORMATION

The commission will hold a public hearing for this proposed SIP revision at the following time and location:

Table 1-2: Public Hearing Information

City	Date	Time	Location
Austin	December 8, 2020	2:00 p.m.	Virtual Hearing (Hearing registration details will be provided on the Texas SIP Revisions webpage by October 9, 2020 and in the formal hearing notice publication in the Texas Register)

The public comment period will open on October 9, 2020 and close on December 9, 2020. Written comments will be accepted via mail or through the eComments (https://www6.tceq.texas.gov/rules/ecomments/) system. All comments should reference the "2021 Regional Haze SIP Revision" and should reference Project Number 2019-112-SIP-NR. Comments may be submitted to Margaret Earnest, MC 206, State Implementation Plan Team, Air Quality Division, Texas Commission on Environmental Quality, P.O. Box 13087, Austin, Texas 78711-3087. If you choose to submit electronic comments, they must be submitted via the eComments system. File size restrictions may apply to comments being submitted via the eComments system. Comments must be received by December 9, 2020.

An electronic version of this proposed 2021 Regional Haze SIP Revision and appendices can be found at the TCEQ's SIP Revision: Regional Haze webpage (https://www.tceq.texas.gov/airquality/sip/bart/haze_sip.html). An electronic version of the hearing notice will also be available on the Texas SIP Revisions webpage (https://www.tceq.texas.gov/airquality/sip/sipplans.html#prosips).

1.7 FEDERAL LAND MANAGERS REVIEW

Public comments, including those from federal agency staff, will be provided on the TCEQ's regional haze webpage. If adopted by the commission, the final SIP revision would incorporate federal comments and the TCEQ's responses, as required per 40 CFR 51.308(i)(3).

CHAPTER 2: REGIONAL PLANNING

2.1 OVERVIEW

In the preamble to the Regional Haze Rule, the United States Environmental Protection Agency (EPA) acknowledged the key role of regional pollutant transport in contributing to haze in Class I areas and required multi-state coordination for planning and implementing regional haze programs (EPA, 1999). The EPA provided grant funding for establishing the initial five regional planning organizations (RPO) as follows:

- Central States Air Resource Agencies (CenSARA) (http://www.censara.org/);
- Western Regional Air Partnership (WRAP) (http://www.wrapair2.org/default.aspx);
- Lake Michigan Air Directors Consortium (LADCO) (http://www.ladco.org/);
- Mid-Atlantic/Northeast Visibility Union (MANE-VU) (https://otcair.org/manevu/); and
- Metro4-Southeastern States Air Resource Managers (SESARM) (http://www.metro4-sesarm.org/).

After the EPA funding for regional haze was reduced, the states contributed funding to the RPO's. Figure 2-1: *Map of the Regional Planning Organizations* shows the geographic areas of the five RPOs. Texas is a member of CenSARA as are Oklahoma, Louisiana, Arkansas, Missouri, Kansas, Nebraska, and Iowa. Some tribes also participate in CenSARA.

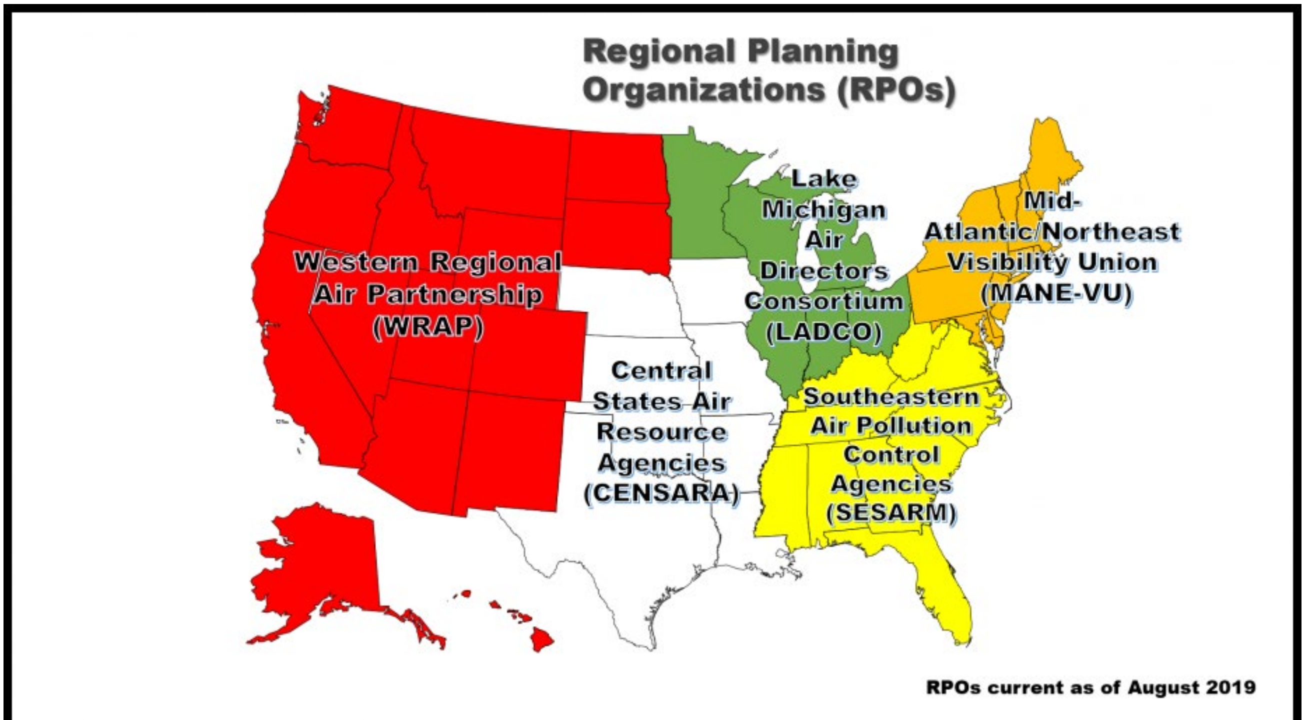

Figure 2-1: Map of the Regional Planning Organizations

Initiated in late 1995, CenSARA held a series of workshops to develop the organization's charter and bylaws, conduct initial long-range planning, and prepare its first grant application regarding air quality. CenSARA created CenRAP to accept funds exclusively for regional haze issues.

CenSARA defines the purposes of the organization as follows:

- identify regional, common air management issues, and develop and identify strategies to address these issues;
- promote policies that ensure fair and equitable treatment of all participating members;
- coordinate science and technology to support air quality policy issues in the central states;
- promote the implementation of federal visibility rules;
- recommend strategies on regional haze and other air quality issues for member states and tribes in developing implementation programs, regulations, and laws; and
- conduct research and undertake other activities, as necessary, to provide the membership with information to support the development of sound state and tribal air pollution policies.

In concurrence with EPA policy, CenSARA's bylaws state, "the CenSARA has no regulatory authority and recognizes that its members, in accordance with existing law, retain all legal authority" (CenSARA, 2000). While Texas participates in CenSARA and benefits from the technical work coordinated by the RPO, Texas has sole responsibility and authority for the development and content of its regional haze state implementation plan (SIP).

2.2 HISTORY OF TEXAS PARTICIPATION

The Texas Commission on Environmental Quality (TCEQ) participated in the planning process for regional haze and has since December 1995 when CenSARA convened a workshop to develop the charter, bylaws, and initial long-range plan. The Central Regional Air Planning Association (CenRAP) was specifically set up for states to work on regional haze. CenRAP has been abolished and CenSARA is now handling regional haze and other air quality issues. The TCEQ has participated in monthly regional haze planning and technical conference calls with CenSARA member states. In addition, the TCEQ is represented on the CenSARA Board of Directors and has been since 1995.

Through its participation, the TCEQ provides data to CenSARA and the EPA to produce emissions inventories and modeling for states to use when drafting their second planning period regional haze SIP revisions.

CHAPTER 3: STATE, TRIBE, AND FEDERAL LAND MANAGER CONSULTATION

3.1 INTRODUCTION

The Regional Haze Rule requires a state to consult with other states and federal land managers (FLM). Title 40 Code of Federal Regulations (CFR) §51.308(f)(2)(ii) requires a state to consult with other states prior to the proposal of this 2021 Regional Haze State Implementation Plan (SIP) Revision. In this plan development, the FLMs were consulted in accordance with the provisions of 40 CFR §51.308(i)(2). In developing its long-term strategy, states are required to consult with other states reasonably anticipated to cause or contribute to visibility impairment in their Class I areas. If a state determines it has emissions that are reasonably anticipated to contribute to visibility impairment in any Class I area in another state, that state must consult with the other states when developing its long-term strategy. In the spring of 2020, the Texas Commission on Environmental Quality (TCEQ) consulted with other states, FLMs, and stakeholders. In addition, the FLMs have an opportunity to submit comments during the public comment period for this proposed SIP revision. The TCEQ is continuing to consult with other states and the FLMs; therefore, this proposal may not include a complete record of consultation. The TCEQ will include any additional consultation information that occurs after July 31, 2020 at adoption per 40 CFR §51.308(i)(4) (see Appendix A).

The National Park Service (NPS) manages the two Class I areas in Texas. The United States (U.S) Fish and Wildlife Service (FWS), the U.S. Forest Service (FS), and NPS manage the other parks discussed in this chapter. All three of these federal agencies employ FLMs that manage parks in the neighboring states and were included in the consultations. FLMs regularly attend regional planning organizations (RPO) calls, conferences, and national meetings and have for over 10 years. The U.S. Environmental Protection Agency (EPA) also attended many RPO calls, conferences, and national meetings since 2010 (CenSARA and WRAP, 2020 https://www.wrapair2.org/).

3.2 CONSULTATION ON CLASS I AREAS IN TEXAS

For this regional haze SIP revision, the TCEQ organized separate initial consultation calls with three states and FLMs for the Class I areas in Texas: Big Bend and Guadalupe Mountains National Parks. In the first round of consultation calls, the TCEQ addressed Comprehensive Air Quality Model with Extensions (CAMx) modeling in Big Bend and Guadalupe Mountains, emission projections through 2028, and four-factor analysis progress. Texas' impacts on surrounding Class I areas outside of Texas were also discussed with the applicable state and the FLMs. The TCEQ's presentation included maps, charts, and glidepaths and was provided to all participants. Appendix A: *Consultation Documents* includes the presentation.

Further consultation calls included open dialogue between the states or FLMs to gather technical input. The TCEQ used results from CAMx and Particulate Matter Source Apportionment Technology (PSAT) to look at other states contributions to visibility impairment at Texas Class I areas. It was determined that other states did not have a significant impact on Texas Class I areas, and the TCEQ is not requesting additional reductions from other states.

3.3 CONSULTATIONS ON CLASS I AREAS IN OTHER STATES

The TCEQ has cooperated with CenSARA states and federal agencies through monthly conference calls and annual meetings for over four years concerning regional haze for the second planning period. The TCEQ also actively participated in developing the EPA's 2016 base case emissions inventory for use by states' in the development of SIP revisions.

The TCEQ developed a presentation for consultation meetings with FLMs and states. The consultation presentation, as referenced in Sections 3.4.1: *Arkansas,* 3.4.2: *New Mexico*, 3.4.3: *Oklahoma*, and 3.4.5: *Federal Land Managers*, included area of influence (AOI) maps for Class I areas in three states, illustrated in Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals*, Figure 7 1: *NO_X Sources Selected for Four-Factor Analysis*, and Figure 7-2: *SO_2 Sources Selected for Four-Factor Analysis*. For reference purposes, the maps showed the portions of Texas that are in the first and second order sulfate and nitrate AOI for the given Class I area. The sulfur dioxide and nitrogen oxides sources on the map are Texas sources the TCEQ identified as high priority because they have an emissions over distance equal to or greater than five ($Q/d \geq 5$) for one or more Class I area. Chapter 7 and Chapter 8: *Reasonable Progress Goals* provides more details on how sources were determined. Appendix A includes lists of names, organizations, presentations with maps, and summaries of calls.

3.4 CONSULTATION SUMMARIES

The TCEQ consulted with Arkansas, New Mexico, and Oklahoma as they were the only states that met the impact criteria. Other Class I areas in Colorado, Louisiana, and Missouri underwent Hybrid Single-Particle Lagrangian Integrated Trajectory and AOI review along with Q/d evaluation. The TCEQ determined that Texas point source emissions do not significantly impact other Class I areas and did not receive requests for consultation from any other state. The TCEQ received a request from Mid-Atlantic/Northeast Visibility Union (MANE-VU), which is discussed in Section 4.4.4: *MANE-VU Ask*.

3.4.1 Arkansas

The TCEQ invited Arkansas to consult on the impact of Texas' emissions on regional haze at two Class I areas: Caney Creek Wilderness Area and Upper Buffalo Wilderness Area. The TCEQ provided a presentation depicting the modeling and technical work required to ascertain source attribution along with 18 facilities selected for the four-factor analysis (see Appendix A). In a February 4, 2020 letter, Arkansas requested Texas consider whether performing a four-factor analysis is appropriate for one additional source beyond the 18 TCEQ had already determined (see Appendix A).

The TCEQ also participated in Arkansas' consultation calls regarding progress on their regional haze technical work. Documentation of Arkansas' consultation with Texas is expected to be available when Arkansas' 2021 regional haze SIP revision is completed.

3.4.2 New Mexico

The TCEQ invited New Mexico to consult on the impact of Texas' emissions on regional haze at five Class I areas: Salt Creek Wilderness Area, Bosque del Apache Wilderness Area, Carlsbad Caverns National Park, White Mountain Wilderness Area, and Wheeler Peak Wilderness Area. The TCEQ provided a presentation depicting the modeling and technical work required to ascertain source attribution and discussed impacts selected Class I areas in New Mexico (see Appendix A). In an April 24, 2020 letter, New Mexico submitted questions on the TCEQ's initial presentation and the TCEQ organized a second consultation call on May 26, 2020 to respond to New Mexico's questions. The letter and summary are also provided in Appendix A.

The TCEQ also participated in New Mexico's consultation calls in 2020. Documentation of New Mexico's consultation with Texas is expected to be available when New Mexico's 2021 regional haze SIP revision is completed.

3.4.3 Oklahoma

The TCEQ invited Oklahoma to consult about one Class I area, the Wichita Mountains National Wildlife Refuge. The TCEQ provided a presentation depicting the modeling and technical work required to ascertain source attribution along with 18 facilities selected for four-factor analysis (see Appendix A). In a July 17, 2020 letter, Oklahoma provided a list of sources that the TCEQ should consider for further analysis. A copy of the letter is provided in Appendix A.

The TCEQ also participated in Oklahoma's consultation calls in 2020. Documentation of Oklahoma's consultation with Texas is expected to be available when Oklahoma's 2021 regional haze SIP revision is completed.

3.4.4 MANE-VU Ask

The MANE-VU RPO included Texas in their consultation process regarding the potential impact of Texas' emissions on regional haze at two Class I areas in the northeastern U.S., Brigantine Wilderness in New Jersey and Moosehorn Wilderness in Maine. Neither of these two MANE-VU states directly contacted Texas. Contact was through the RPO, as reported in the MANE-VU Regional Haze Consultation Report (MANE-VU, 2018). Through conference calls with MANE-VU, the RPO requested Texas evaluate suggested regulatory actions in its SIP revision for the second planning period. The details of the MANE-VU ask can be found in Appendix A.

The TCEQ submitted comments disagreeing with the MANE-VU conclusion that sources within Texas substantially contribute to visibility impairment in Class I areas in the region (MANE-VU, 2018). The TCEQ disagreed with the assertion that emissions from sources within Texas significantly impact Class I areas in the northeast because the approaches MANE-VU took to determine potential impact overstated the contribution from sources in Texas. Texas, as well as the Lake Michigan Air Directors Consortium (LADCO) and other states, raised concerns about the use of the emissions over distance by wind direction constant (Q/d*C) and the California Puff (CALPUFF) Model methodologies. More specifically, they had concerns regarding these tools' limitations: the use of pooled statewide emissions for Q/d rather than individual sources and the use of CALPUFF at distances greater than 300 kilometers, where the model becomes unreliable.

MANE-VU asked that the TCEQ consider the following measures in the 2021 Regional Haze SIP Revision:

- Ensure the most effective use of control technologies on a year-round basis for EGUs with 25 MW or greater capacity.

- Pursue an ultra-low sulfur fuel oil standard similar to the one adopted by MANE-VU states in 2007.
- Pursue updated permits for EGUs and other large point sources with 250 million British thermal units (MMBtu) per hour heat emissions to lock in lower emissions rates.
- Pursue energy efficiency measures including increased use of combined heat and power (CHP) and other clean distributed generation technologies including fuel cells, wind, and solar.

The TCEQ disagreed with MANE-VU's conclusion that Texas sources significantly impact Class I areas within the MANE-VU region. This stance is supported by the screening analysis (Areas of Influence and Q/d) conducted by the TCEQ and included in this proposed SIP revision. These results indicate that emissions from sources within Texas are unlikely to impact Class I areas in the northeast. As such, the TCEQ did not include a formal analysis of the measures listed above.

3.4.5 Federal Land Managers

Per 40 CFR §51.308(f)(2)(ii), §51.308(i)(2), and §51.308(i)(4), Texas consulted with states and FLMs for all in-state Class I areas and affected out-of-state Class I areas on an ongoing basis through CenSARA and separate calls.

The TCEQ consulted the FLMs about the impact of Texas' emissions on regional haze at the regional Class I areas through conference calls. The TCEQ gave a presentation and discussed impacts to Class I areas in the region (see Appendix A). During a second call, NPS requested Texas look at 15 additional sources that were not included in the TCEQ's four-factor analysis (see Appendix A). Also, in the second call, NPS requested the TCEQ look again at three New Mexico Class I areas: Bandelier, Salt Creek, and Carlsbad Caverns.

CHAPTER 4: ASSESSMENT OF BASELINE AND CURRENT CONDITIONS AND ESTIMATE OF NATURAL CONDITIONS IN CLASS I AREAS

4.1 VISIBILITY REQUIREMENTS

The Federal Clean Air Act's (FCAA) visibility protection program, implemented at 40 Code of Federal Regulations (CFR) §51.300 through §51.309, requires reasonable progress towards achieving the national goal of natural visibility conditions in the 156 Class I areas identified in the 1977 FCAA Amendments. Title 40 CFR §51.301 defines natural conditions as naturally occurring phenomena that reduce visibility as measured in terms of light extinction, visual range, contrast, or coloration, and may refer to the conditions on a single day or a set of days. These phenomena include, but are not limited to, humidity, fire events, dust storms, volcanic activity, and biogenic emissions from soils and trees. These phenomena may be near or far from a Class I area and may be outside the United States. State regional haze plans must contain measures that make "reasonable progress" toward this goal by reducing anthropogenic emissions that cause haze. Title 40 CFR §51.308(f)(1)(i)-(vi) contains three metrics of visibility:

- baseline conditions, i.e., the average of the five annual averages of the individual values of daily visibility for the period 2000 through 2004 unique to each Class I area for either the most anthropogenically impaired days (most impaired days) or the clearest days;
- natural conditions, i.e., the average of individual values of daily natural visibility unique to each Class I area for either the most impaired days or the clearest days; and
- current conditions, i.e., the average of the five annual averages of individual values of daily visibility for the most recent period for which data are available unique to each Class I area for either the most impaired days or the clearest days.

To calculate these metrics, the concentrations of visibility-impairing pollutants are included as distinct terms in a light extinction algorithm with respective extinction coefficients and relative humidity factors (see the Interagency Monitoring of Protected Visual Environments (IMPROVE) algorithm in Chapter 8: *Reasonable Progress Goals* of this SIP revision.) Total light extinction is converted to deciviews and then averaged for the 20% clearest and 20% most impaired visibility days (EPA, 2018). Title 40 CFR §51.301 defines a deciview as "the unit of measurement on the deciview index scale for quantifying in a standard manner human perceptions of visibility." The deciview index is calculated based on the following equation:

$$\text{Deciview index} = 10 \ln (\text{Bext}/10\ \text{Mm}^{-1})$$

Where:

Bext = the atmospheric light extinction coefficient, expressed in inverse megameters (Mm^{-1})

The Regional Haze Rule requires a revised approach to tracking visibility improvements over time within the Uniform Rate of Progress (URP) framework (EPA, 2017b). Under these Regional Haze Rule revisions, in the second and future implementation periods, states must select the "20% most impaired days" each year at each Class I area based on daily anthropogenic impairment. The 20% most impaired days are those days with the highest anthropogenic visibility impairment, in deciviews (dv), defined as:

$$\Delta\ dv_{anthropogenic\ visibility\ impairment} = dv_{total} - dv_{natural}$$

Where:

dv_{total} = the overall deciview value for a day; and

$dv_{natural}$ = the natural portion of the deciview value for a day.

There are several steps required to calculate the $dv_{natural}$ value, including the assignment of the daily extinction values into episodic natural, routine natural, and anthropogenic components. The episodic natural extinction is typically associated with extreme episodic events like wildfire smoke and dust storms that are identified by a site-specific threshold of carbon (organic carbon + elemental carbon) and dust (fine soil + coarse matter) based on observed IMPROVE 95th percentile values from 2000 through 2014. The non-episodic extinction values for each day are then allocated to the routine natural and anthropogenic categories based on the ratio of the Natural Conditions II estimates and non-episodic annual average for each chemical species. Any remaining extinction after determining the episodic and routine natural extinction is assigned to the anthropogenic category. Days selected as the 20% most impaired have the highest anthropogenic extinction relative to the natural extinction.

Baseline visibility was obtained from IMPROVE monitoring data for 2000 through 2004 and represents visibility conditions for the baseline period. Comparison of baseline conditions to natural visibility conditions shows the improvement necessary to attain natural visibility by 2064. Natural visibility is determined by estimating the natural concentrations of visibility-impairing pollutants and then calculating total light extinction with the IMPROVE algorithm, see Figure 4-1: *Example Diagram Showing the Important Parameters Used to Calculate the Visibility Metrics for the Regional Haze Rule* (EPA, 2018). Each state must estimate natural visibility levels for Class I areas within its borders in consultation with FLMs and other states that impact the Class I areas per 40 CFR §51.308(f)(1).

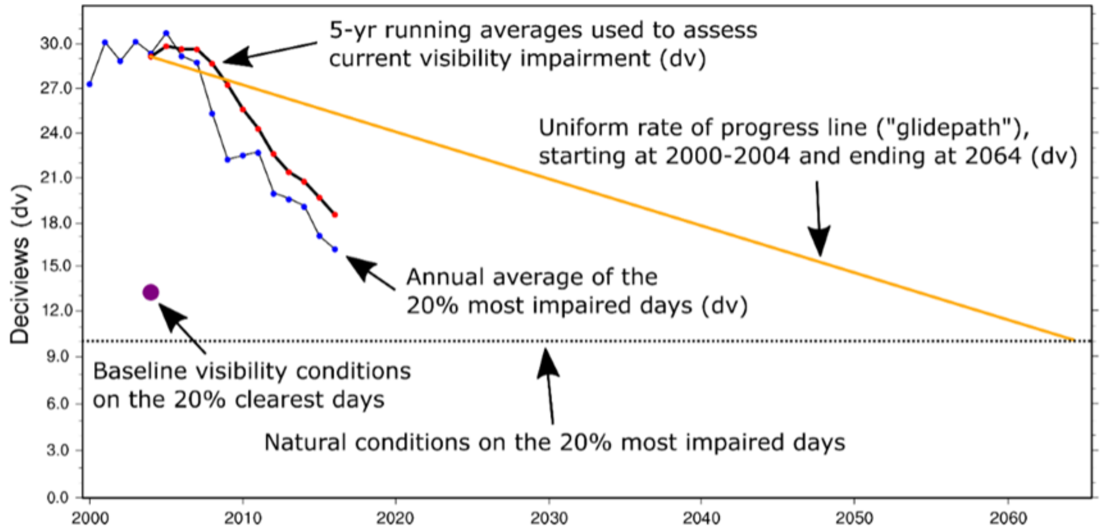

Figure 4-1: Example Diagram Showing the Important Parameters Used to Calculate the Visibility Metrics for the Regional Haze Rule

4.1.1 Default and Refined Values for Natural Visibility Conditions

The EPA's *Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program* provides guidance for estimating daily natural and anthropogenic visibility fractions and light extinction budgets and calculating the 20% most impaired and 20% clearest days (EPA, 2018). The first step in determining the natural portion of the deciview value for a given day is to split the daily light extinction into natural and anthropogenic fractions. Because these are not directly measured, a statistical or computational method must be used to estimate these fractions. The steps involved in identifying the 20% most impaired days and calculating natural conditions are as shown in Figure 4-2: *Flow Chart of the Steps Involved in Calculating the 20% Most Impaired Days*.

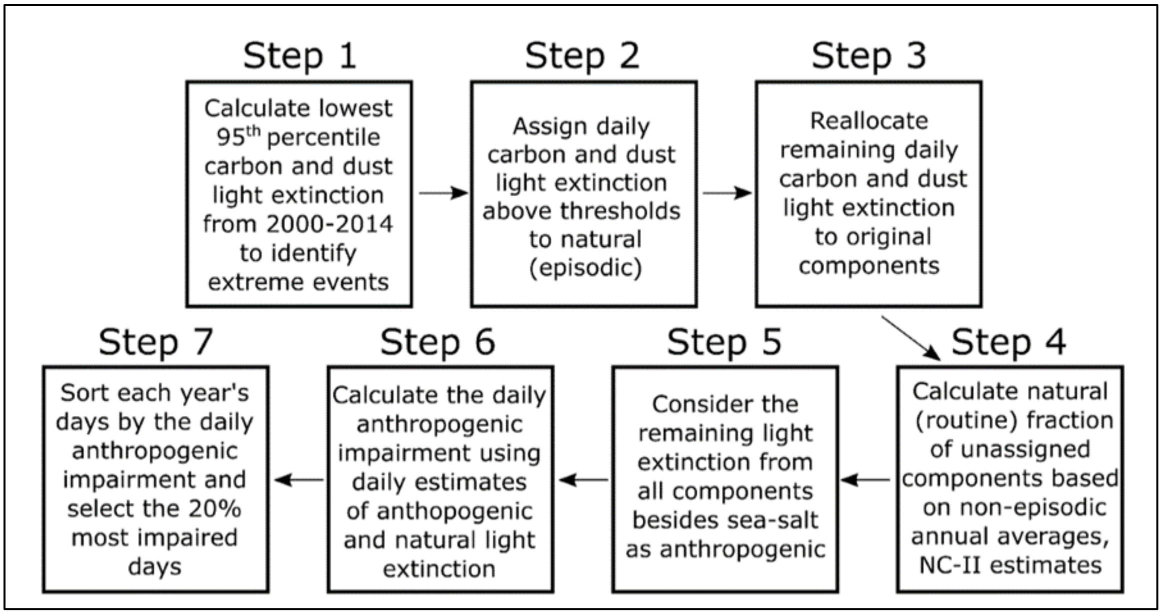

Figure 4-2: Flow Chart of the Steps Involved in Calculating the 20% Most Impaired Days

4.2 BASELINE VISIBILITY CONDITIONS

The Regional Haze Rule requires states to determine the baseline (2000 through 2004) visibility condition for the 20% most impaired days. For the five-year baseline period, sites are required to have three valid years of data from which baseline conditions can be constructed. The Federal Land Manager Environmental Database[3] has posted data, based on the revised IMPROVE algorithm (Pitchford, 2007), for the 20% most impaired and clearest days for each complete year of the baseline period. From these values, the baseline haze index is calculated by averaging over the baseline period. Table 4-1: *Baseline Haze Indices* shows this calculation for both Big Bend and Guadalupe Mountains.

Baseline visibility for the Big Bend Class I area is 8.0 deciviews for the 20% clearest days and 15.6 deciviews for the 20% most impaired days. This baseline visibility is based on sampling data collected at the Big Bend IMPROVE monitoring site. Baseline visibility for Big Bend is based on valid data for 2001 through 2004 because 2000 did not meet completeness criteria.

Baseline visibility for the Guadalupe Mountains Class I area is 10.2 deciviews for the 20% clearest days and 14.6 deciviews for the 20% most impaired days. This baseline visibility is based on sampling data collected at the Guadalupe Mountains IMPROVE monitoring site. Table 4-1: *Baseline Haze Indices for Big Bend* and Table 4-2: *Baseline Haze Indices for Guadalupe Mountains* show the baseline visibility conditions for 2000 through 2004 for Big Bend and Guadalupe Mountains IMPROVE monitors.

[3] Accessed June 2020 http://views.cira.colostate.edu/fed/

Table 4-1: Baseline Haze Indices for Big Bend

Year	Most Impaired Haze Index (dv)	Clearest Haze Index (dv)
2001	15.68	10.41
2002	16.20	9.12
2003	14.80	7.29
2004	15.60	5.29
Average	15.57	8.03

Table 4-2: Baseline Haze Indices for Guadalupe Mountains

Year	Most Impaired Haze Index (dv)	Clearest Haze Index (dv)
2000	14.98	9.41
2001	14.67	9.54
2002	15.99	11.85
2003	13.66	12.52
2004	13.71	7.65
Average	14.60	10.19

4.3 NATURAL VISIBILITY CONDITIONS

The *Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program* (EPA, 2018) indicates the following should be reported by states in the Regional Haze SIP for the second planning period: baseline, current, and natural visibility conditions for the 20% most anthropogenically impaired days and the 20% clearest days. These six conditions must be quantified in deciviews. The natural conditions for the 20% clearest days are given as the Natural Conditions II values for the p10 group (same as 20% clearest days) as described in http://vista.cira.colostate.edu/Improve/wp-content/uploads/2016/03/naturalhazelevelsIIreport-1.ppt. These values were obtained from the IMPROVE Committee website at the following location: http://vista.cira.colostate.edu/Improve/rhr-summary-data/. Specifically, the Natural Conditions II file, which was updated December 2019.

Using the revised IMPROVE algorithm (Pitchford, 2007) and the methodology described in the EPA guidance (EPA, 2018), the TCEQ determined that natural visibility conditions for the Big Bend Class I area are best represented by 5.3 deciviews for the 20% most impaired days. The Guadalupe Mountains Class I area is best represented by 4.8 deciviews for the 20% most impaired days. Table 4-2: *Estimate of Natural Visibility Conditions for the Class I Areas in Texas*, Table 4-3: *Estimate of Baseline Visibility Conditions (2000 through 2004) for the Class I Areas in Texas*, and Table 4-4: *Estimate of Recent Visibility Conditions (2012 through 2018) for the Class I Areas in Texas* report the visibility metrics computed for Big Bend and Guadalupe Mountains.

Table 4-3: Estimate of Natural Visibility Conditions for the Class I Areas in Texas

Class I Area	Most Impaired Haze Index (dv)	Clearest Haze Index (dv)
Big Bend	5.33	1.62
Guadalupe Mountains	4.83	0.99

Table 4-4: Estimate of Baseline Visibility Conditions (2000 through 2004) for the Class I Areas in Texas

Class I Area	Most Impaired Haze Index (dv)	Clearest Haze Index (dv)
Big Bend	15.57	8.03
Guadalupe Mountains	14.60	10.19

Table 4-5: Estimate of Recent Visibility Conditions (2014 through 2018) for the Class I Areas in Texas

Class I Area	Most Impaired Haze Index (dv)	Clearest Haze Index (dv)
Big Bend	14.06	6.77
Guadalupe Mountains	12.64	6.76

Per 40 CFR §51.308(f)(1)[4], Texas determined the following for each in-state Class I area:

- the baseline visibility conditions for the 20% most anthropogenically impaired days and for the 20% clearest days;
- the current visibility conditions for the 20% most anthropogenically impaired days and for the 20% clearest days; and
- the natural visibility conditions for the 20% most anthropogenically impaired days and for the 20% clearest days.

[44] As defined in 40 CFR §51.308(f)(1), (https://www.ecfr.gov/cgi-bin/text-idx?SID=f2c7482e0fc58eb09b2c1b9dc401d688&mc=true&node=sp40.2.51.p&rgn=div6)

CHAPTER 5: MONITORING STRATEGY

5.1 INTRODUCTION

Title 40 Code of Federal Regulations (CFR) §51.308(f)(6) of the Regional Haze Rule requires a monitoring strategy for measuring, characterizing, and reporting regional haze visibility impairment that is representative of the Class I areas within Texas. The monitoring strategy relies upon data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. A steering committee with representatives from federal, regional, and state organizations governs the program. These organizations include the United States (U.S.) Environmental Protection Agency (EPA), the National Parks Service, the (U.S.) Fish and Wildlife Service, the (U.S.) Forest Service, the Bureau of Land Management, and other entities. The IMPROVE Steering Committee allocates IMPROVE monitoring resources, which come from a number of agencies. The IMPROVE program arranges for the operation of IMPROVE monitors, the analysis of samples from the monitors, and the validation and internet posting of the IMPROVE data.

5.2 MONITORING AT CLASS I AREAS IN TEXAS

Currently, the IMPROVE program provides an IMPROVE monitor at each of the two Class I areas in Texas, Big Bend and Guadalupe Mountains. Because of their location, the monitors are appropriate for determining progress in reducing visibility impairment in the Texas Class I areas. The monitoring strategy relies on continuation of IMPROVE monitoring at these sites. No additional monitoring is required or necessary for assessing visibility conditions at the two Class I areas in Texas.

The IMPROVE program reviewed its aerosol monitoring sites in 2006[5] to set priorities for maintaining the sites in the event of federal budget cuts affecting the IMPROVE program. This review determined that the IMPROVE aerosol samplers at Texas' two Class I areas represent conditions different from the conditions at the nearest Class I area IMPROVE monitors. Texas' two Class I IMPROVE monitors are not candidates for discontinuation since other IMPROVE monitors cannot represent conditions at Big Bend or Guadalupe Mountains.

5.3 ASSESSMENT OF VISIBILITY IMPROVEMENT AT CLASS I AREAS

Future assessments of visibility impairment and progress in reducing visibility impairment at Texas' two Class I areas, and at Class I areas in other states that Texas' emissions may potentially affect, will use the revised IMPROVE algorithm (Pitchford, 2007) and will use data as prescribed in the EPA's Regional Haze Rule (40 CFR Part 51, Subpart P- Visibility Protection). The assessment will follow, as appropriate, the EPA guidance including *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period* (EPA, 2019) and *Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program* (EPA, 2018).

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[5] https://www3.epa.gov/ttnamti1/visdata.html

5.4 REPORTING VISIBILITY MONITORING DATA TO THE ADMINISTRATOR

The TCEQ does not directly collect or handle IMPROVE data. The TCEQ will continue to participate in the IMPROVE Visibility Information Exchange Web System (VIEWS). The TCEQ considers VIEWS to be a core part of the overall IMPROVE program. The TCEQ will report IMPROVE data from the two Class I areas in Texas to the EPA using the VIEWS web system.

If Texas collects any visibility monitoring data through the state's air quality monitoring networks, the TCEQ will report those data to the EPA as specified under the Performance Partnership Grant agreement negotiated with the EPA Region 6. All validated data and data analysis results from any TCEQ visibility-related special studies are public information. The TCEQ will continue its practice of sharing the data and information with the EPA.

Per 40 CFR 51.308(f)(1) of the rule, the TCEQ has determined the state has met the requirements of analysis of visibility monitoring data. The TCEQ used IMPROVE data provided by federal agencies for inclusion in this SIP. More analysis of data is found in other chapters throughout this SIP.

5.5 ASSESSING THE IMPACT OF EMISSIONS FROM TEXAS ON CLASS I AREAS

Chapter 4: *Assessment of Baseline and Current Conditions and Estimate of Natural Conditions*, Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals*, and Chapter 8: *Reasonable Progress Goals* describe the procedures used in developing this SIP revision. These chapters include the procedures to assess the quantitative impact of emissions from Texas on Class I areas in Texas and on Class I areas that Texas' emissions affect in other states.

Chapter 6: *Emissions Inventory* describes the procedures used for this SIP revision to produce the statewide emissions inventory of pollutants reasonably anticipated to cause or contribute to visibility impairment in the Class I areas that Texas' emissions affect. Chapter 9: *Requirements for Periodic Reports* describes the state's confirmation to submit a 2028 regional haze SIP revision.

The Performance Partnership Grant agreement negotiated with the EPA Region 6, the TCEQ's quality management plan, and the quality assurance project plans for collecting and reporting periodic emissions inventories to the EPA describe the collection, quality assurance, record keeping, maintenance, availability, and reporting of emissions and monitoring data to the EPA.

CHAPTER 6: EMISSIONS INVENTORY

6.1 INTRODUCTION

The Regional Haze Rule, Title 40 Code of Federal Regulations (CFR) §51.308(f)(6)(v), requires the establishment of a statewide emissions inventory (EI) of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any Class I area. The EI must include emissions for the most recent year for which data are available. In addition, 40 CFR §51.308(f)(2)(iii) requires that emissions information from the most recent triennial reporting year be included in this state implementation plan (SIP) revision.

The Texas Commission on Environmental Quality (TCEQ) complies with 40 CFR Part 51, Subpart A, Air Emissions Reporting Requirements (AERR) to develop and submit periodic emissions inventories (PEI) to the United States Environmental Protection Agency (EPA) every three years. Per the AERR, the 2011, 2014, and 2017 PEIs were reported to the EPA's National Emissions Inventory (NEI) as a comprehensive and detailed estimate of statewide air emissions. The 2011, 2014, and 2017 statewide emissions information are included in Chapter 7 to satisfy the Regional Haze Rule requirements outlined in 40 CFR §§51.308(f)(2)(iii) and 51.308(f)(6)(v).

The reported pollutants include nitrogen oxides (NO_X), volatile organic compounds (VOC), carbon monoxide (CO), sulfur dioxide (SO_2), ammonia (NH_3), fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), and fine particulate matter less than 10 microns in diameter (PM_{10}). The type of emissions sources, amount of each pollutant emitted, and the types of processes and control devices employed at each facility or source category are identified in the inventory. The AERR EI is derived from estimates developed for four general categories of anthropogenic emissions sources: point, area, non-road mobile, and on-road mobile. The EI provides data for a variety of air quality planning tasks, including establishing baseline emissions levels, calculating federally required emissions reduction targets, developing emissions inputs for air quality models, and tracking actual emissions reductions against established emissions growth and control budgets.

This chapter discusses general EI development for each of the anthropogenic source categories. Section 8.3: *Modeling* details specific EIs and emissions inputs developed for the Regional Haze photochemical modeling.

6.2 POINT SOURCES

The TCEQ annually collects stationary point source emissions data from sites that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. This rule establishes EI reporting thresholds including those in ozone nonattainment areas that are currently at or less than major source thresholds. Therefore, some minor sources report to the point source EI.

To collect the data, the TCEQ provides detailed reporting instructions and tools for completing and submitting an EI. Companies submit EI data using a web-based system called the Annual Emissions Inventory Report System. Companies are required to report emissions data and to provide sample calculations used to determine the emissions. Information characterizing the process equipment, the abatement units, and the emissions points is also required. Further, per Federal Clean Air Act (FCAA) §182(a)(3)(B), company representatives certify that reported emissions are true, accurate, and fully represent emissions that occurred during the calendar year to the best of the representative's knowledge.

The TCEQ reviews submitted EI data for quality assurance purposes and then stores the data in the State of Texas Air Reporting System database. The TCEQ's Point Source Emissions Inventory webpage (https://www.tceq.texas.gov/airquality/point-source-ei/psei.html) contains guidance documents and historical point source emissions data.

6.3 AREA SOURCES

Stationary emissions sources that do not meet the reporting requirements for point sources are classified as area sources. Area sources are small-scale stationary industrial, commercial, and residential sources that use materials or perform processes that generate emissions. Examples of typical area sources include oil-and-gas production sources, printing operations, industrial coatings, degreasing solvents, house paints, gasoline service station underground tank filling, vehicle refueling operations, stationary source fossil fuel combustion at residences and businesses, outdoor refuse burning, and structure fires.

Area source emissions are calculated as county-wide totals rather than as individual sources. Area source emissions are typically calculated by multiplying an EPA- or TCEQ -developed emissions factor (emissions per unit of activity) by the appropriate activity or activity surrogate responsible for generating emissions. Population is one of the more commonly used activity surrogates for area source calculations. Other activity data commonly used include the amount of gasoline sold in an area, employment by industry type, and crude oil and natural gas production.

The emissions data for the different area source categories are developed, quality assured, stored in the Texas Air Emissions Repository database system, and compiled to develop the statewide area source EI.

6.4 NON-ROAD MOBILE SOURCES

Non-road vehicles do not normally operate on roads or highways and are often referred to as off-road or off-highway vehicles. Non-road emissions sources include agricultural equipment, commercial and industrial equipment, construction and mining equipment, lawn and garden equipment, aircraft and airport equipment, locomotives, drilling rigs, and commercial marine vessels (CMV).

For this proposed regional haze SIP revision, EIs for non-road sources were developed for the following subcategories: NONROAD model categories, airports, locomotives, CMVs, and drilling rigs used in upstream oil-and-gas exploration activities. The airport subcategory includes estimates for emissions from the aircraft, auxiliary power units (APU), and ground support equipment (GSE) subcategories. The following sections describe the emissions estimation methods used for the non-road mobile source subcategories.

6.4.1 NONROAD Model Categories

The Motor Vehicle Emission Simulator 2014b (MOVES2014b) model is the EPA's latest mobile source emissions model for estimating non-road source category emissions. The most recent Texas-specific utility for the non-road mobile component of MOVES2014b model, called Texas NONROAD (TexN2), was used to calculate emissions from all non-road mobile source equipment and recreational vehicles, except for airports, locomotives, CMVs, and drilling rigs used in upstream oil-and-gas exploration activities.

Because emissions for airports, CMVs, and locomotives are not included in either the MOVES2014b model or the TexN2 utility, the emissions for these categories are estimated using other EPA-approved methods and guidance.

6.4.2 Drilling Rigs

Although emissions for drilling rig diesel engines are included in the MOVES2014b model, alternate emissions estimates were developed for that source category to develop more accurate county-level inventories. The equipment populations for drilling rigs were set to zero in the TexN2 utility to avoid double counting emissions.

Due to significant growth in the oil-and-gas exploration and production industry, a 2015 TCEQ-commissioned survey of oil-and-gas exploration and production companies was used to develop updated drilling rig emissions characterization profiles. The drilling rig emissions characterization profiles from this study were combined with county-level drilling activity data obtained from the Texas Railroad Commission to develop the EI.

6.4.3 CMVs and Locomotives

The locomotive EI was developed from a TCEQ-commissioned study using EPA-accepted EI development methods. The locomotive EI includes line haul and yard emissions activity data from all Class I, II, and III locomotive activity and emissions by rail segment. The method and procedures used to develop the locomotive EI for this Regional Haze SIP revision can be found in the Eastern Research Group, Inc. (ERG) report *2014 Texas Statewide Locomotive Emissions Inventory* and *2008 through 2040 Trend Inventories*, available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155153802FY15-20150826-erg-locomotive_2014aerr_inventory_trends_2008to2040.pdf.

The CMV EI was developed from a TCEQ-commissioned study using EPA-accepted EI development methods. The CMV EI includes at-port and underway emissions activity data from Category I, II, and III CMVs by county. The method and procedures used to develop the CMV EI for this Regional Haze SIP revision can be found in the ERG report *2014 Texas Statewide Commercial Marine Vessel Emissions Inventory* and *2008 through 2040 Trend Inventories*, available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155149301FY15-20150826-erg-commercial_marine_vessel_2014aerr_inventory_trends_2008to2040.pdf.

6.4.4 Airports

The airport EI was developed from a TCEQ-commissioned study using the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT). AEDT is the most recent FAA model for estimating airport emissions and has replaced the FAA's Emissions and Dispersion Modeling System. The airport emissions categories used for this Regional Haze SIP revision included aircraft (commercial air carriers, air taxis, general aviation, and military), APU, and GSE operations.

The method and procedures used to develop the airport EIs for this revision can be found in the Eastern Research Group, Inc. reports:

- *Development of the Statewide Aircraft Inventory for 2011* (available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582188250819-20190515-erg-2011_statewide_airport_emissions_inventory.pdf)
- *Aircraft Emissions Inventory for Texas Statewide 2014 AERR Inventory and 2008 to 2040 Trend Analysis Years* (available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155160603FY1508-20160516-erg-2014_AERR_Inventory_Aircraft_Revised.pdf)
- *Development of Statewide Aircraft Inventory for 2017* (available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582188250819-20190104-erg-2017_statewide_airport_emissions_inventory.pdf)

6.5 ON-ROAD MOBILE SOURCES

On-road mobile emissions sources consist of automobiles, trucks, motorcycles, and other motor vehicles traveling on public roadways. On-road mobile source ozone precursor emissions are usually categorized as combustion-related emissions or evaporative hydrocarbon emissions. Combustion-related emissions are estimated for vehicle engine exhaust. Evaporative hydrocarbon emissions are estimated for the fuel tank and other evaporative leak sources on the vehicle. To calculate emissions, both the rate of emissions per unit of activity (emission factors) and the number of units of activity must be determined.

Updated on-road EIs and emission factors for this proposed regional haze SIP revision were developed using the EPA's mobile emissions factor model, MOVES2014a.[6] The MOVES2014a model may be run using national default information or the default information may be modified to simulate specific data, such as the control programs, driving behavior, meteorological conditions, and vehicle characteristics. Because modifications to the national default values influence the emission factors calculated by the MOVES2014a model, parameters that are used in TCEQ EI development reflect local conditions to the extent that local values are available. The localized inputs used for the on-road mobile EI development include vehicle speeds for each roadway link, vehicle populations, vehicle hours idling, temperature, humidity, vehicle age

[6] For on-road EI development, MOVES2014a is technically the most recent on-road model release. The more recent MOVES2014b update only impacts non-road model components and does not change the on-road portion of the model.

distributions for each vehicle type, percentage of miles traveled for each vehicle type, type of inspection and maintenance program, fuel control programs, and gasoline vapor pressure controls.

To estimate on-road mobile source emissions, emission factors calculated by the MOVES2014a model must be multiplied by the level of vehicle activity. On-road mobile source emissions factors are expressed in units of grams per mile, grams per vehicle (evaporative), and grams per hour (extended idle). Therefore, the activity data required to develop the on-road mobile source EI are vehicle miles traveled (VMT) in units of miles per day, vehicle populations, and source hours idling. The level of vehicle travel activity is developed using travel demand models (TDM) run by the Texas Department of Transportation or by the local metropolitan planning organizations. The TDMs are validated against a large number of ground counts, i.e., traffic passing over counters placed in various locations throughout a county or area. For SIP inventories, VMT estimates are calibrated against outputs from the federal Highway Performance Monitoring System, a model built from a different set of traffic counters. Vehicle populations by source type are derived from the Texas Department of Motor Vehicles' registration database and, as needed, national estimates for vehicle source type population.

In addition to the number of miles traveled on each roadway link, the speed on each roadway type or segment is also needed to complete an on-road EI. Roadway speeds, required inputs for the MOVES2014a model, are calculated by using the activity volumes from the TDM and a post-processor speed model.

6.6 EI IMPROVEMENT

The TCEQ EI reflects years of emissions data improvement, including extensive point and area source inventory reconciliation with ambient emissions monitoring data. Reports detailing recent TCEQ EI improvement projects can be found at the TCEQ's Air Quality Research and Contract Projects webpage (https://www.tceq.texas.gov/airquality/airmod/project/pj.html).

6.7 EMISSIONS SUMMARIES

The summaries of the latest NEI years for 2011, 2014, and 2017 statewide emissions for this proposed Regional Haze SIP revision are presented in Table 6-1: *2011 Statewide Pollutant Summary by Source Category*, Table 6-2: *2014 Statewide Pollutant Summary by Source Category*, and Table 6-3: *2017 Statewide Pollutant Summary by Source Category*. Emissions are provided in annual (routine) tons per year (tpy) by source category for each pollutant. Point source electric generating units (EGU) are represented separately from non-EGU point sources.

Table 6-1: 2011 Statewide Pollutant Summary by Source Category

Source Category	NO_X (tpy)	VOC (tpy)	CO (tpy)	SO_2 (tpy)	NH_3 (tpy)	$PM_{2.5}$ (tpy)	PM_{10} (tpy)
EGU Point Sources	145,553.49	3,864.99	172,417.41	425,548.43	1,334.80	13,804.20	21,238.82
Non-EGU Point Sources	177,667.73	99,473.80	137,200.28	87,504.46	2,107.59	19,995.74	31,491.61
Area Sources	229,306.65	1,344,087.33	291,637.66	18,421.94	311,136.94	311,485.83	2,381,421.10
On-road Mobile Sources	468,480.19	148,385.73	1,820,081.14	1,986.85	8,667.03	16,721.62	21,547.63
Non-road Mobile Sources	263,301.70	108,884.90	872,896.54	6,646.50	768.58	16,849.90	17,573.85

Table 6-2: 2014 Statewide Pollutant Summary by Source Category

Source Category	NO_X (tpy)	VOC (tpy)	CO (tpy)	SO_2 (tpy)	NH_3 (tpy)	$PM_{2.5}$ (tpy)	PM_{10} (tpy)
EGU Point Sources	122,079.27	3,446.30	170,600.75	343,604.78	1,399.38	14,703.15	20,020.55
Non-EGU Point Sources	162,703.68	95,871.38	125,681.74	78,676.81	2,069.73	19,065.22	28,198.47
Area Sources	270,598.38	1,430,217.07	322,182.23	25,284.13	432,632.54	349,302.22	2,617,765.56
On-road Mobile Sources	348,797.75	122,718.89	1,422,745.64	2,147.04	8,029.42	11,896.87	22,877.40
Non-road Mobile Sources	232,686.95	87,059.10	790,558.21	3,660.63	647.43	14,275.41	14,909.41

Table 6-3: 2017 Statewide Pollutant Summary by Source Category

Source Category	NO_X (tpy)	VOC (tpy)	CO (tpy)	SO_2 (tpy)	NH_3 (tpy)	$PM_{2.5}$ (tpy)	PM_{10} (tpy)
EGU Point Sources	109,142.78	2,824.02	172,975.46	276,028.02	1,089.02	13,913.70	18,277.68
Non-EGU Point Sources	141,225.06	86,396.03	115,070.85	77,005.53	2,352.17	18,741.54	27,580.18
Area Sources	263,299.37	1,276,034.14	308,376.74	26,679.72	432,991.72	287,849.74	2,354,423.15
On-road Mobile Sources	264,062.00	100,467.57	1,200,846.10	1,699.46	7,346.84	8,708.29	19,648.30
Non-road Mobile Sources	183,836.69	66,748.53	682,512.49	2,619.26	246.89	10,355.40	10,870.55

6.8 NO_X AND SO_2 EMISSIONS TRENDS

Emissions of NO_X and for SO_2 declined for most anthropogenic sources between 2011 and 2017. The data is presented in Table 6-4: *Anthropogenic NO_X Emissions by Source Type in tons per year (tpy)* and Table 6-5: *Anthropogenic SO_2 Emissions by Source Type in TPY*. Graphic representations of anthropogenic NO_X and SO_2 trends for 2011, 2014, and 2017 are presented in Figure 6-1: *Anthropogenic NO_X Emissions Trends* and Figure 6-2: *Anthropogenic SO_2 Emissions Trends*.

The point source category showed decreases in NO_X and SO_2 emissions between 2011 and 2017. The decreases in NO_X emissions occurred at EGUs, oil-and-gas production and processing sites, and cement kilns. The decreases were due to various reasons, including decreased activity, equipment turnover, and the use of equipment-specific emission factors. For the cement sector, NO_X emissions also decreased due to upgrades to kilns from equipment turnover and consent decrees. The vast majority (over 90%) of the decrease in SO_2 emissions occurred at EGUs and was due to decreased generation from coal-fired EGUs.

The area source category showed an increase in NO_X emissions between 2011 and 2014. This is due to a 13% increase in Texas natural gas production resulting in increased compressor engine emissions as well as an updated emissions calculation method for industrial, commercial, and institutional combustion-related sources. Area source SO_2 emissions increased between 2011 and 2017 due to an increase in flaring at oil-and-gas wells due to a corresponding increase in oil-and-gas production.

The non-road mobile source category showed a decrease in NO_X and SO_2 emissions between 2011 and 2017. This is due to fleet turnover resulting in Tier 2 and Tier 3 engines with advanced emissions control technology entering the fleet coupled with the use of ultra-low sulfur diesel fuel (15 parts per million (ppm)).

The on-road mobile source category showed a decrease in NO_X emissions between 2011 and 2017 due to the Federal Motor Vehicle Control Program, the Vehicle Inspection and Maintenance programs, the Federal Reformulated Gasoline Program, the Texas Low Emissions Diesel Program, ultra-low sulfur gasoline regulations, and ultra-low sulfur diesel regulations. On-road mobile SO_2 emissions increased between 2011 and 2014 due to increased vehicle activity but decreased in 2017 when the Tier 3 Light-Duty vehicle emissions rule lowered the sulfur content in gasoline from 30 ppm to 10 ppm.

Table 6-4: Anthropogenic NO_X Emissions by Source Type (tpy)

Source Category	2011	2014	2017
Point Sources	323,221.22	284,782.95	250,367.85
Area Sources	229,306.65	270,598.38	263,299.37
On-road Mobile Sources	468,480.19	348,797.75	264,062.00
Non-road Mobile Sources	263,301.70	232,686.95	183,836.69
Total	1,284,309.76	1,136,866.03	961,565.91

Table 6-5: Anthropogenic SO_2 Emissions by Source Type (tpy)

Source Category	2011	2014	2017
Point Sources	513,052.89	422,281.58	353,033.55
Area Sources	18,421.94	25,284.13	26,679.72
On-road Mobile Sources	1,986.85	2,147.04	1,699.46
Non-road Mobile Sources	6,646.50	3,660.63	2,619.26
Total	540,108.18	453,373.38	384,031.99

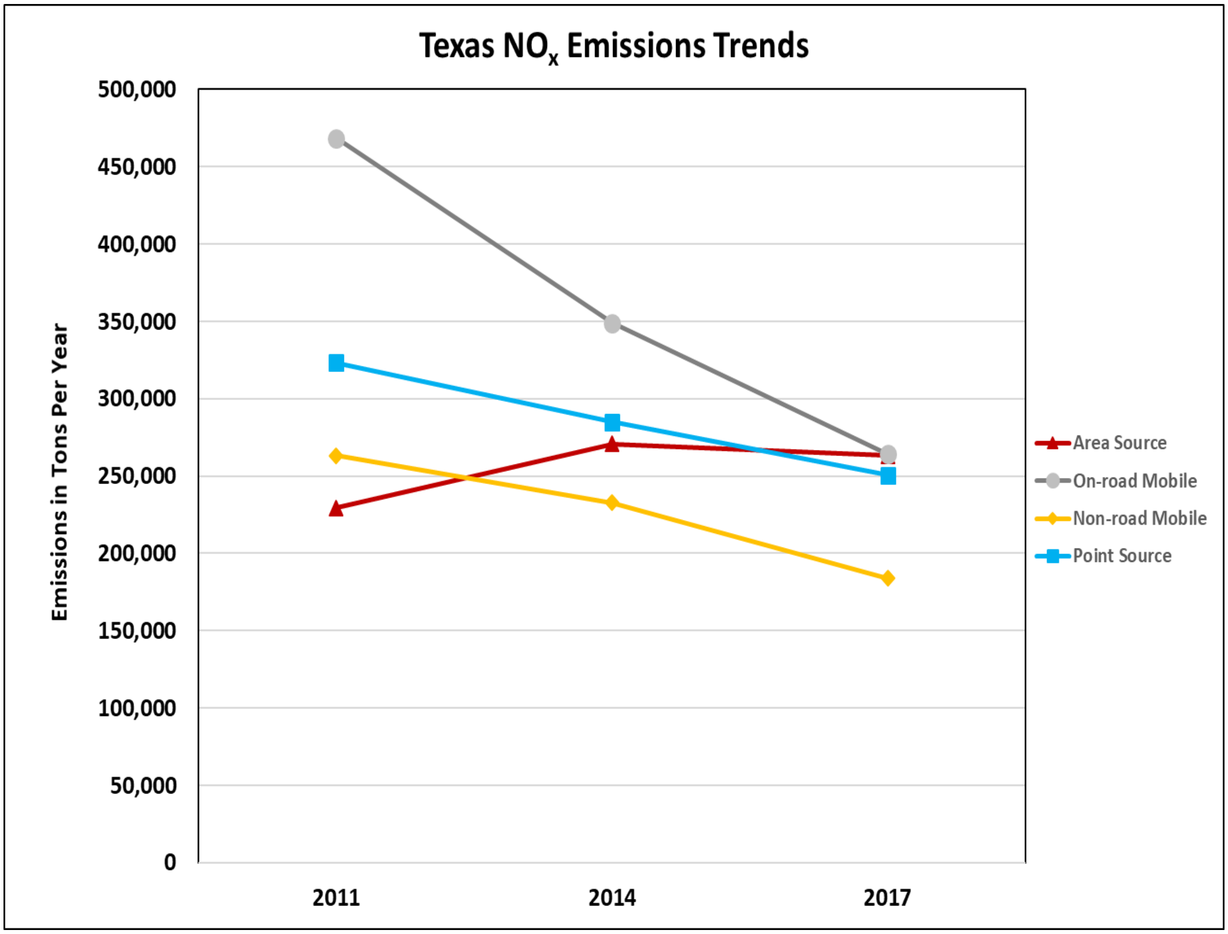

Figure 6-1: Anthropogenic NO_x Emissions Trends

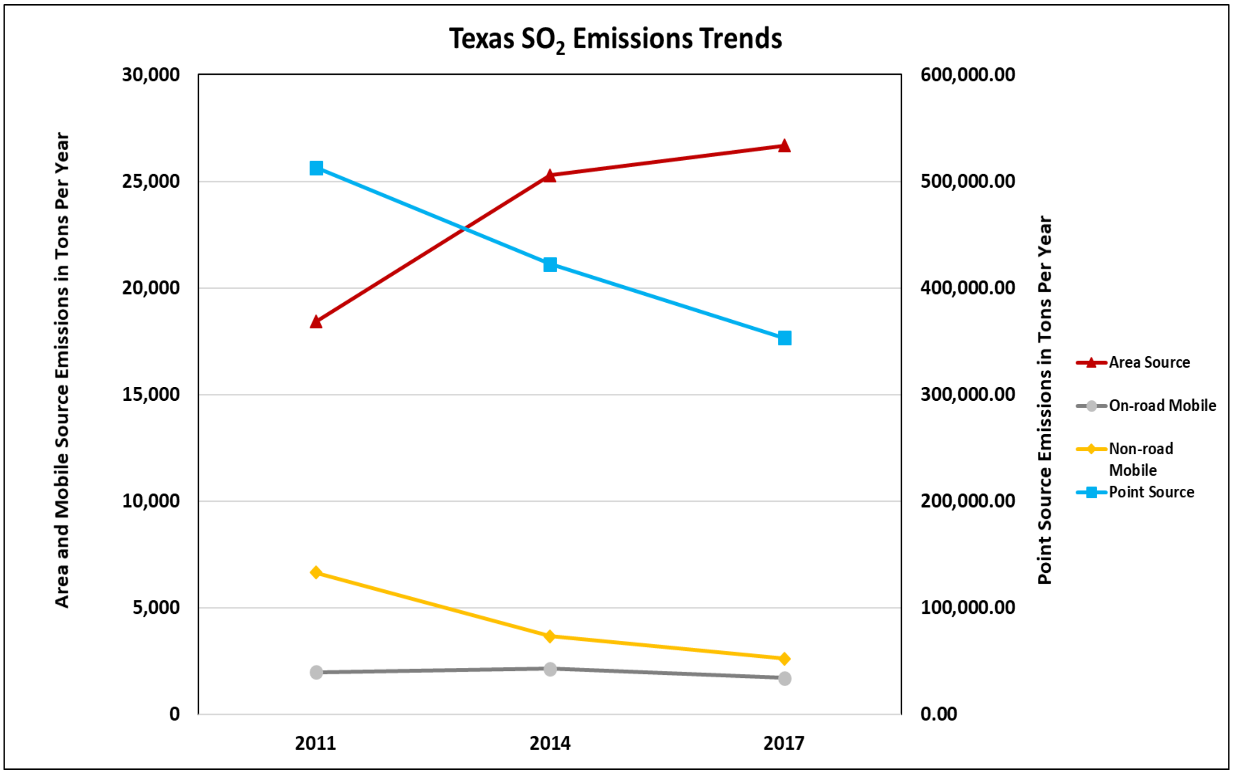

Figure 6-2: Anthropogenic SO_2 Emissions Trends

Per 40 CFR §51.308(f), Texas met the emissions inventory requirements. The TCEQ identified the emissions information on which the state's strategies were based and explained how this information meets the Regional Haze Rule's requirements regarding the year(s) represented in the information, i.e., the tie to the submission of information to the NEI as stated in 40 CFR 51.308(f)(2)(iii).

CHAPTER 7: LONG-TERM STRATEGY TO ESTABLISH REASONABLE PROGRESS GOALS

7.1 INTRODUCTION

The Regional Haze Rule requires the state to develop a long-term strategy (LTS) that addresses visibility impairment for each Class I area located within the state, and for each Class I area located outside the state that may be affected by emissions from the state. To satisfy the LTS requirements of 40 Code of Federal Regulations (CFR) §51.308(f)(2)(i), the state must evaluate and determine the control measures if needed, including emission reduction measures, necessary to make reasonable progress toward the national goal of achieving natural visibility conditions at a Class I area by the end of 2064. The state must consider the four statutory criteria listed in the Federal Clean Air Act (FCAA), §169A(g), when determining the set of control measures if needed, that may be necessary to make reasonable progress for the second planning period. The four criteria for evaluating control measures are 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. The LTS for the 2021 Regional Haze State Implementation Plan (SIP) revision incorporates planning for the next 10 years, from 2019 through 2028.

The main anthropogenic emissions that affect visibility in Class I areas in Texas and neighboring states are sulfur dioxide (SO_2) and nitrogen oxides (NO_X). There is a much smaller anthropogenic particulate matter (PM) impact in Texas from stack, engine exhaust, and fine soil emissions compared to SO_2 and NO_X. Additional discussion on the impact of NO_X, SO_2, and PM emissions is provided in Section 8.3: *Model Performance Evaluation* and Appendix F: *Photochemical Modeling*. Although the contribution of anthropogenic VOC to the formation of secondary organic carbon PM is small, as seen in Section 8.3.7.5: *Particulate Matter Source Apportionment*, there is a contribution. The impact of coarse mass and fine soil at the two Texas Class I areas comes primarily from natural dust storms and dust blowing from the Chihuahuan Desert, which the modeling does not represent well. The modeled impact of wildfire and prescribed burning emissions on primary organic carbon is uncertain because of questions about the accuracy of fire emission inventories. However, the modeled projections show that fires are the main source of the impacts, as seen in Appendix F, Sections 1.2.4.1 and 1.2.4.2 for Guadalupe Mountains and Big Bend, respectively.

The projections for 2028 set the relative response factors (RRFs) for coarse mass (dust) and fine soil equal to one based on analysis showing that dust storms and wind-blown desert dust are the dominant cause of the coarse mass and fine soil pollution at Big Bend and Guadalupe Mountains National Parks. Since the dominant source of these pollutants is natural, the Texas Commission on Environmental Quality (TCEQ) does not expect the RRFs for course mass and fine soil ~~that~~ to change between the base period and 2028. See Section 3.0: *Visibility Projections* of the contractor project report[7] for RRF details (Ramboll, 2020).

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[7] https://www.tceq.texas.gov/airquality/airmod/project/pj_report_pm.html

The primary organic carbon and elemental carbon (i.e., black carbon) captured in the modeling are largely from fire. The term "primary" refers to a pollutant emitted directly to the atmosphere. The term "secondary" refers to a pollutant formed in the atmosphere by reaction, condensation, or both. The modeling indicates that primary organic carbon and black carbon, or elemental carbon, at Big Bend on the 20% most impaired days come overwhelmingly from boundary conditions, which include the areas of southern Mexico, the Yucatan, and Central America with extensive agricultural burning and sometimes wildfire emissions each April and May. See Appendix F, Section 1.2.4.2 for details. The TCEQ's air pollution meteorologists have documented many of these episodes over the past decade. The data and satellite images of the smoke moving into Texas confirm the large impact of smoke from the fires in southern Mexico, the Yucatan, and Central America.

The state calculates the uniform rate of progress (URP), required under 40 CFR §51.308(f)(1)(vi), for each Class I area located within the state by comparing the baseline visibility condition for the most impaired days to the natural visibility condition for the most impaired days. The state then calculates the uniform rate of visibility improvement that would need to be maintained during each 10-year planning period of the Regional Haze Program for a Class I area to attain natural visibility conditions by the end of 2064. The URP is a straight-line comparison of the baseline conditions for the most impaired days and estimated natural conditions for the same set of days. The calculation of baseline visibility conditions for the 20% most impaired days and estimations of natural visibility conditions for the same 20% most impaired days for each Class I area located in the state is detailed in Chapter 4: *Assessment of Baseline and Current Conditions and Estimate of Natural Conditions in Class I Areas*.

In effect, the LTS comprises the set of control measures determined by the state to be necessary to make reasonable progress towards natural visibility by the end of 2064 as well as necessary to make reasonable progress during each 10-year planning period. The state uses this set of determined control measures with their corresponding emission reductions, to project the reasonable progress goal (RPG) for a Class I area. The state must determine what emission reductions, if any, may be necessary for making reasonable progress by considering the four factors listed in both the FCAA and the Regional Haze Rule. The URP is a tool for comparing the RPG of a Class I area established by the state with the visibility improvement that would be needed to reach natural conditions by the end of 2064. This RPG and URP comparison for each Class I area indicates the emission reduction measures necessary to make reasonable progress for the planning period covered by this SIP revision.

The TCEQ determined that the rate of visibility improvement by the end of the second planning period, 2028, is reasonable and will be implemented as the RPG for each of the listed Class I areas. The TCEQ derived these RPGs from TCEQ modeling of the control measures included in the long-term strategy and reflect emissions reductions from state and federal programs already in place, including the federal SO_2 cap and trade program for Texas electric generating utilities (EGU) subject to the Best Available Retrofit Technology (BART) requirements of the Regional Haze Rule (EPA, 2019b), the NO_X trading program under the Cross-State Air Pollution Rule for Texas EGUs subject to BART (EPA, 2017a), and consent decrees requiring SO_2 and NO_X emissions reductions between the EPA and certain refineries, carbon black manufacturing plants, and cement manufacturing plants. Potential control measures for inclusion in the long-term strategy were evaluated after considering and applying the four statutory factors to each source selected for the analysis: 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 the source. Appendix B: *Analysis of Control Strategies to Establish Reasonable Progress Goals* provides an analysis showing that these goals will make reasonable progress toward meeting the national goal of prevention and remedying visibility impairment in the Class I areas.

7.2 SOURCE SELECTION AND CONTROL MEASURE EVALUATION FOR DETERMINING REASONABLE PROGRESS

The TCEQ focused its control strategy analysis on emissions of NO_X and SO_2 for the second planning period. These are the main anthropogenic pollutants that affect visibility at Class I areas in Texas and Class I areas in neighboring states. On an individual basis, point sources are the largest contributors to SO_2 and NO_X; therefore, the TCEQ elected to focus on point sources in this planning period.

7.2.1 Area of Influence and Q/d Analysis for Source Selection

The 2017 Regional Haze Rule, under 40 CFR §51.308(f)(2), requires that states determine which Class I areas in other states may be affected by the state's own emissions. The TCEQ paired an area of influence (AOI) analysis with an emissions over distance (Q/d) analysis to select the sources for four-factor analysis. Projected emissions to 2028, Q in tons per year, and distance from the monitor to the source, d in kilometers, were used. The AOIs were created using ammonium sulfate and ammonium nitrate extinction-weighted residence times (EWRT). The AOIs were then paired with a Q/d analysis. The TCEQ used these analyses to select the sources to be included in four-factor analysis.

Figure 7-1: *NO_X Sources Selected for Four-Factor Analysis* shows the results for the analyses performed for NO_X sources. Figure 7-2: *SO_2 Sources Selected for Four-Factor Analysis* shows the results of the analyses performed for SO_2. Table 7-1: *NO_X Sources Selected for Four-Factor Analysis* presents the selected NO_X sources. Similarly, Table 7-2: *SO_2 Sources Selected for Four-Factor Analysis* shows the select SO_2 sources. The site names of the sources are shown in Figures 7-1 and 7-2, respectively.

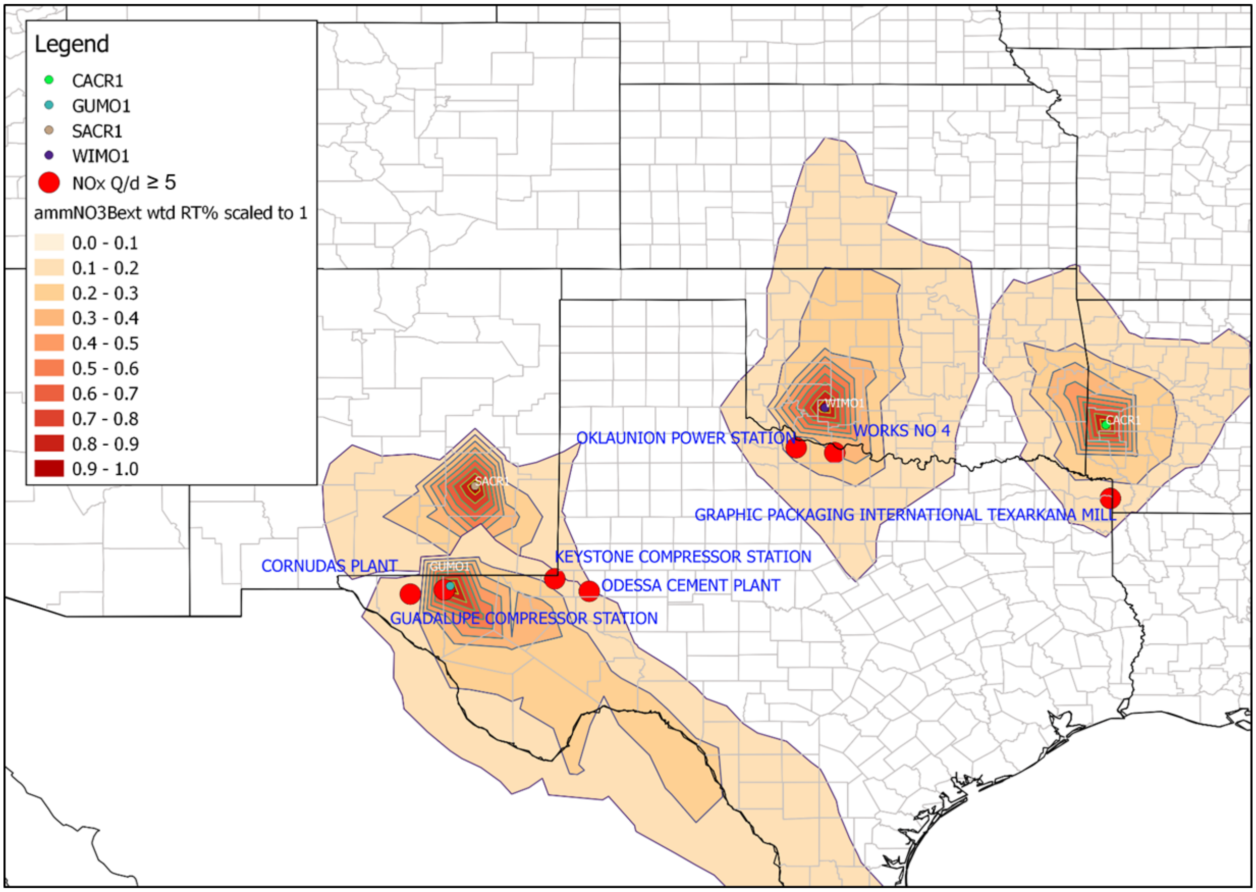

Figure 7-1: NO_x Sources Selected for Four-Factor Analysis

Table 7-1: NO_x Sources Selected for Four-Factor Analysis

Site Name	Company
Cornudas Plant	El Paso Natural Gas Company LLC
Graphic Packaging International Texarkana Mill	Graphic Packaging International LLC
Guadalupe Compressor Station	El Paso Natural Gas Company LLC
Keystone Compressor Station	El Paso Natural Gas Company LLC
Odessa Cement Plant	GCC Permian LLC
Oklaunion Power Station	Public Service Company of Oklahoma
Works No 4	Vitro Flat Glass LLC

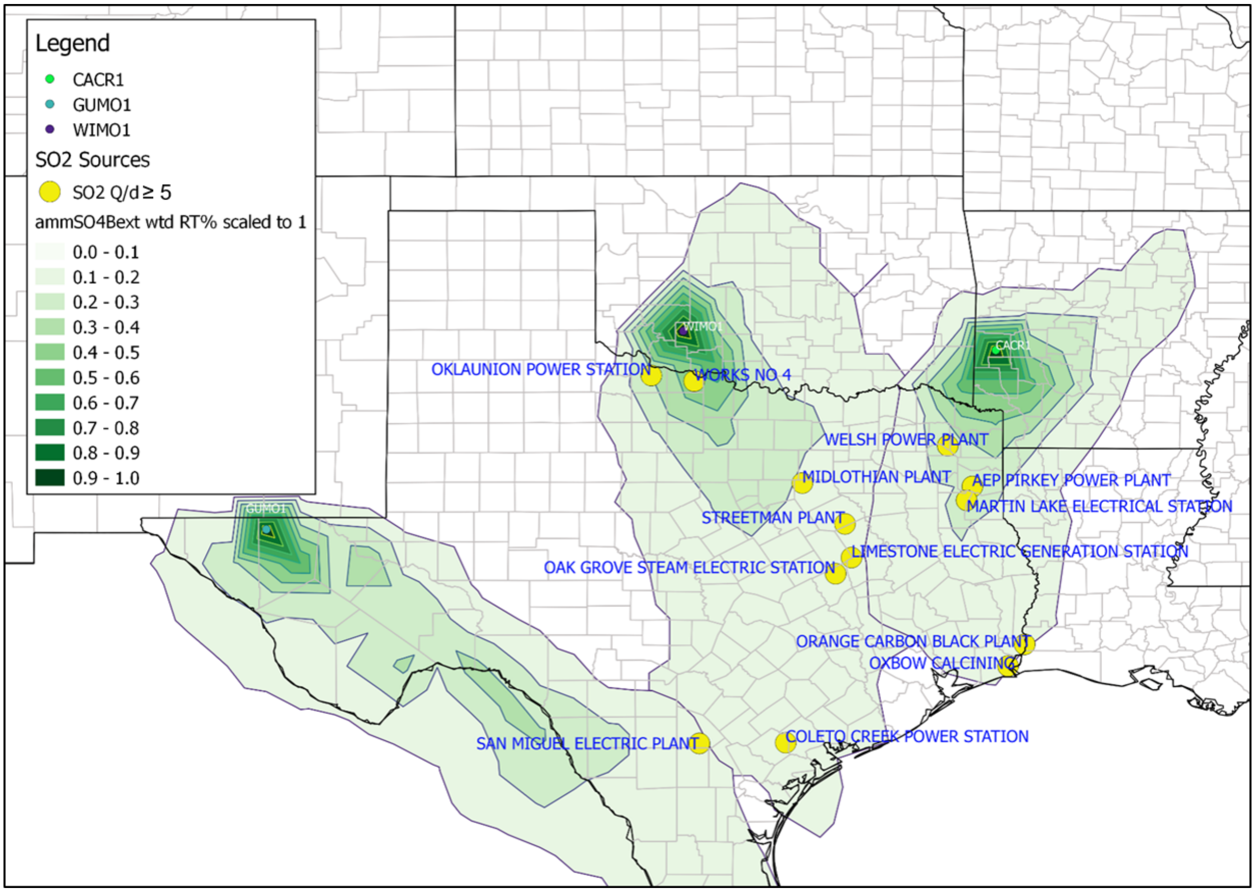

Figure 7-2: SO_2 Sources Selected for Four-Factor Analysis

Table 7-2: SO_2 Sources Selected for Four-Factor Analysis

Site Name	Company
AEP Pirkey Power Plant	Southwestern Electric Power Company
Coleto Creek Power Station	Coleto Creek Power LLC
Limestone Electric Generating Station	NRG Energy LLC
Martin Lake Electric Station	Vistra Energy LLC
Midlothian Plant	Holcim Texas LP
Oak Grove Steam Electric Station	Vistra Energy LLC
Oklaunion Power Station	Public Service Company of Oklahoma
Orange Carbon Black Plant	Orion Engineered Carbons LLC
Oxbow Calcining	Oxbow Calcining LLC
San Miguel Electric Plant	San Miguel Electric Cooperative Inc
Streetman Plant	TRNLWS LLC
Welsh Power Plant	Southwestern Electric Power Company
Works No 4	Vitro Flat Glass LLC

Although Figure 7-1 only shows the AOIs for Caney Creek (CACR), Guadalupe Mountains (GUMO), Salt Creek (SACR) and Wichita Mountains (WIMO) for the NO_X analyses, and Figure 7-2 only shows the AOIs for CACR, GUMO and WIMO for the SO_2 analysis, AOIs were determined for 13 Class I areas in Texas and nearby states:

Arkansas (AR), Colorado (CO), Louisiana (LA), New Mexico (NM), Missouri (MO), Oklahoma (OK). The Class I areas included in the analysis are presented in Table 7-3: *Class I Areas included in AOI Analyses*. The figures above are simplified and only show areas that select sources. Additional AOIs do not add any additional sources.

Table 7-3: Class I Areas included in AOI Analysis

Site	Code	State	County	Latitude	Longitude
Big Bend National Park	BIBE1	TX	48043	29.3027	-103.178
Breton Island	BRIS1	LA	22075	30.10863	-89.76168
Caney Creek	CACR1	AR	05113	34.4544	-94.1429
Great Sand Dunes	GRSA1	CO	08003	37.7249	-105.5185
Guadalupe Mountains National Park	GUMO1	TX	48109	31.833	-104.8094
Hercules-Glades	HEGL1	MO	29213	36.6138	-92.9221
Mingo	MING1	MO	29207	36.9717	-90.1432
Rocky Mountain National Park	ROMO1	CO	08069	40.2783	-105.5457
Salt Creek	SACR1	NM	35005	33.4598	-104.4042
Upper Buffalo Wilderness	UPBU1	AR	05101	35.8258	-93.203
Wheeler Peak	WHPE1	NM	35055	36.5854	-105.452
White Mountain	WHIT1	NM	35027	33.4687	-105.5349
Wichita Mountains	WIMO1	OK	40031	34.7323	-98.713

The TCEQ conducted 72-hour back trajectory analyses using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (developed by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (ARL)). The TCEQ acknowledges the NOAA ARL for the provision of the HYSPLIT transport and dispersion model and the READY website (*http://www.ready.noaa.gov*) used in this SIP revision. The HYSPLIT model was used to model 72-hour back trajectories at 100, 500, and 1000-meter heights, and four start times were used for each day (6:00, 12:00, 18:00, and 24:00 Central Standard Time (CST)). The HYSPLIT-compatible meteorological data used to run the model were acquired from NOAA ARL's Data Archive. The North American Mesoscale Forecast System (NAM) NAM 12-kilometer data were used. The back trajectories were started on the 20% most impaired days during 2012 through 2016 at each site as indicated in the data acquired on June 14, 2018. (Flag4 = 90) from the Federal Land Manager (FLM) Environmental Database.

The AOIs were generated using the HYSPLIT model output and the light extinction (Bext) values for ammonium sulfate and ammonium nitrate. The day-specific Bext values were obtained from the FLM Environmental Database on June 14, 2018. A 32 x 32 degree "grid" of hexagonal cells, using the computer programming language, Python, was used, and the HYSPLIT trajectory endpoints within each of these "cells" were counted for each day. An illustration of the HYSPLIT model results and the hexagonal grid are shown in Figure 7-3: *Illustration of HYSPLIT Endpoints and Hexagonal Grid at the CACR Monitor*. The frequency in each cell for each day was multiplied by the Bext for each day. The product of the frequency and the Bext for all days was added together (all days and all heights) in each cell. The product of the frequency and the Bext at each cell was divided by the product of the frequency and the Bext across the entire domain for all the days and all the heights. This method results in the "scaled" EWRT at each cell. Isopleths were then made using Quantum Geographic Information System (QGIS). The QGIS is a user-friendly Open Source Geographic Information System (GIS) licensed under the GNU, General Public License. The QGIS uses an algorithm based on the Delaunay triangulation method to generate the isopleths (Delaunay, 1934). These EWRT isopleths, or AOIs, indicate the possible areas where sources of emissions may influence the monitor of interest.

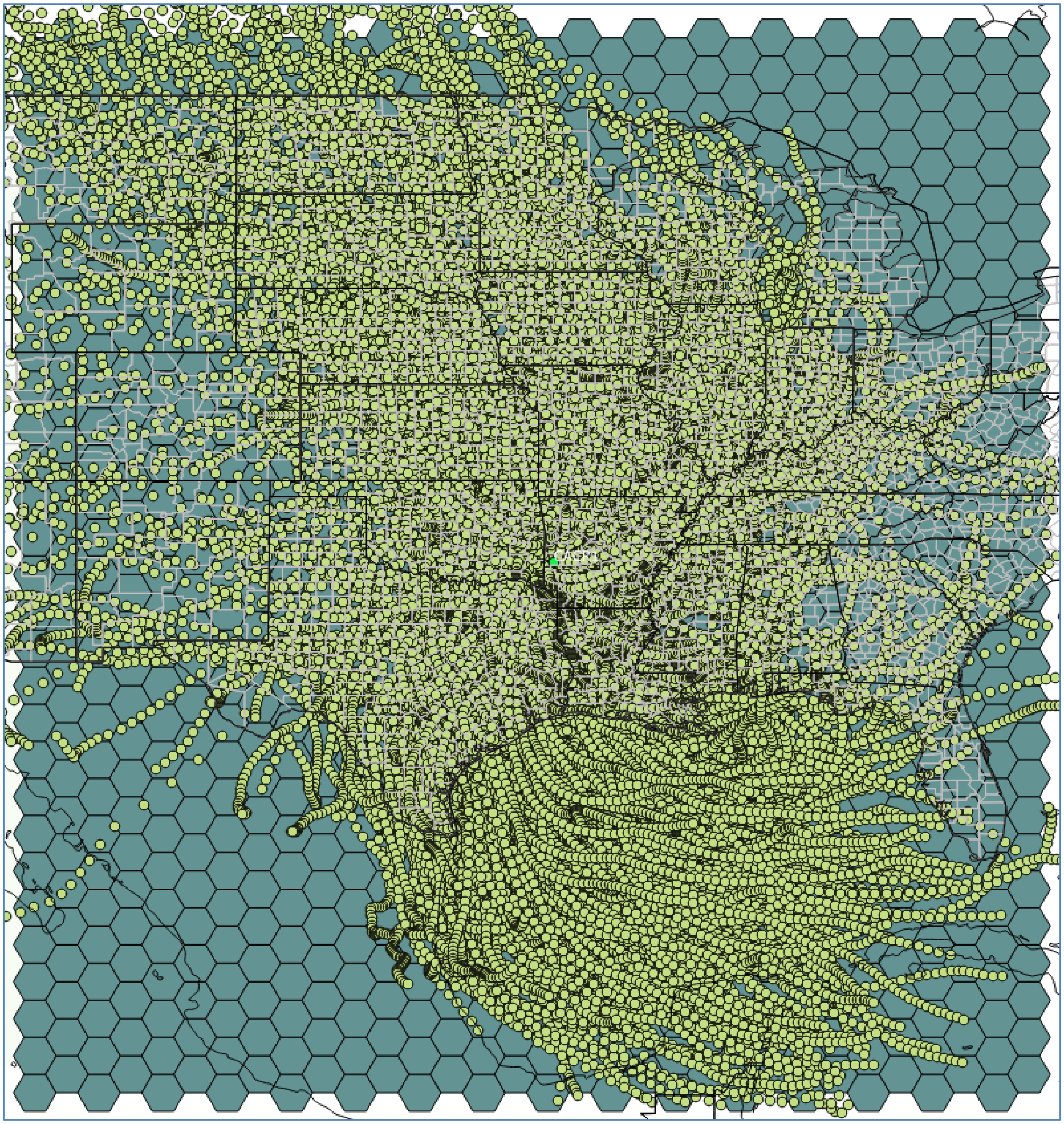

Figure 7-3: Illustration of HYSPLIT Endpoints and Hexagonal Grid at the CACR Monitor

An example of the results of applying this method is shown in Figure 7-4: *Caney Creek (CACR)* NO_X *AOI.*

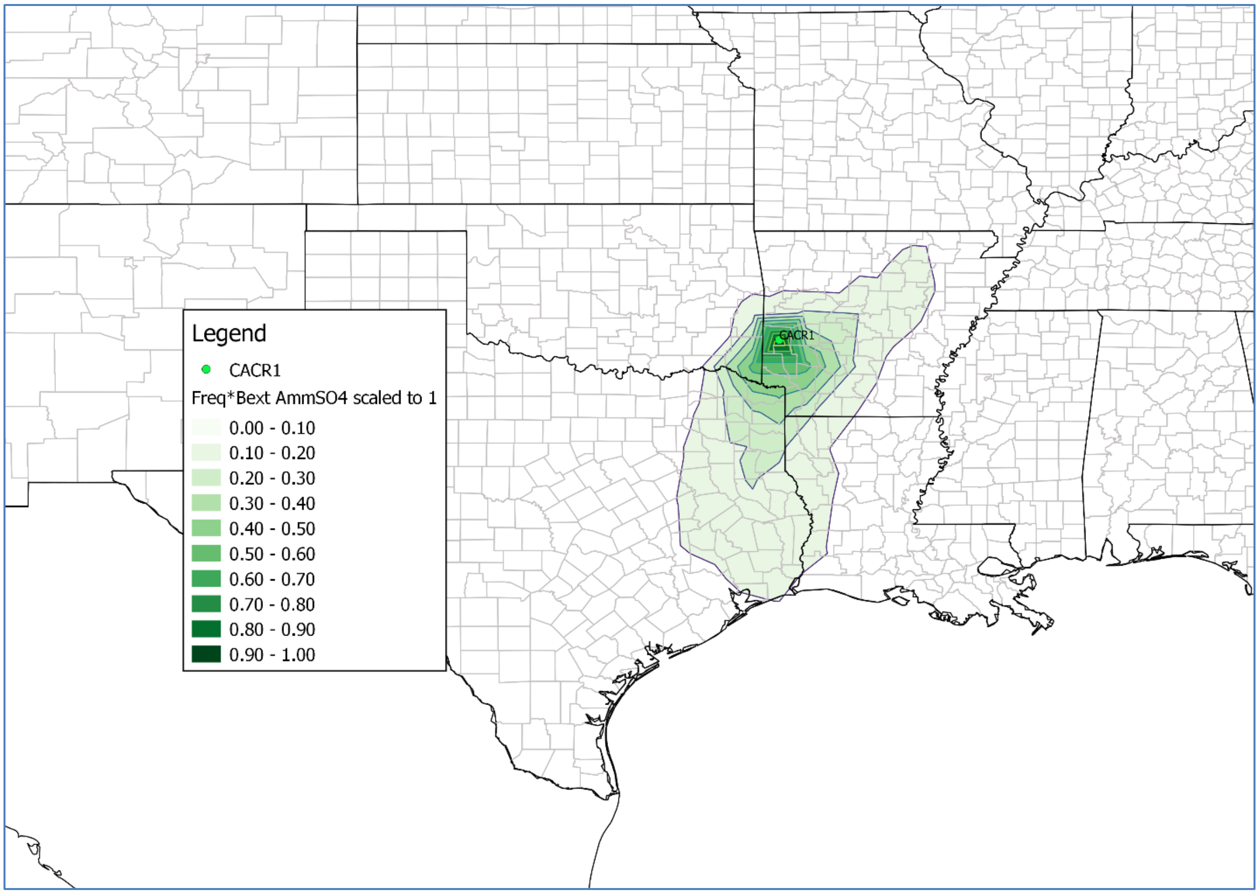

Figure 7-4: Caney Creek (CACR) NO_X AOI

Once the AOIs were created, they were plotted along with the emission sources where the Q/d was equal to or greater than five. The emissions projections for the end of the second planning period, 2028, as recommended in the U.S. Environmental Protection Agency (EPA) guidance (EPA, 2019a) were used. For both electric generating units (EGU) and non-EGUs, 2028 future year emissions were estimated from 2016 reported emissions from State of Texas Air Reporting System (see Section 8.3.6.3: *Point Sources* for additional detail on inventory projections). To do this, growth factors developed by the consulting firm, Eastern Research Group, Inc. (ERG), were applied for non-EGUs. The TCEQ used data from the Eastern Regional Technical Advisory Committee were used to estimate EGU projections for 2028. The ERG report, "Growth Factors for Area and Point Sources," (ERG, 2016) can be found on the TCEQ website at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582166257608FY1608-20160630-erg-growth_factors_area_point.pdf.

For the Class I areas affected by emissions from Texas, the main visibility impairing pollutants resulting from human activity are ammonium nitrate and ammonium sulfate, which the TCEQ focused on for the second planning period. The emissions that react to form these pollutants are NO_X and SO_2, respectively. Because of the differences between the meteorological and emission source-specific conditions that can lead to high nitrate and high sulfate conditions at a Class I area, the AOIs for NO_X and SO_2 can be substantially different for Class I areas affected by Texas emissions.

The TCEQ used these emissions data along with potential control measures in the base case and sensitivity photochemical modeling to determine the impacts of potential emission reductions from selected sources emitting NO_x and SO_2 in Texas. This approach allowed the TCEQ to focus its analysis on moderate, cost-effective, and reasonable control measures for anthropogenic stationary point sources that were likely to contribute to visibility impairment in Class I areas.

The TCEQ assessed the costs of potential controls and potential emission reductions of NO_x and of SO_2 for Texas sources expected to contribute to visibility impairment at seven Class I areas. These Class I areas are Big Bend, Caney Creek, Guadalupe Mountains, Salt Creek, Upper Buffalo, White Mountain, and Wichita Mountains. Texas used the AOI of a Class I area to define the boundaries within which to apply the Q/d threshold to point sources. For this planning period, the Q/d threshold selected for NO_x and for SO_2 was greater than or equal to five. The future year 2028 emissions, grown from the 2016 TCEQ point source EI for non-EGUs and 2028 Eastern Regional Technical Advisory Committee (ERTAC) projections for EGUs, were used as the values for Q. The TCEQ established the AOIs and Q/d threshold as the criteria to apply to point sources of NO_x and of SO_2 for selecting sources to which the statutory four factors would be applied pursuant to 40 CFR §51.308(f)(2)(i). For the Big Bend, Upper Buffalo, and White Mountain Class I areas, no anthropogenic stationary point sources of NO_x or SO_2 were identified within the respective Class I area's AOI that satisfied the Q/d threshold of equal to or greater than five. For the Salt Creek Class I area, no anthropogenic stationary point sources of SO_2 were identified within the AOI that satisfied the Q/d threshold equal to or greater than five. The significant anthropogenic stationary point sources within each AOI are in Appendix A: *Consultation Documents*. A master list of potential additional control costs associated with the units at these sources in the Class I area(s) is in Appendix B.

7.2.2 Four-Factor Analysis

The LTS must address regional haze visibility impairment for the Big Bend and Guadalupe Mountains Class I areas and for each Class I area located outside the state that may be affected by emissions from Texas. In establishing the LTS, the TCEQ evaluated and determined emission reduction measures that are necessary to make reasonable progress by considering the four statutory factors listed in FCAA, §169A(g)(1) and codified in 40 CFR §51.308(f)(2)(i). The four criteria in the FCAA are the cost 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.

- **Cost of Compliance**
  The cost of compliance is a factor used to determine whether compliance costs associated with control measures considered reasonable and necessary for making reasonable progress toward the goal of natural visibility conditions for existing sources, are reasonable given the emissions reductions expected to be achieved.
- **Time Necessary for Compliance**
  The time necessary for compliance factor may be used to estimate the time needed for a source to comply with a potential control measure and to set compliance deadlines for selected control measures.

- **Energy and Non-Air Quality Environmental Impacts of Compliance**
  The energy and non-air quality environmental impacts of compliance factor is meant to consider whether the energy requirements of the control technology selected for a source result in energy penalties or benefits, or whether there are non-air quality impacts such as water quality and solid waste impacts resulting from the application to the source of the selected control measure.
- **Remaining Useful Life of the Source**
  The remaining useful life of a source factor is applicable only to those measures which would require retrofitting of control devices or possible production changes, at existing sources. This factor can be related to the cost of compliance factor and be addressed in the control cost analysis. Shutdown of sources were only counted if the shutdowns were enforceable.

Although visibility impact is not one of the factors required for consideration under FCAA, §169A(g)(1), the EPA's Regional Haze guidance issued in August 2019 indicates that visibility impact from a selected control measure can be a consideration when a state is determining what is necessary to make reasonable progress. The TCEQ evaluated the visibility impacts from selected control measures resulting from the four-factor analysis through photochemical sensitivity run modeling, described in Section 8.3: *Modeling*.

7.2.2.1 Applying the Statutory Factors

Determination of Potential Controls

The future year 2028 emissions inventory included the controls currently enforceable in Texas. The list of potential controls resulting from the four-factor analysis is for controls beyond those already included in the modeling of Texas sources. This is necessary to provide a frame of reference to estimate the amount of emissions available for additional control and to estimate the effect of potential control measures. Additionally, the progress toward the RPG with only currently enforceable controls can also be assessed.

The TCEQ evaluated control strategies specific to NO_X and SO_2 emissions from point sources selected for application of the four statutory factors. Control measures were analyzed based on the results of the screening analysis. For example, if the emissions unit was within the AOI and above the Q/d threshold for NO_X, this triggered analysis for potential control retrofit or production changes for that pollutant. If an emissions unit triggered analysis for both NO_X and SO_2, control strategies for both pollutants were analyzed separately and concurrently. For one source, the TCEQ was able to procure control device vendor information for the control of both NO_X and SO_2. If TCEQ found that no feasible control measure or technique for a source-type could be identified, the control strategy analysis was considered complete for that source and pollutant. In addition, the TCEQ did not consider the theoretical application of a control measure as reasonable for a source if the same control measure had never been technically demonstrated for the source-type.

7.2.2.2 Four-Factor Analysis Process

Cost of Compliance

The TCEQ assessed all units in Texas located within a Class I area's AOI for either nitrate or sulfate and that met the Q/d threshold for either NO_X or SO_2 within the respective AOI. The TCEQ performed a cost analysis for each control option determined to be technically feasible for all selected EGUs and non-EGUs to arrive at a cost per ton of emissions reduced for controls. The TCEQ estimated the capital cost of air pollution control equipment or methods using the most recent data available from Sargent and Lundy for EGUs, and cost data and information from the EPA and the literature for non-EGUs. For one non-EGU source, the TCEQ was able to rely on vendor cost information for capital cost of control equipment. For all sources, the TCEQ estimated annualized capital costs by multiplying the capital costs by the capital recovery factors. The EPA's estimation of a capital recovery factor accounts for source financing of air pollution control equipment. Annual operating and maintenance costs associated with the potential control measure were estimated from the same data and information used for estimating capital costs for each source. The annualized capital cost was then summed with the annual operating cost for a control measure to arrive at a final total annualized cost, for each potential control option. After estimating total potential emission reductions of each NO_X and SO_2 control option using baseline emissions for EGUs and non-EGUs, the total annualized cost was divided by the tons of pollutant emissions reduced to estimate the cost per ton of emissions reduced.

As part of the cost analysis, units at a source selected for application of the four statutory factors with NO_X or SO_2 emissions of less than 5% of the total emissions of the same pollutant were removed from further control measure analysis screening. Excluding those units with relatively low emissions was considered reasonable regarding application of the cost of compliance criterion. Controlling these smaller units is not justified by the likely benefit at this time considering both the cost to control and the anticipated improvement in visibility from those units with relatively lower emissions. This approach allowed focus on the NO_X and SO_2 units with relatively greater emissions at a source.

A cost threshold of $5,000 per ton for NO_X and SO_2 emissions reduced was used to further refine source selection within the initial list of sources selected for four-factor analysis. This allowed for the identification of sources to which potential control measures could be applied cost-effectively. The TCEQ eliminated potential control measures considered at a source exceeding the $5,000 per ton of NO_X and SO_2 emissions reduced from inclusion in the modeling sensitivity analysis. The TCEQ then used the resulting set of sources as part of a modeling sensitivity analysis to determine the corresponding anticipated visibility impact.

The TCEQ evaluated annualized capital costs of control, and subsequently total annualized costs and costs per ton, based on capital recovery factors of five, 15, and 30 years. In addition to the different capital recovery factors, the TCEQ further considered cost effectiveness thresholds of $2,700 per ton, $5,000 per ton, and $10,000 per ton of NO_X and of SO_2 emissions reduced. Maximum emission reductions for NO_X and SO_2, were estimated at all three cost effectiveness thresholds with constant capital recovery factors over each time period. The TCEQ determined that a capital life of 15 years was a reasonable 'mid-point' given that some of the selected Texas EGUs could not reasonably be expected to operate an additional 30 years and the difficulty in estimating remaining source life for non-EGUs. The TCEQ also recognized that a capital life of five years may be too short since most of the units selected for cost control analysis for this planning period could reasonably be expected to continue to operate longer than five years. The TCEQ also concluded that the threshold of $5,000 per ton of NO_X and of SO_2 emissions reduced represented a reasonable 'mid-point' to select units with total annualized control costs and NO_X and SO_2 emission reductions resulting from potential control measures that could be applied in a cost-effective manner for the purpose of demonstrating reasonable progress.

For the lower end of the cost thresholds, \$2,700 per ton of NO_X and of SO_2 emissions reduced was considered because it was applied as an initial screening tool to limit source population with relatively cost-effective control strategies for the first planning period. This value was based on the EPA's Clean Air Interstate Rule. However, \$2,700 per ton of pollutant reduced was determined to be too low for source selection refinement for the second planning period since it could screen out controls on units that could be applied in a cost-effective manner.

For the upper-end of the cost thresholds, \$10,000 per ton of NO_X and of SO_2 emissions reduced was considered because this threshold may be used for permitting new, modified, and reconstructed sources of air pollutants under the New Source Review (NSR) air permitting program. This threshold may be used for the NSR air permitting program authorizing construction of new sources and modification or reconstruction at existing sources undergoing a best available control technology review. However, for purposes of demonstrating reasonable progress for the second planning period, this threshold was determined to be inappropriate to apply to existing sources not undergoing any kind of physical or operational change. Therefore, the TCEQ did not consider potential control measures at this cost threshold to be reasonable for purposes of refined source selection for the second planning period.

Time Necessary for Compliance

The time necessary for compliance was not a critical factor for the determination of applicable additional controls for Texas sources. The time necessary for a single source to design, build, and install SO_2 scrubbing technology is anticipated to be about three years. The time needed to build and commence operation of dry sorbent injection (DSI) technology could be less given that scrubbing vessels would not need to be constructed. The time to design, build, and install NO_X control technologies would also be about three years.

Energy and Non-Air Quality Environmental Impacts of Compliance

To the extent energy impacts are quantifiable for a particular control measure or technique, they have been included in the cost estimates. Source-by-source review of the energy and non-air quality environmental impacts of the potential controls would have possibly led to a different determination about the reasonableness of the set of potential additional control measures evaluated for the sources selected for review.

For instance, dry and wet scrubbers, DSI systems, selective catalytic reduction (SCR) systems, and selective non-catalytic reduction (SNCR) systems would require electricity to operate fans, pumps, and other ancillary equipment. Steam would be required for some scrubbing systems and SCR systems. If the electricity were generated on-site, additional fuel would be consumed by the source to produce this electricity, or the necessary additional electricity would be consumed from the electric grid. Additional fuel would be consumed by the source to produce the steam. In the case of the EGUs, the additional fuel consumption to meet the electric and steam demand would result in the lowering of the energy efficiency of the source itself. Additional fuel consumption to meet a higher steam demand would have similar effects on non-EGUs.

In addition, some low-NO_X combustion technologies require electricity for turbocharging or steam for steam injection. Systems that require only modifications to alter fuel-air mixing and combustion temperatures are not expected to produce any additional electricity or steam demands or generate wastewater or solid waste.

Finally, scrubber and DSI systems for SO_2 control would require additional safeguards for fuel handling and waste systems to avoid additional non-air environmental impacts such as increased effluents in wastewater discharges and storm water runoff. Post-control NO_X systems such as SCR and SNCR, would require additional safeguards for proper handling of reducing reagents such as urea or ammonia. These factors would be considered individual sources and measures.

Remaining Useful Life

In its initial analyses, the TCEQ did not assume a unit life except for when estimating total annualized costs and the resulting cost of control per ton NO_X and SO_2 emissions reduced values, and to inform the cost-effective thresholds used for additional source screening, as described earlier in subsection *Cost of Compliance* of this section. The TCEQ eliminated from further analysis only those units that were scheduled for shutdown under enforceable decrees.

7.2.2.3 Results of Four-Factor Analysis

Many of the controls for which costs were estimated are for sources located in more than one AOI. The total cost of all potential state-wide anthropogenic stationary point source controls is summarized in Table 7-4: *TCEQ Potential Point Source Control Strategy Summary.*

Table 7-4: TCEQ Potential Point Source Control Strategy Summary

Pollutant	Total Emissions Reductions (tons per year)	Estimated Total Annualized Cost
Nitrogen Oxides (NO_X)	3,171	$9,335,087
Sulfur Dioxide (SO_2)	79,285	$195,539,404
Total Costs		$204,874,491

For each source selected as part of the four-factor analysis, potential control measures demonstrated to be technically feasible were considered. Using a cost threshold of $5,000 per ton for NO_X and SO_2 reduced, the TCEQ identified the potential control measures for each source that could be applied in a cost-effective manner. Table 7-5: *Sources Selected for Four-Factor Analysis* shows the 18 sources selected for four-factor analysis based on the AOIs and Q/d threshold criteria. The sources identified as having potential control measures meeting the $5,000 per ton threshold for NO_X or SO_2 were included in the photochemical modeling sensitivity runs conducted by the TCEQ. The results of this modeling analysis were used to estimate the visibility impact those controls identified using the $5,000 per ton threshold would have on the Class I areas impacted by Texas' emissions.

Table 7-5: Sources Selected for Four-Factor Analysis

Company/Site Name	Unit(s)	Class I Area(s)	Pollutant(s)
Coleto Creek Power LLC/Coleto Creek Power Station	(1) coal boiler	Wichita Mountains	SO_2
Southwestern Electric Power/Welsh Power Plant	(2) coal boilers	Caney Creek & Wichita Mountains	SO_2
Southwestern Electric Power/AEP Pirkey Power Plant	(1) coal boiler	Caney Creek & Wichita Mountains	SO_2
NRG Energy LLC/Limestone Electric Generating Station	(2) coal boilers	Wichita Mountains	SO_2
Vistra Energy LLC/Martin Lake Electric Station	(3) coal boilers	Caney Creek & Wichita Mountains	SO_2
San Miguel Electric Cooperative/San Miguel Electric Plant	(1) coal boiler	Guadalupe Mountains & Wichita Mountains	SO_2
Public Service Company of Oklahoma/Oklaunion Power Station	(1) coal boiler	Wichita Mountains	SO_2 and NO_X
Vistra Energy LLC/Oak Grove Steam Electric Station	(2) coal boilers	Wichita Mountains	SO_2
Holcim Texas LP/Midlothian Plant	(2) cement kilns	Wichita Mountains	SO_2
Vitro Flat Glass LLC/Works No 4 Wichita Falls Plant	(2) glass melting furnaces	Wichita Mountains	SO_2 and NO_X
Graphic Packaging International LLC/Texarkana Mill	(4) boilers	Caney Creek	NO_X
El Paso Natural Gas Company LLC/Keystone Compressor Station	(15) reciprocating engines	Guadalupe Mountains & Salt Creek	NO_X
El Paso Natural Gas Company LLC/Cornudas Plant	(6) turbines	Guadalupe Mountains	NO_X
El Paso Natural Gas Company LLC/Guadalupe Compressor Station	(1) turbine	Guadalupe Mountains	NO_X
GCC Permian LLC/Odessa Cement Plant	(2) cement kilns	Guadalupe Mountains	NO_X
Orion Engineered Carbons LLC/Orange Carbon Black Plant	(1) incinerator, (4) dryers, (2) tail gas and NG boilers, (1) flare	Caney Creek	SO_2
Oxbow Calcining LLC/Oxbow Calcining-Port Arthur	(4) coke calcining kilns	Caney Creek	SO_2
TRNLWS LLC/Streetman Plant	(1) lightweight aggregate kiln	Wichita Mountains	SO_2

The results of projected visibility improvement at Class I areas impacted by emission sources in Texas are in Table 7-6: *Estimated Haze Index Improvements for Affected Class I Areas*. These results show the estimated visibility improvements in deciviews (dv) likely expected to result from the potential control measures applied to the Texas sources selected for evaluation in the four-factor analysis as identified in Table 7-5. These Texas sources are anthropogenic stationary point sources considered most likely to contribute to visibility impairment at those Class I areas.

Table 7-6: Estimated Haze Index Improvements for Affected Class I Areas

Class I Area	Haze Index Improvement (dv)
Big Bend	0.07
Caney Creek	0.56
Guadalupe Mountains	0.03
Salt Creek	0.07
Upper Buffalo	0.21
White Mountain	0.02
Wichita Mountains	0.23

The EPA's final guidance on regional haze SIP revisions for the second planning period (EPA, 2019a) indicates a state may consider visibility benefit to inform the determination of whether it is reasonable to require a certain measure and when determining what measures are necessary to make reasonable progress at a Class I area. Sensitivity run modeling results demonstrate the greatest change in visibility over the 20% most impaired days for all Class I areas evaluated is approximately 0.56 deciviews. As shown in Table 7-4, the total annualized cost of controls resulting from the four-factor analysis are $204,874,491. Given the projected visibility benefit of the modeled control strategy for each Class I area, as shown in Table 7-6, which is imperceptible, and the corresponding costs associated with those controls, which is over $200 million, the TCEQ does not consider it reasonable to implement additional control measures for reasonable progress during this planning period.

7.3 REASONABLY ATTRIBUTABLE VISIBILITY IMPAIRMENT

Under 40 CFR 51.308(f)(2)(iv)(A), states are required to consider emission reductions due to ongoing air pollution control programs as part of the LTS, including measures to address reasonably attributable visibility impairment (RAVI). Limitations in RAVI requirements for improving visibility at many Class I areas led to provisions in the 1990 Clean Air Act Amendments that added the broader requirements to reduce regional haze impacts at Class I areas. The EPA implemented these provisions in the Regional Haze Regulations first issued July 1, 1999.

The FLMs for Big Bend and Guadalupe Mountains National Parks have not identified any reasonably attributable visibility impairment from Texas. The FLMs for the Class I areas that Texas' emissions impact in other states have not identified any reasonably attributable visibility impairment caused by Texas sources. For these reasons, the TCEQ does not have reasonably attributable visibility impairment to address.

7.4 FEDERAL PROGRAMS THAT REDUCE STATIONARY SOURCE EMISSIONS

Under 40 CFR §51.308(f)(2)(iv), states are required as part of the LTS to consider emission reductions due to ongoing air pollution control programs. The EPA's Texas BART FIP SO_2 Trading Program is expected to produce reductions in Texas EGU emissions of SO_2 while also satisfying SO_2 BART requirements for Texas EGUs (EPA, 2019b). The Cross-State Air Pollution Rule (CSAPR) continues to reduce Texas EGU emissions of NO_X, and Texas continues to rely on CSAPR participation for ozone-season NO_X to satisfy NO_X BART requirements for Texas EGUs (EPA, 2020a). The EPA's consent decrees for carbon black manufacturing plants are expected to reduce emissions of NO_X, SO_2, and PM in Texas and surrounding states, like Louisiana and Oklahoma. The EPA's consent decrees for cement manufacturing plants are also expected to continue to reduce emissions of NO_X and SO_2 emissions in Texas and surrounding states, like Arkansas and Oklahoma. For affected EGUs in surrounding states, like Arkansas and Oklahoma, BART requirements exist in the state's respective regional haze SIP revision, or the state continues to rely on CSAPR participation to satisfy as a BART alternative. The programs are described in Table 7-7: *Existing Federal Stationary Source Measures* listed as follows.

Table 7-7: Existing Federal Stationary Source Measures

Measure	Description	Start Date(s)
Texas BART FIP SO_2 Trading Program	Cap and Trade Program for SO_2 for affected Texas EGUs	January 1, 2020
CSAPR	Cap and Trade Program for ozone-season NO_X for affected Texas EGUs	January 1, 2015
EPA Carbon Black Consent Decrees	Emission reductions of NO_X, SO_2, and PM at carbon black manufacturing plants in Texas and surrounding states	Starting March 2020 and continuing through June 2024
EPA Cement Plant Consent Decrees	Emission reductions of NO_X and SO_2 at cement kilns in Texas and surrounding states	Starting December 2010 and continuing through February 2018
BART Requirements in Surrounding States	Regional Haze SIP requirements and CSAPR for certain Arkansas EGUs Regional Haze SIP requirements and a BART FIP for certain Oklahoma EGUs	September 2008 and continuing through February 2018 for states other than Arkansas and September 2019 for Arkansas February 2010 and continuing through January 2017 for Oklahoma

7.5 FEDERAL PROGRAMS THAT REDUCE MOBILE SOURCE EMISSIONS

Under 40 CFR §51.308(f)(2)(iv), states are required as part of the LTS to consider emission reductions due to ongoing air pollution control programs. The Federal Motor Vehicle Control Program (FMVCP) has produced and is continuing to produce large reductions in motor vehicle emissions of NO_X, PM, and VOCs. In addition, the increasingly lower federal limits on sulfur content for gasoline and diesel fuel are continuing to reduce the sulfur input to total sulfur emissions from internal combustion engines. Federal fuel programs are enabling lower NO_X, PM, and VOC emission limits for on-road motor vehicles, both diesel and gasoline, as well as for non-road engines. The lower sulfur fuel content is also enabling implementation of lower emission limits on new on-road and non-road engines. Significant federal mobile source programs are described in Table 7-8: *Existing Federal Mobile Measures* listed as follows.

Table 7-8: Existing Federal Mobile Measures

Measure	Description	Start Date(s)
Summer Gasoline Volatility Standard	Reid vapor pressure (RVP) limit for gasoline sold from May 1 to September 15 each year, applicable in Hardin, Jefferson, and Orange Counties	Phased in from 1991
Large Non-Road Spark-Ignition Engine Emissions Standards	Emission standards for land-based spark-ignition recreational engines, land-based spark-ignition engines rated over 19 kilowatts, and recreational marine diesel engines	November 2000 - Phased in from model year 2004 through 2007
Regulations to Reduce On-Road Mobile Source Emissions	Series of emissions limits implemented by the EPA for on-road vehicles, including Tier 1, Tier 2, and Tier 3 light-duty and medium-duty passenger vehicle standards, heavy-duty vehicle standards, low sulfur diesel standards, National Low Emission Vehicle standards, and reformulated gasoline	Phase in through 2010 Tier 3 phase in from 2017 through 2025
Regulations to Reduce Area/Non-Road Mobile Source Emissions	Series of emissions limits implemented by the EPA for area and non-road sources, such as diesel and gasoline engine standards for locomotives and leaf-blowers	Phase in through 2018
International Standards to Reduce Emissions from Marine Diesel Engines and Fuels	Fuel sulfur limits and NO_X emissions standards for oceangoing vessels operating in the North American Emission Control Area	January 2015 for fuel standards and January 2016 for engine standards

7.6 STATE AIR POLLUTION CONTROL PROGRAMS

7.6.1 Existing State Controls

Under 40 CFR §51.308(f)(2)(iv), states are required as part of the LTS to consider emission reductions due to ongoing air pollution control programs. The TCEQ has implemented rules that limit and minimize emissions causing both local and regional visibility impairment. Table 7-9: *Existing Stationary Source Control Measures* describes the regulations in Title 30 Texas Administrative Code (30 TAC) Chapter 112, Subchapter A that address emissions of SO_2, in 30 TAC Chapter 117 that address emissions of NO_X,, and in 30 TAC Chapter 111 that address visible emissions and PM. Table 7-10: *Existing Mobile Source Control Measures* describes the existing state regulations in 30 TAC Chapter 114 that address on-road and non-road mobile sources.

Table 7-9: Existing Stationary Source Control Measures

Measure	Description	Start Date(s)
Visible Emissions and PM Control Measures 30 TAC Chapter 111, Subchapter A	Limits visible emissions from all sources in Texas These rules establish general emission limits and specific emission limits for a variety of source types, including industrial and power plant stacks, motor vehicles, and incinerators	February 16, 2012
Outdoor Burning 30 TAC Chapter 111, Subchapter B	General prohibition against outdoor burning, except for activities explicitly listed in which case the methods to gain approval for outdoor burning are given	September 16, 1996
SO_2 Control Measures 30 TAC Chapter 112, Subchapter A	Limits SO_2 emissions from all sources in Texas These rules establish emission limits and monitoring, reporting, and recordkeeping requirements for a variety of source types, including sulfuric acid plants, sulfur recovery plants, solid fossil fuel-fired steam generators, liquid fuel-fired steam generators, furnaces, or heaters, and nonferrous smelter processes	October 23, 1992
Other Sulfur Compounds Control Measures 30 TAC Chapter 112, Subchapters B – D	Limits hydrogen sulfide, total reduced sulfur compounds, and sulfuric acid from a variety of sources including EGUs, sulfuric acid plants, smelters, and sulfur recovery units	January 1976 for Subchapter B and July 1989 for Subchapter C and D
NO_X Control Measures – Dallas-Fort Worth (DFW) Industrial, Commercial, and Institutional (ICI) Major Source Rule 30 TAC Chapter 117, Subchapter B, Division 4	Applies to major sources (50 tpy of NO_X or more) with affected units in Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise Counties NO_X emission limits for affected source categories include: boilers, process heaters, stationary gas turbines, and duct burners used in turbine exhaust ducts, lime kilns, heat treat and reheat metallurgical furnaces, stationary internal combustion engines, incinerators, glass, fiberglass, and mineral wool melting furnaces, fiberglass and mineral wool curing ovens, natural gas-fired ovens and heaters, brick and ceramic kilns, lead smelting reverberatory and blast furnaces, natural gas-fired dryers used in organic solvent, printing ink, clay, brick, ceramic tile, calcining, and vitrifying processes, and wood-fired boilers	March 1, 2009 or March 1, 2010, depending on source category January 1, 2017 for Wise County and for wood-fired boilers in all 10 counties of the DFW area

Measure	Description	Start Date(s)
NO_x Control Measures – DFW ICI Minor Source Rule 30 TAC Chapter 117, Subchapter D, Division 2	Applies to all minor sources (less than 50 tpy of NO_x) with stationary internal combustion engines in Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties NO_x emission limits for stationary gas-fired, dual-fuel, and diesel-fired reciprocating internal combustion engines	March 1, 2009 for rich-burn gas-fired engines, diesel-fired engines, and dual-fuel engines March 1, 2010 for lean-burn gas-fired engines
NO_x Control Measures – Stationary Diesel and Dual-Fuel Engines 30 TAC Chapter 117, Subchapter B, Division 4 and Subchapter D, Division 2	Restrictions on operating stationary diesel and dual-fuel engines for testing and maintenance purposes between 6:00 a.m. and noon in Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties	March 1, 2009
NO_x Control Measures – DFW Major Utility Electric Generation Source Rule 30 TAC Chapter 117, Subchapter C, Division 4	NO_x control requirements for major source (50 tpy of NO_x or more) utility electric generating facilities in Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise Counties Applies to utility boilers, auxiliary steam boilers, stationary gas turbines, and duct burners used in turbine exhaust ducts used in electric power generating systems	March 1, 2009 for Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties January 1, 2017 for Wise County
NO_x Mass Emissions Cap and Trade (MECT) Program and 30 TAC Chapter 117 NO_x Emission Standards for Attainment Demonstration Requirements 30 TAC Chapter 101, Subchapter H, Division 3 30 TAC Chapter 117, Subchapter B, Division 3, Subchapter C, Division 3, and Subchapter D, Division 1	NO_x emission limits: Overall 80% NO_x reduction from existing industrial sources and utility power plants, implemented through a cap and trade program for the Houston-Galveston-Brazoria (HGB) ozone nonattainment area NO_x emission limits for affected source categories include: boilers; process heaters; stationary gas turbines, and duct burners used in turbine exhaust ducts; stationary internal combustion engines; fluid catalytic cracking units (including CO boilers, furnaces, and catalyst regenerators); boilers and industrial furnaces; pulping liquor recovery furnaces; lime kilns; lightweight aggregate kilns; heat treating furnaces and reheat furnaces; magnesium chloride fluidized bed dryers; incinerators; utility boilers, auxiliary steam boilers, stationary gas turbines, and duct burners used in turbine exhaust ducts used in electric power generating systems	April 1, 2003 and phased-in through April 1, 2007

Measure	Description	Start Date(s)
NO_x System Cap Requirements for Electric Generating Facilities (EGFs) 30 TAC Chapter 117, Subchapter B, Division 3 and Subchapter C, Division 3	Mandatory daily and 30-day system cap emission limits (independent of the MECT Program) for all EGFs at utility power plants and certain industrial/commercial EGFs that also provide power to the electric grid NO_X control requirements for major sources (25 tpy of NO_X or more)	March 31, 2007 (industrial/commercial EGFs) March 31, 2004 (utility power plants)
NO_x Control Measures – HGB Minor Source NO_X Controls for Non-MECT Sites 30 TAC Chapter 117, Subchapter D, Division 1	NO_X emission limits on boilers, process heaters, stationary internal combustion engines, stationary gas turbines, and duct burners used in turbine exhaust ducts at minor sources of NO_X not included in the MECT Program (uncontrolled design capacity to emit of less than 10 tpy)	March 31, 2005
Stationary Diesel and Dual-Fuel Engines 30 TAC Chapter 117, Subchapter B, Division 3 and Subchapter D, Division 1	Restrictions on operating stationary diesel and dual-fuel engines for testing and maintenance purposes between 6:00 a.m. and noon	April 1, 2002
NO_x Control Measures – Utility Electric Generation in East and Central Texas 30 TAC Chapter 117, Subchapter E, Division 1	NO_X control requirements (approximately 55%) on utility boilers and stationary gas turbines (including duct burners used in turbine exhaust ducts) at utility electric generation sites in East and Central Texas, including Parker County, placed into service before December 31, 1995 Rules cover 31 counties	May 1, 2003 through May 1, 2005
NO_x Control Measures – Cement Kilns 30 TAC Chapter 117, Subchapter E, Division 2	NO_X emission limits for all portland cement kilns located in Bexar, Comal, Ellis, Hays, McLennan Counties, either on a unit-by-unit basis or through a source cap Kilns located in Ellis County must also comply with a source cap from March through October Voluntary agreed order number 2017-1648-SIP with TXI Operations, LP, limits Number 5 Kiln to 1.95 pounds of NO_X per ton of clinker	March 1, 2009 August 8, 2018 for TXI voluntary agreed order number 2017-1648-SIP
NO_x Control Measures – Natural Gas-Fired Small Boilers, Process Heaters, and Water Heaters 30 TAC Chapter 117, Subchapter E, Division 3	NO_X emission limits on small-scale residential and industrial boilers, process heaters, and water heaters equal to or less than 2.0 MMBtu/hr (statewide rule)	July 1, 2002

Measure	Description	Start Date(s)
NO_x Control Measures – East Texas Combustion Sources 30 TAC Chapter 117, Subchapter E, Division 4	NO_x emission limits for stationary rich-burn, gas-fired internal combustion engines (240 horsepower and greater) Measures implemented to reduce ozone in the DFW area although controls not applicable in the DFW area Rules cover 33 counties	March 1, 2010
NO_x Control Measures – Adipic Acid Manufacturing 30 TAC Chapter 117, Subchapter F, Division 1	NO_x emission limits for adipic acid manufacturing facilities in the HGB ozone nonattainment area	November 15, 1999
NO_x Control Measures – Nitric Acid Manufacturing 30 TAC Chapter 117, Subchapter F, Division 2	NO_x emission limits for nitric acid manufacturing facilities in the HGB ozone nonattainment area	November 15, 1999
NO_x Control Measures – Nitric Acid Manufacturing - General 30 TAC Chapter 117, Subchapter F, Division 3	NO_x emission limits for nitric acid manufacturing facilities (statewide rule)	November 15, 1999
NO_x Control Measures – Beaumont-Port Arthur (BPA) ICI Major Source Rule 30 TAC Chapter 117, Subchapter B, Division 1	Applies to major sources of NO_x (50 tpy of NO_x or more) with affected units in Hardin, Jefferson, and Orange Counties. NO_x emission limits for affected source categories include: industrial, commercial, or institutional boilers and process heaters; stationary gas turbines; and stationary internal combustion engines.	For turbines and engines subject to RACT, November 15, 1999 For boilers and process heaters subject to ESADs, May 1, 2005
NO_x Control Measures – BPA Major Utility Electric Generation 30 TAC Chapter 117 Subchapter C, Division 1	Rules for limiting NO_x emissions from utility boilers; auxiliary steam boilers; and stationary gas turbines (including duct burners)	For RACT, November 15, 1999 For ESADs, May 1, 2005

Table 7-10: Existing Mobile Source Control Measures

Measure	Description	Start Date(s)
Texas Low Emission Diesel (TxLED) 30 TAC Chapter 114, Subchapter H, Division 2	Fuel standards applicable in 110 central and eastern Texas counties for diesel that may be used to power diesel-fueled compression-ignition engines within the affected counties	Phased in from October 31, 2005 through January 31, 2006

Measure	Description	Start Date(s)
TxLED for Marine Fuels 30 TAC Chapter 114, Subchapter H, Division 2	Fuel standards applicable in 110 central and eastern Texas counties for marine distillates X and A and diesel marine gas oil that may be used to power compression-ignition engines on marine vessels in the eight counties of the HGB ozone nonattainment area	October 1, 2007 and phased in through January 1, 2008
RVP Gasoline 30 TAC Chapter 114, Subchapter H, Division 1	RVP limit for gasoline sold from May 1 through October 1 each year in 95 counties in central and eastern Texas	May 1, 2000
California Gasoline Engines	California standards for non-road gasoline engines 25 horsepower and larger	May 1, 2004
El Paso Low RVP 30 TAC Chapter 115, Subchapter C, Division 5	RVP limit for gasoline sold from May 1 through September 16 each year in El Paso County	May 1, 1996
Refueling – Stage I 30 TAC, Chapter 115, Subchapter C, Division 2	Control strategy to capture and prevent gasoline vapors released during gasoline delivery to storage tanks from being released into ambient air	1979 January 1, 2017 for Wise County
Vehicle Inspection/ Maintenance (I/M) 30 TAC Chapter 114, Subchapter C	Annual inspection for high emissions of NO_X, VOC, and CO in gasoline-powered vehicles 2–24 years old through Department of Public Safety–certified inspection stations in 15 affected counties in the DFW, HGB, and El Paso areas, and in Travis and Williamson Counties	May 1, 2002 in Collin, Dallas, Denton, and Tarrant Counties in DFW; Harris County in HGB May 1, 2003 in Ellis, Johnson, Kaufman, Parker, and Rockwall Counties in DFW; Brazoria, Fort Bend, Galveston, and Montgomery Counties in HGB November 17, 2004 in Travis and Williamson Counties January 1, 2007 in El Paso County

7.6.2 Best Available Control Technology (BACT) Requirements

BACT requirements have been in effect since 1972 for new and modified sources of air pollution for SO_2, NO_X, PM, and VOC. While federal new source review (NSR) rules requiring BACT apply only to major new sources or modifications, Texas law requires BACT for all emissions increases at new or modified units. The basic requirement is that each new and modified source of air pollution built in Texas use BACT to minimize or eliminate emissions of all pollutants subject to the national ambient air quality standards (NAAQS). This includes all the emissions from human activity that contribute to regional haze, including NO_X, SO_2, PM, and VOC. These requirements can be found in 30 TAC Chapter 116: Control of Air Pollution by Permits for New Construction or Modification.

Each applicable source must obtain a construction permit before beginning construction. Issuance of a construction permit can occur only after an engineering determination that the facility will use BACT. In some cases, the BACT requirements apply through permits by rule or standard permits rather than through case-by-case review of each new or modified source of air pollution.

7.6.3 Additional Measures

This section outlines additional measures, not included in the photochemical modeling, that are expected to further reduce visibility impairing pollution. Various federal, state, and local control measures exist that are anticipated to provide real emissions reductions. Because they may not meet all of the EPA's standard tests of SIP creditability (permanent, enforceable, surplus, and quantifiable), these measures are not included in the photochemical model for this SIP revision. However, these measures still assist in reducing visibility impacts in Class I areas in and around Texas. Any estimated past emission reductions provided for these measures are for informational purposes and do not represent any commitment by Texas toward future reductions.

7.6.3.1 Texas Emission Reduction Plan

Texas Emissions Reduction Plan (TERP) was created in 2001 by the 77th Texas Legislature to provide grants to offset the incremental costs associated with reducing NO_X emissions from high-emitting heavy-duty internal combustion engines on heavy-duty vehicles, non-road equipment, marine vessels, locomotives, and some stationary equipment. For more program and financial details, see TERP Report to 86th Texas Legislature, 2017 through 2018[8] (TCEQ, 2018).

The primary emissions reduction incentives are awarded under the Diesel Emissions Reduction Incentive (DERI) program. DERI grants are awarded to projects to replace, repower, or retrofit eligible vehicles and equipment to achieve NO_X emission reductions in Texas ozone nonattainment areas and other counties identified as affected counties under the TERP where ground-level ozone is a concern.

From 2001 through August 2019, DERI grants reached $1,153,991,148 that were awarded for projects projected to help reduce an estimated 184,207 tons of NO_X in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $60.4 million in grants under the DERI program in fiscal year 2021.

The Drayage Truck Incentive Program was established in 2013 to provide grants for the replacement of drayage trucks operating in and from seaports and rail yards located in nonattainment areas. The name of this program was recently changed to the Seaport and Rail Yard Areas Emissions Reduction (SPRY) program, and replacement or repower of cargo handling equipment was added to the eligible project list. Through

[8] https://www.tceq.texas.gov/assets/public/comm_exec/pubs/sfr/079-18.pdf

August 2019, the program awarded $15.5 million, with an estimated 773.45 tons of NO_x reduced in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $9.3 million in grants under the SPRY Program in the 2020-2021 fiscal biennium.

The Texas Clean Fleet Program (TCFP) was established in 2009 to provide grants for the replacement of light-duty and heavy-duty diesel vehicles with vehicles powered by alternative fuels, including: natural gas, liquefied petroleum gas, hydrogen, methanol (85% by volume), or electricity. This program is for larger vehicle fleets; therefore, applicants must commit to replacing at least 10 eligible diesel-powered vehicles with qualifying alternative fuel or hybrid vehicles. From 2009 through August 2019, over $62 million in TCFP grants were awarded for projects to help reduce an estimated 671 tons of NO_x in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $7.7 million in grants under the TCFP in fiscal year 2021.

The Texas Natural Gas Vehicle Grant Program (TNGVGP) was established in 2011 to provide grants for the replacement of medium-duty and heavy-duty diesel vehicles with vehicles powered by natural gas. This program may include grants for individual vehicles or multiple vehicles. From 2011 through August 2019, over $55.9 million in TNGVGP grants were awarded for projects to help reduce an estimated 1,685.6 tons of NO_x in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $15.4 million in grants under the TNGVGP in the 2020-2021 fiscal biennium.

Through fiscal year 2017, both the TCFP and TNGVGP required that the majority of the grant-funded vehicle's operation occur in the Texas nonattainment areas, other counties designated as affected counties under the TERP, and the counties in and between the triangular area between Houston, San Antonio, and Dallas-Fort Worth. Legislative changes in 2017 expanded the eligible areas into a new Clean Transportation Zone, to include the counties in and between an area bounded by Dallas-Fort Worth, Houston, Corpus Christi, Laredo, and San Antonio.

7.6.3.2 Clean School Bus Program

House Bill (HB) 3469, 79th Texas Legislature, 2005, Regular Session, established the Clean School Bus Program, which provides monetary incentives for school districts in the state for reducing emissions of diesel exhaust from school buses through retrofit of older school buses with diesel oxidation catalysts, diesel particulate filters, and closed crankcase filters. As a result of legislative changes in 2017, this program also includes replacement of older school buses with newer, lower-emitting models. Through August 2019, the TCEQ Clean School Bus Program had reimbursed approximately $40.6 million in grants for nearly 7,700 retrofit and replacement activities across the state. This amount included $4.7 million in federal funds. The TCEQ expects to award an additional $7.9 million in projects under the Clean School Bus Program in fiscal year 2020.

7.6.3.3 Energy-Efficiency (EE) Programs and Renewable Energy (RE) Measures

State Energy Conservation Office (SECO) partners with Texas local governments, county governments, public schools-Kindergarten through 12th grade, public institutions of higher education and state agencies, to reduce utility costs and maximize efficiency. SECO also adopts energy codes for single-family residential, commercial, and state-funded buildings (SECO, 2020).

Money is appropriated by the Texas Legislature directly to the Energy Systems Laboratory (ESL) of the Texas A&M Engineering Experiment Station, Texas A&M University System, for administrative costs associated with evaluating energy efficiency programs established under the TERP.

ESL compiles the information on energy-efficiency programs and assesses the annual electricity savings and annual NO_X emissions reductions that can be attributed to those savings. In addition to the programs explained above, under Texas Health and Safety Code (THSC) 386.252(a) the TCEQ contracts with the ESL for the development of annual computation of statewide emissions reductions obtained through wind and renewable energy resources. The ESL has also assessed the electricity savings from residential air conditioner replacements.

The ESL prepares a report of integrated annual electricity savings and total NO_X emissions reductions from these programs entitled Energy Efficiency/Renewable Energy Impact in the TERP. The ESL reports are available from the ESL website at http://esl.tamu.edu/terp/reports. A link to the reports is also provided on the TERP website at www.terpgrants.org.

Tables 7-11: *Annual Electricity Savings and Wind Generation in 2016 and 2017 in MWh/Year* and Table 7-12: *Annual Electricity Savings and Wind Generation in 2016 and 2017 in Tons of NO_X* provide information from the calendar year 2016 report on total annual electricity savings in megawatt hours per year (MWh/year) and the ESL's calculated annual NO_X emissions reductions from these programs in 2016. The savings and emissions reductions for 2017 are based on ESL's preliminary projections included in the calendar year 2016 report. Updated estimates for 2017 will be available in the calendar year 2017 report. The estimates of energy savings, renewable generation, and emissions reductions provided by ESL use 2008 as a base year. Electric Reliability Council of Texas (ERCOT) generated the information provided in the renewable generation by wind row.

Texas leads the nation in RE generation from wind. As of the first quarter 2019, Texas has 24,895 megawatts (MW) of installed wind generation capacity, 25.6% of all installed wind capacity in the U.S.[9] In 2018, Texas' total net electrical generation from renewable wind generators was 75.7 million megawatt-hours (MWh), approximately 27.6% of the total wind net electrical generation for the U.S at that time.[10] In 2018, Texas' total net electrical generation from renewable wind generators in Texas increased approximately 13% more than in 2017. Texas non-residential solar electricity

[9] U.S. Department of Energy, National Renewable Energy Laboratory, https://windexchange.energy.gov/maps-data/321

[10] U.S. Department of Energy, Energy Information Administration, https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=008&geo=0000000002&sec=g&linechart=ELEC.GEN.WND-TX-99.A&columnchart=ELEC.GEN.WND-TX-99.A&map=ELEC.GEN.WND-TX-99.A&freq=A&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=

generation in 2018 totaled 3.3 million MWh, a 53% increase from 2017.[11] The 2018 total installed solar electricity generation capacity in Texas was 2,924 MW, a 52% increase from 2017.[12]

While EE/RE measures are beneficial and do result in lower overall emissions from fossil fuel-fired power plants in Texas, emission reductions resulting from these programs are not explicitly included in photochemical modeling for SIP purposes because local efficiency or renewable energy efforts may not result in local emissions reductions or may be offset by increased demand in electricity. The difficulty in determining the accuracy of historical dispatch patterns and predicting future dispatch patterns makes accurately quantifying emission reductions from EE/RE measures difficult.

Table 7-8: Annual Electricity Savings and Wind Generation 2016 and 2017 in MWh/Year

Program	2016 (MWh/year)	2017* (MWh/year)
Texas Building Energy Performance Standards	3,087,080	4,065,005
Goal for Energy Efficiency	3,498,867	3,897,019
Energy Efficiency Programs in Institutions of Higher Education and Certain Government Entities	1,100,775	1,191,083
Renewable Generation - Wind (ERCOT)	36,069,833	39,135,769
Residential Air Conditioner Retrofits	260,026	247,025
Total Integrated Annual Savings	**44,016,581**	**48,535,902**

*The 2017 figures are the ESL's projections from a 2008 baseline through the end of 2017, as included in the calendar year 2016 final report.

Table 7-9: Annual Electricity Savings and Wind Generation 2016 and 2017 in Tons of NO_x

Program	2016 tons of NO_x	2017* tons of NO_x
Texas Building Energy Performance Standards	769	1019
Goal for Energy Efficiency	874	973
Energy Efficiency Programs in Institutions of Higher Education and Certain Government Entities	294	322
Renewable Generation - Wind (ERCOT)	10,143	11,005
Residential Air Conditioner Retrofits	61	58
Total Integrated Annual NO_x Emissions Reductions	**12,142**	**13,377**

*The 2017 figures are the ESL's projections from a 2008 baseline through the end of 2017 as included in the calendar year 2016 final report.

[11] U.S. Department of Energy, Energy Information Administration, https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=0000k&geo=0000000002&sec=g&freq=A&start=2001&end=2018&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0

[12] Solar Energy Industries Association, https://www.seia.org/state-solar-policy/texas-solar

7.6.3.4 Program to Lower the Impact of Construction Activity on Air and Water Quality

To address measures to mitigate the impacts of construction activities pursuant to the requirement under 40 CFR §51.308(f)(2)(iv)(B), the main regulatory requirements that the TCEQ uses to minimize the air and water quality impacts of dust and soil from construction activity in Texas are under water pollution control requirements to prevent pollution from storm water runoff and mud and dirt tracked from construction sites. The reduction in silt-bearing runoff on paved roads and in mud and dirt tracked onto paved roads around construction sites reduces the amount of fine soil material suspended in the air from traffic in these areas.

The TCEQ's Texas Pollutant Discharge Elimination System (TPDES) General Permit TXR150000 regulates activities at construction sites one acre or larger. The size threshold applies to single projects or multiple projects as part of a larger development plan. The TCEQ issued this permit March 5, 2003, pursuant to §26.040 of the Texas Water Code and §402 of the Clean Water Act.

State rules in 30 TAC Chapter 111, §§111.143 - 111.149, regulate dust emissions associated with materials handling, construction, roads, streets, alleys, and parking lots in the specified geographical areas within the state.

7.6.3.5 Programs to Manage Smoke Impacts on Class I Areas

To address basic smoke management practices for prescribed fire used for agricultural and wildland vegetation management purposes and smoke management programs pursuant to the requirement under 40 CFR §51.308(f)(2)(iv)(D), the Texas Forest Service (TFS) coordinates fire and smoke management issues in Texas. The 34th Texas Legislature created the TFS in 1915. The legal mandate of the TFS includes the responsibility to "assume direction of all forest interests and all matters pertaining to forestry within the jurisdiction of the state." The TFS has developed a voluntary approach called the Texas Forest Service Smoke Management System, under which all land managers in Texas, including the NPS, inform the TFS before performing prescribed burns. The TFS dispatch office maintains communications with the TCEQ.

Examination of the data and modeling for the 20% most impaired visibility days at both Big Bend and Guadalupe Mountains indicates that smoke from agricultural burning and wildfires in Texas are not the primary contributors to visibility impairment in Texas on these days. There is no indication that agricultural burning and wildfires in Texas are significant contributors to regional haze on the most impaired days at Class I areas that Texas impacts outside the state. See Appendix F, Section 1.2.2: *Glidepath Results* for details showing the impacts from fires at each of the Class I areas evaluated. For these reasons, the current rules, policies and plans listed below, along with the NPS smoke management plans, and the smoke management plans of other federal agencies responsible for Class I areas that Texas impacts, are adequate to meet the long-term strategy requirements. Appendix C: *Components of Texas Smoke Management Program* contains links to documents in the following list. The TCEQ provides the documents as examples of the fire management plans that the responsible agencies maintain. This SIP revision does not incorporate the following non-TCEQ documents.

- Texas Wildfire Protection Plan (TFS, 2020)
- Texas Forest Service Smoke Management System (TFS, 2018)
- Outdoor Burning in Texas (TCEQ, 2015)
- 30 TAC Chapter 111, Subchapter B: Outdoor Burning, current 2017, proposed 2020, (Texas Secretary of State, 2017)
- General Plan for Prescribed Burning on Texas Parks and Wildlife Department Lands (TPWD, 2015)
- Master Cooperative Wildland Fire Management and Stafford Act Response Agreement with U.S. Forest Service, National Park Service, U.S. Fish & Wildlife Service, Bureau of Indian Affairs, Texas Forest Service, and Texas Parks and Wildlife Department, 2015.
- Big Bend National Park Fire Management Plan (NPS, 2005)
- Guadalupe Mountains National Park Fire Management Plan (NPS, 2005, revised 2012)
- Big Thicket National Preserve Fire Management Plan (NPS, 2017)
- Lyndon B. Johnson National Historical Park Fire Management Plan (NPS, 2005)
- Padre Island National Seashore Fire Management Plan (NPS, 2004)
- San Antonio Missions National Historical Park Fire Management Plan (NPS, 2004).

A significant component of preventing wildfires is the authority that Texas counties have to prohibit open burning in times of drought. The counties get their authority from §352.081 and §352.082 of the Texas Local Government Code, relating to outdoor burning. Another component in reducing wildfire hazards is the red flag warnings that the National Weather Service issues in times of drought, low humidity, and windy conditions. The broadcast media routinely publicize these warnings, especially during times of drought and outdoor burning bans.

Because of the relatively low contribution of smoke from Texas to 20% most impaired days at Texas' Class I areas and the Class I areas Texas' emissions affect in other states, the TCEQ is not certifying a smoke management plan as part of this SIP revision.

7.6.3.6 SmartWay Transport Partnership and the Blue Skyways Collaborative

Among its various efforts to improve air quality in Texas, the TCEQ continues to promote two voluntary programs in cooperation with the EPA: SmartWay Transport Partnership and Blue Skyways Collaborative.

The SmartWay Transport Partnership is a market-driven partnership aimed at helping businesses move goods in the cleanest, most efficient way possible. This is a voluntary EPA program primarily for the freight transport industry that promotes strategies and technologies to help improve fleet efficiency while also reducing air emissions (for more information see *References*: EPA, 2020b).

There are over 3,700 SmartWay partners in the U.S., including most of the nation's largest truck carriers, all the Class 1 rail companies, and many of the top Fortune 500 companies. Since its founding, SmartWay has reduced oil consumption by 280 million barrels.[13] Since 2004, the SmartWay Truck Carrier Partners prevented the release of 134,000,000 tons of air pollution into the atmosphere.[14] Currently, 217 Texas companies are SmartWay partners.[15] The SmartWay Transport Partnership will continue to benefit Texas by reducing emissions as more companies and affiliates join and additional idle reduction, trailer aerodynamic kits, low-rolling resistance tire, and retrofit technologies are incorporated into SmartWay-verified technologies.

The Blue Skyways Collaborative was created to encourage voluntary air emission reductions by planning or implementing projects that use innovations in diesel engines, alternative fuels, and renewable energy technologies applicable to on-road and non-road sources. The Blue Skyways Collaborative partnerships include international, federal, state, and local governments, non-profit organizations, environmental groups, and private industries.

7.6.3.7 86th Texas Legislature, 2019

Summaries of the bills passed during the 86th Texas Legislature, 2019, Regular Session, that have the potential to impact visibility impairing pollutants are discussed in this section.

House Bill 1346

HB 1346 gives the TCEQ authority to set the minimum usage of TERP grant funded equipment in nonattainment and affected areas under the DERI program lower than the current 75%, but not lower than 55%. This could increase the number of projects funded, though the NO_x emissions reductions for projects that include equipment used less than 75% in the eligible areas could be lower than projects to date.

House Bill 3745

HB 3745 creates a TERP Trust Fund, effective September 1, 2021, and extends the TERP fees until attainment, effective August 30, 2019. This fund would exist outside of the state treasury and would allow the TCEQ to expend all the revenue from the TERP fees that accrue over the state biennium. HB 3745 could potentially result in the TCEQ funding more TERP projects and achieving greater NO_x emissions reductions.

7.6.3.8 Potential Effects of Economically Driven Coal Burning Power Plant Closures

Within the past decade, the economic viability of coal-burning power plants has been transitioning. The advent of hydraulic fracturing, the resulting shale oil-and-gas production, federal rules that impact coal-fired power plants, and the carbon cost of emissions in certain states are some of the factors that have impacted the cost-effectiveness of coal-fired power generation.

The Energy Information Administration (EIA) reported that 12.9 gigawatts (GW) of coal-fired generating capacity was retired in 2018 in the United States. Texas experienced the largest retirement of coal-fired generating capacity at 4.3 GW. Specifically, the EIA included the retirements of Luminant Energy's Big Brown, Monticello, and Sandow (Units 4 and 5) plants, which permanently ceased operations from November 2017

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[13] https://www.epa.gov/smartway/smartway-program-successes
[14] *Id*
[15] https://www.epa.gov/smartway/smartway-partner-list

through February 2018. Additional shutdowns include City Public Services' J.T. Deely plant, which ceased operations on December 31, 2018 and is currently mothballed, and Texas Municipal Power Agency's Gibbons Creek Steam Electric Station, which had been operating seasonally since 2017 but was mothballed indefinitely as of June 1, 2019.

The closure of these large SO_2 and NO_X sources is likely to have air quality impacts, because SO_2 and NO_X both react with ammonia to form ammonium sulfate and ammonium nitrate, which are the primary visibility impairing pollutants at Texas Class I areas. The TCEQ accounted for any known closures in this SIP revision's modeling emissions inventory (EI). However, the SIP modeling demonstration may not include all the SO_2 and NO_X emission reductions that will take place before the 2028, because the emissions from facilities whose closure have not yet been announced or from certain mothballed facilities are still part of the EI.

Though the emissions from the coal-burning power plants may cease, the electrical generating capacity must be replaced in some manner, and renewable, zero-emission power generation such as wind, solar, or nuclear may not be available to supply the missing capacity. It cannot be assumed, then, that the emissions will simply disappear; part of the generating capacity is likely to be met by another plant that has non-zero SO_2 or NO_X emissions. Given the complexity of power supply networks, it may not be possible to predict exactly how EGU SO_2 or NO_X emissions will redistribute, but despite the uncertainties, the overall trend is moving towards shutdown of coal-burning power plants.

7.7 CONCLUSION

Per 40 CFR 51.308(f)(2), this chapter describes how this proposed SIP revision meets the requirements for the LTS. The TCEQ considered all source categories in developing screening criteria for four-factor analysis. Point sources were selected for further evaluation, and sources that met the selected criteria were assessed for potential control by considering each of the four factors. Potential controls identified by the four-factor analysis were then evaluated for visibility impacts at affected Class I areas. This chapter also includes state and federal regulations to reduce emissions that contribute to regional haze, as well as additional measures, such as TERP, that are also expected to reduce emissions. Finally, this chapter considers the additional LTS requirements in 40 CFR 51.308(f)(2)(iv)(A) through (D) regarding RAVI, measures to mitigate the impacts of construction activities, source retirement and replacement schedules, and basic smoke management practices. The anticipated effect of emissions reductions due to the LTS on visibility, as required by 40 CFR 51.308(f)(2)(iv)(E), is included in the RPG as described in Chapter 8.

As discussed in Section 7.2, based on the results of the four-factor analysis and sensitivity analysis evaluating the visibility impacts of selected controls, the TCEQ finds that additional measures for visibility improvement at Texas Class I areas and Class I areas affected by Texas emissions are not reasonable for this planning period.

CHAPTER 8: REASONABLE PROGRESS GOALS

8.1 INTRODUCTION

For each Class I area located within the state, the Regional Haze Rule under 40 Code of Federal Regulations (CFR) §51.308(f)(3)(i) requires the state to establish a reasonable progress goal (RPG), expressed in deciviews, that reflects the visibility conditions that are projected to be achieved by the end of the implementation period as a result of the long-term strategy (LTS). The LTS encompasses the measures adopted as a result of the four-factor analysis required under 40 CFR §51.308(f)(2), control measures that other contributing states have determined to be necessary to make reasonable progress, and state or federal measures adopted to meet other requirements of the Federal Clean Air Act (FCAA) to determine the RPG for the implementation period. The RPGs for Class I areas must provide for improvement of visibility for the most impaired days since the baseline period and ensure no degradation of visibility for the clearest days since the baseline period. Texas did this via photochemical air quality modeling, consistent with the United States Environmental Protection Agency's (EPA) Regional Haze Rule Guidance (EPA, 2019). An RPG is a projected outcome, rather than visibility conditions established directly, and meeting an RPG is not an enforceable requirement of the Regional Haze Rule. While an RPG is not enforceable, it can be a useful metric for evaluating progress.

Under 40 CFR §51.308(f)(3)(ii)(A), a state is required to demonstrate that additional control measures for anthropogenic sources or groups of sources are not reasonable to include in the LTS when the RPG for a Class I area provides for a slower rate of improvement in visibility than the uniform rate of progress (URP) for the Class I area. A state is also required to make a demonstration, under 40 CFR §51.308(f)(3)(ii)(B), that additional control measures for anthropogenic sources or groups of sources anticipated to contribute to visibility impairment in another state's Class I area are not reasonable to include in its own LTS, where the RPG for that Class I area provides for a slower rate of improvement in visibility than the URP for the Class I area. These demonstrations must include documenting the criteria used to determine the sources or groups of sources evaluated for control measures and documenting the four-factor analysis required as part of the LTS.

8.2 REASONABLE PROGRESS GOALS FOR TEXAS CLASS I AREAS

There are no requirements in the Regional Haze Rule regarding the method and tools used to project the RPGs, such as the details of the air quality modeling platform including the base period of air quality data and the year of the base modeling inventory. However, many of the details associated with the EPA-recommended modeling process for projecting RPGs are explained in EPA's *Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, herein referred to as Modeling Guidance Section 5, (EPA, 2018a) which directs states through the recommended steps to apply base period and future year air quality model simulation results to ambient data, resulting in future year visibility projections. The RPGs established by the Texas Commission on Environmental Quality (TCEQ) reflect visibility improvements from emission reductions associated with the FCAA, the Texas Clean Air Act, Texas' ozone SIP revisions and rules, and agreements between the EPA and petrochemical refineries and carbon black manufacturing plants for nitrogen oxides (NO_X) and sulfur dioxide (SO_2) emissions reductions. As part of establishing the RPGs, the TCEQ evaluated the impact of emissions reductions from these adopted measures on visibility in Class I areas using photochemical modeling. Further, the TCEQ evaluated the impacts of additional controls beyond those already adopted using photochemical modeling in a sensitivity analysis (Section 8.5: *Sensitivity Scenarios*). As discussed in Chapter 7, based on the results of the four-factor analysis and the sensitivity analysis, the TCEQ finds that additional measures for visibility improvement at Texas Class I areas and Class I areas affected by Texas emissions are not reasonable for this planning period. This chapter provides details of the modeling conducted by the TCEQ as part of establishing RPGs per 40 CFR §51.301(f)(3).

8.3 MODELING

8.3.1 Introduction

The TCEQ conducted photochemical modeling to establish RPGs and evaluate the impact of identified emissions reductions on visibility in Class I areas based on Modeling Guidance and consistent with Appendix G, *Modeling Protocol*. For the second planning period for the Regional Haze program, the TCEQ conducted photochemical modeling with assistance from a contractor, Ramboll US Corporation (Ramboll). The contractor assisted the TCEQ by evaluating model performance, post-processing model output, and other technical assistance.

8.3.2 Overview of Photochemical Modeling Process

Photochemical modeling to support the TCEQ Regional Haze planning consisted of a base case model run, two future year model runs, two source apportionment runs, and three sensitivity runs. Post-processing and analysis were conducted after each of these runs. The TCEQ used the Comprehensive Air Quality Model with Extensions (CAMx), to conduct the photochemical modeling.

8.3.3 Modeling Process

8.3.3.1 Episode Selection

Guidance

The EPA's Modeling Guidance provides suggested criteria for choosing a time period to model:

- Model time periods close to a National Emissions Inventory (NEI) year but consider the availability of ambient air quality, meteorological, and special study data;
- Choose time periods where observed concentrations values are similar to the visibility impairment of the area; and
- Model a full year.

The TCEQ considered the Modeling Guidance criteria and the availability of modeling platforms for this application. The TCEQ invested significant resources developing a 2012 modeling platform that was rigorously tested through multiple attainment demonstration SIP revisions (TCEQ, 2016). Due to changing emissions such as the transformation of the electric generating unit fleet mix from coal to other energy sources, 2012 was determined to not be current enough. The only other modeling platform available with a more recent year was the 2016 National Emissions Inventory Collaborative (NEIC) modeling platform (NEIC, 2020).

2016 National Emissions Inventory Collaborative Modeling Platform

The EPA, states (including Texas), local areas, and other groups collaboratively developed a North American emission inventory for 2016. A Base Year Selection Workgroup was created, with TCEQ participation, to evaluate and select the base year for the collaborative modeling platform (NEIC, 2017). After a year of research and analysis on regulatory timelines, meteorological conditions, and emission inventories, 2016 was chosen as the preferred year.[16]

A coordination committee was formed with EPA and state representatives to select the workgroups and their co-leads, plan data releases, and report out the 2016 modeling platform development to the modeling community. The TCEQ was involved in the overall coordination of the platform development as well as participating in many of the workgroups that created the 2016 emission inventories.

The regional haze modeling year selected was 2016 because of the availability of emissions inventory data from the collaborative modeling platform, being more representative of current conditions than 2012, and consistency with modeling efforts by the EPA, other states, and regional planning organizations.

2016 Regional Haze Episode

Because visibility impairment occurs throughout the year, the episode timeframe for this Regional Haze SIP is January 1 through December 31, 2016 with a 15-day ramp-up period beginning on December 16, 2015.

Base Case Modeling

The TCEQ modeled all days of calendar year 2016 as the base case.

The TCEQ used lateral and top boundary conditions (BC) for the CAMx 36-kilometer (km) resolution domain from the global 3-D model of atmospheric chemistry driven by meteorological input from the Goddard Earth Observing System (GEOS) of the National Aeronautics and Space Agency (NASA) Global Modeling and Assimilation Office, known as GEOS-Chem. The base case GEOS-Chem modeling used GEOS-Chem version 11-02rc and a standard chemical mechanism configuration, which includes Universal tropospheric-stratospheric Chemistry eXtension (UCX mechanism) along with complex secondary organic aerosol chemistry. The meteorological inputs were prepared from NASA's GEOS-FP ('forward processing') reanalysis meteorology. The GEOS-Chem domain covers the globe with horizontal grid resolution of 2° x 2.5° and 72 vertical layers from ground level into the stratosphere. Initial conditions also included data from December 15 through 31, 2015, to 'spin up' the model. The BC were obtained from the Electric Power Research Institute (EPRI) who contracted with Ramboll to conduct modeling in support of regional haze planning. As part of their contract with EPRI, Ramboll conducted model performance evaluation (MPE) on the GEOS-Chem modeling.[17]

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[16] https://drive.google.com/file/d/1o0e75dIliyjDZOmBDOPxIdMUhUTeph4Y/view

[17] "*International Contribution to Regional Haze*", May 9, 2019, Eladio Knippin, Naresh Kumar, Uarporn Nopmongcol, Ralph Morris, presentation to Scientific Review Panel. Available on request.

The CAMx particulate matter calculation option the TCEQ used, coarse/fine (CF), tracks chemically inert particles in two sizes: coarse and fine. The cutoff size between the categories is a diameter of 2.5 micrometers (µm). The complete list of inorganic particulate matter species modeled in the CAMx CF aerosol option is shown in Table 8-1: *List of Inorganic PM Species for the CAMx CF Aerosol Option*.

Table 8-1: List of Inorganic PM Species for the CAMx CF Aerosol Option

CAMx Label	Name
PSO4	Particulate Sulfate
PNO3	Particulate Nitrate
PNH4	Particulate Ammonium
PEC	Primary Elemental Carbon
FPRM	Fine Other Primary (diameter ≤ 2.5 µm)
FCRS	Fine Crustal (diameter ≤2.5 µm)
CPRM	Coarse Other Primary
CCRS	Coarse Crustal
PH20	Aerosol Water Content
NA	Sodium
PCL	Particulate Chloride

CAMx calculates secondary organic aerosols (SOA) produced from chemical reactions of primary emissions. The CAMx secondary aerosol chemistry option the TCEQ used, SOAP2.2, computes and partitions SOA into six species: SOA1, SOA2, SOA3, SOA4, SOPA, and SOPB. CAMx also tracks directly emitted and non-chemically evolving organic aerosols as primary organic aerosols (POA). The anthropogenic SOA species SOA1 and SOA2 are partitioned based on chemical volatility, as are the biogenic SOA species SOA3 and SOA4. The non-volatile anthropogenic aerosols are tracked as SOPA, and non-volatile aerosols condensed from biogenic sources are tracked as SOPB.

When calculating light extinction, the CAMx species used need to be mapped onto the PM species measured at the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors. Table 8-2: *CAMx to IMPROVE Particulate Matter Species Cross Reference*, shows the mapping.

Table 8-2: CAMx to IMPROVE Particulate Matter Species Cross Reference

IMPROVE PM Species	Short Name	CAMx Species
Ammonium Sulfate	AmmSO4	1.375 x PSO4
Ammonium Nitrate	AmmNO3	1.290 x PNO3
Organic Aerosol	OA or OMC	POA + SOA1 + SOA2 + SOPA + SOA3 + SOA4 + SOPB
Elemental Carbon	EC	PEC
Crustal Material	Soil	FPRM + FCRS
Sea salt	Sea salt	NA + PCL
Coarse Mass	CM	CPRM + CCRS

Visibility impairment at IMPROVE monitors was calculated using the “revised” IMPROVE equation (Hand and Malm, 2006; Pitchford, 2007). Equation 8-1: *IMPROVE*

Equation, uses PM species concentrations and relative humidity data to calculate visibility impairment or beta extinction (Bext) in units of inverse megameters (Mm^{-1}).

Equation 8-1: IMPROVE Equation

Bext_Total = Bext_AmmSO4 + Bext_AmmNO3 + Bext_OA + Bext_EC + Bext_Soil + Bext_Seasalt + Bext_CM + Bext_Rayleigh

where

Bext_AmmSO4 = 2.2 x f_s(RH) x [small AmmSO4] + 4.8 x f_L(RH) x [large AmmSO4]
Bext_AmmNO3 = 2.4 x f_s(RH) x [small AmmNO3] + 5.1 x f_L(RH) x [large AmmNO3]
Bext_OA = 2.8 x [small OMC] + 6.1 x [large OMC]
Bext_EC = 10 x [Elemental Carbon]
Bext_Soil = 1 x [Fine Soil]
Bext_Seasalt = 1.7 x f_{ss}(RH) x [Sea salt]
Bext_CM = 0.6 x [Coarse Mass]
Bext_Rayleigh = Rayleigh Scattering (site specific)

and

f_s(RH) = the unitless site-specific water growth factor for small particles as a function of relative humidity (RH),
f_L(RH) = the site-specific water growth for large particles,
f_{ss}(RH) = the water growth factor for sea salt,
[ ] = particulate matter concentrations in $\mu g/m^3$, and each particle type has a numeric dry mass extinction efficiency factor in units of (m^2/g).

Ammonium sulfate, ammonium nitrate and organic aerosols are split into small and large modes based on their mass. For masses less than 20 $\mu g/m^3$, the fraction in the large mode is estimated by dividing the total concentration of the component by 20 $\mu g/m^3$. For example, if the total fine particulate OA concentration is 4 $\mu g/m^3$, the fraction in the large mode is calculated as 4/20 = 1/5 of 4 $\mu g/m^3$ = 0.8 $\mu g/m^3$, the remaining 3.2 $\mu g/m^3$ is in the small mode. If the total concentration of a component exceeds 20 $\mu g/m^3$, all of it is assumed to be in the large mode.

Rayleigh scattering is the light extinction due to scattering from the non-particulate molecules of the air. It is site-specific because it depends on average atmospheric pressure at the site. Rayleigh scattering is not modeled because it is not due to particulate matter, nor is it related to the speciated particulate matter gathered and measured by the IMPROVE monitors.

Future Year Modeling

Three versions of the 2028 future year were modeled to determine on-the-books 2028 conditions; a 2028 base case, a 2028 simulation with all anthropogenic emissions outside the United States set to zero (Zero Out the Rest of the World; ZROW), and a source apportionment run. The ZROW simulation was used to determine the international anthropogenic contributions to visibility impairment at IMPROVE monitors for use in a glidepath adjustment. Simulations for 2028 used meteorology inputs from 2016 with estimates of 2028 emissions as described in Section 8.3.6: *2028 Future Case Emissions.*

The CAMx Particulate Source Apportionment Technology (PSAT) was used to estimate the effect of emissions from emission sectors and regions on visibility impairment at Class I areas of interest. Emissions in 2028 were arranged into source categories for a PSAT model run. Industrial sectors in Texas were grouped by type, whereas the rest of the anthropogenic and natural sources in the U.S. and other areas were grouped by region. Natural sources were kept together across the model domain. The PSAT source categories are explained in Section 8.3.7.5: *Particulate Matter Source Apportionment.*

8.3.4 Weather Research and Forecasting (WRF) Modeling

The TCEQ used version 3.8.1 of the WRF model to generate the meteorological inputs for the photochemical modeling. The WRF modeling system was developed by a broad user community, including the Air Force Weather Agency, national laboratories, and academia.

8.3.4.1 Modeling Domains

The WRF modeling was conducted for the 48-state Continental United States and certain surrounding areas (CONUS). The extent of the WRF modeling period is provided in Table 8-3: *CONUS 2016 Meteorological Modeling*.

Table 8-3: CONUS 2016 Meteorological Modeling

Episode	Begin Date Time (UTC)	End Date Time (UTC)
2016 Season	December 16, 2015 00:00	December 31, 2016 00:00

A Lambert Conformal Conic (LCC) map projection with geographical coordinates defined in Table 8-4: *Lambert Conformal Map Projections*, was used for the WRF modeling.

Table 8-4: Lambert Conformal Map Projections

Projection Parameter	Value
First True Latitude (Alpha):	33°N
Second True Latitude (Beta):	45°N
Central Longitude (Gamma):	97°W
Projection Origin:	97°W, 40°N
Spheroid:	Perfect Sphere, Radius = 6370 km

WRF was configured for a single 12 km grid covering almost all North America. Figure 8-1: *WRF Regional Haze Modeling Domain* shows the single WRF domain includes portions of all Canadian provinces, Mexico, and portions of Central America and Venezuela. The easting and northing ranges for each grid in the LCC projection are defined in Table 8-5: WRF *Modeling Domain Definitions* in units of km.

Table 8-5: WRF Modeling Domain Definitions

Domain	Easting Range (km)	Northing Range (km)	East/West Grid Points	North/South Grid Points
12 km	-3492,3492	-1324,3024	583	505

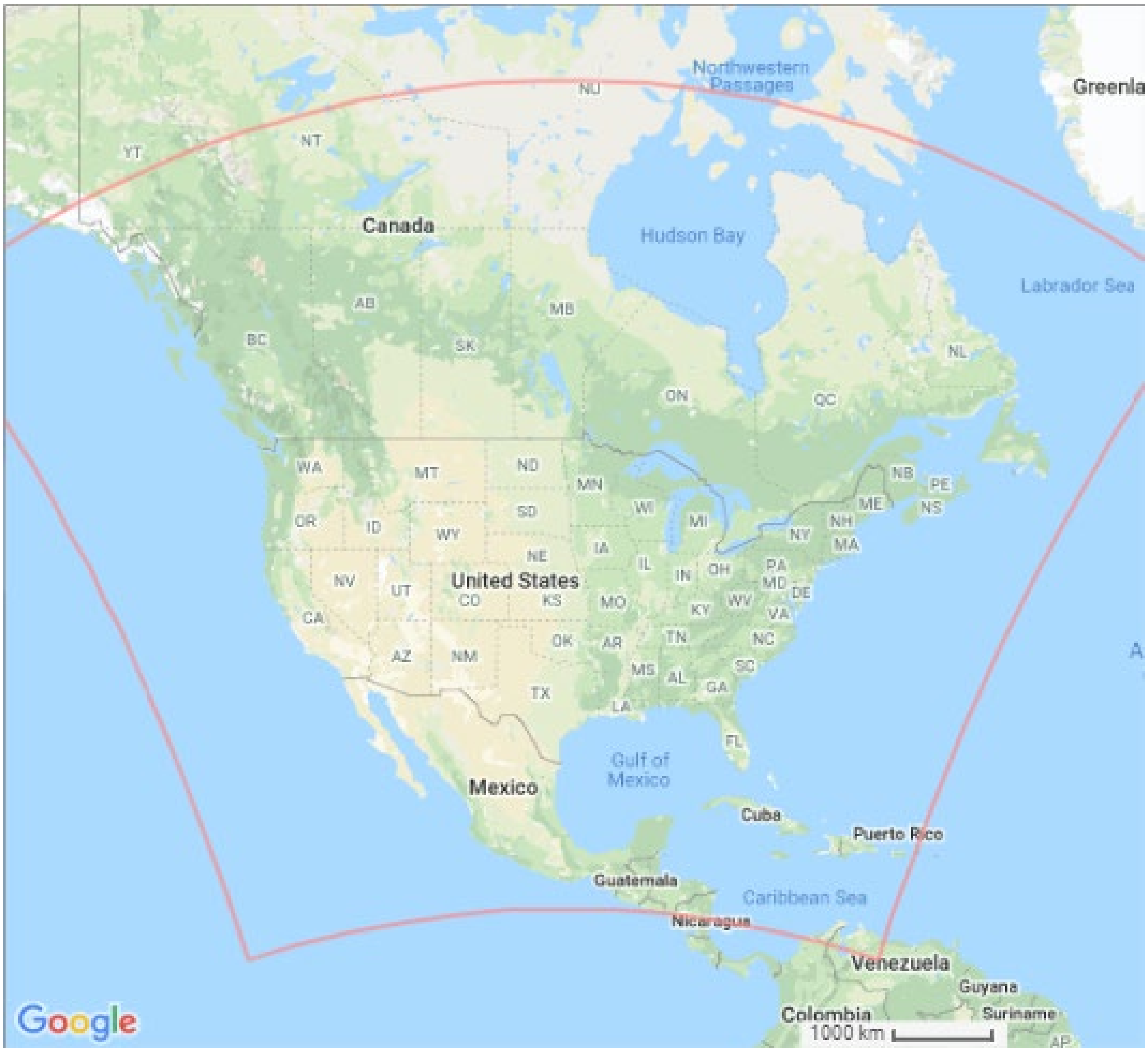

Figure 8-1: WRF Regional Haze Modeling Domain

Table 8-6: *WRF Vertical Layer* provides details regarding the heights, in meters above ground level (m AGL), and thickness of the vertical layers in WRF. The WRF vertical layer structure is intended to provide high resolution in the lowest part of the atmosphere where pollutant mixing is critical, as shown in Figure 8-2: *WRF Vertical Layer Diagram*.

Table 8-6: WRF Vertical Layer Structure

WRF Layer	Sigma Level	Top (m AGL)	Center (m AGL)	Thickness (m)
44	0.000	20581	20054	1054
43	0.010	19527	18888	1278
42	0.025	18249	17573	1353
41	0.045	16896	16344	1103
40	0.065	15793	15215	1156
39	0.090	14637	14144	987
38	0.115	13650	13136	1029
37	0.145	12621	12168	906
36	0.175	11716	11245	941
35	0.210	10774	10294	962
34	0.250	9813	9379	867
33	0.290	8946	8550	792
32	0.330	8154	7790	729
31	0.370	7425	7128	594
30	0.405	6830	6551	559
29	0.440	6271	6007	528
28	0.475	5743	5492	501
27	0.510	5242	5037	410
26	0.540	4832	4636	393
25	0.570	4439	4250	378
24	0.600	4061	3878	365
23	0.630	3696	3520	352
22	0.660	3344	3173	341
21	0.690	3003	2838	330
20	0.720	2673	2513	320
19	0.750	2353	2224	259
18	0.775	2094	1967	253
17	0.800	1841	1717	247
16	0.825	1593	1472	242
15	0.850	1352	1280	143
14	0.865	1209	1138	141
13	0.880	1068	999	139
12	0.895	929	860	137
11	0.910	792	746	91
10	0.920	701	656	90
9	0.930	611	566	89
8	0.940	522	477	89
7	0.950	433	389	88
6	0.960	345	301	87
5	0.970	258	214	87
4	0.980	171	128	86
3	0.990	85	60	51
2	0.996	34	26	17
1	0.998	17	8	17
0	1.000	0	0	0

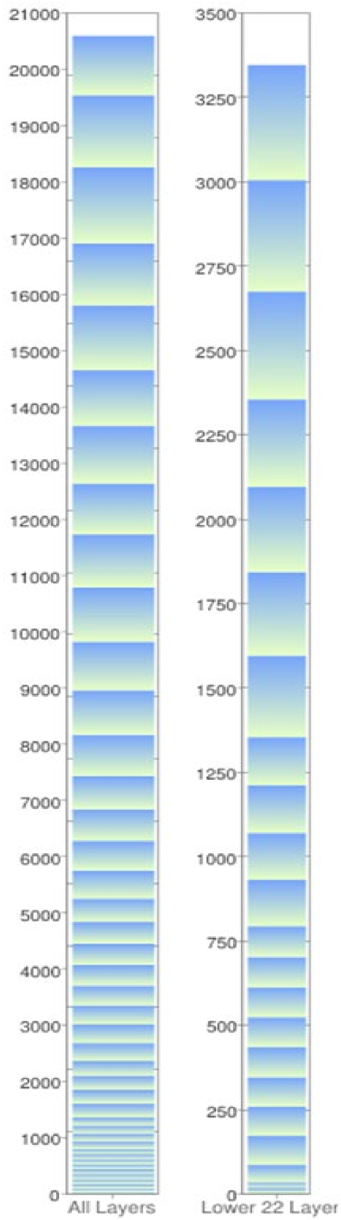

Figure 8-2: WRF Vertical Layer Diagram

<u>8.3.4.2 WRF Model Configuration</u>

The selection of the final meteorological modeling configuration for 2016 resulted from numerous sensitivity tests and MPE. The final WRF parameterization schemes and options selected are shown in Table 8-7: *2016 WRF Configuration*.

Table 8-7: 2016 WRF Configuration

Domain	Nudging Type	PBL	Cumulus	Radiation	Land-Surface	Microphysics
12 km	3-D Analysis	ACM2	Kain-Fritsch	RRTM Dudhia	Pleim-Xiu	Morrison

Note: ACM2 = Asymmetric Convective Model, version 2, RRTM = Rapid Radiative Transfer Model

The selected WRF configuration used the Pleim-Xiu (PX) land surface model (LSM) with soil nudging. The PX soil nudging does not use new soil or soil moisture data. Instead, this is a force restore technique that adjusts soil moisture provided by the National Centers for Environmental Prediction archived data to more closely match the 2-meter WRF temperature and humidity data.

WRF output was post-processed using the WRFCAMx utility to convert the WRF meteorological fields to the CAMx grid and input format. The WRFCAMx utility generates several alternative vertical diffusivity (Kv) files based upon multiple methodologies for estimating mixing given the same WRF meteorological fields. The WRF Kv option selected was the Community Multiscale Air Quality planetary boundary layer profile.

8.3.4.3 WRF MPE

To evaluate the performance of WRF, surface data for wind speed, wind direction, temperature and specific humidity were collected from the NOAA ds472.0 dataset and the Meteorological Assimilation Data Ingest System. There were over 2,800 stations across the 12 km domain as shown in Figure 8-3: *All ds472.0 Data Use for Model Validation in the Modeling Domain*.

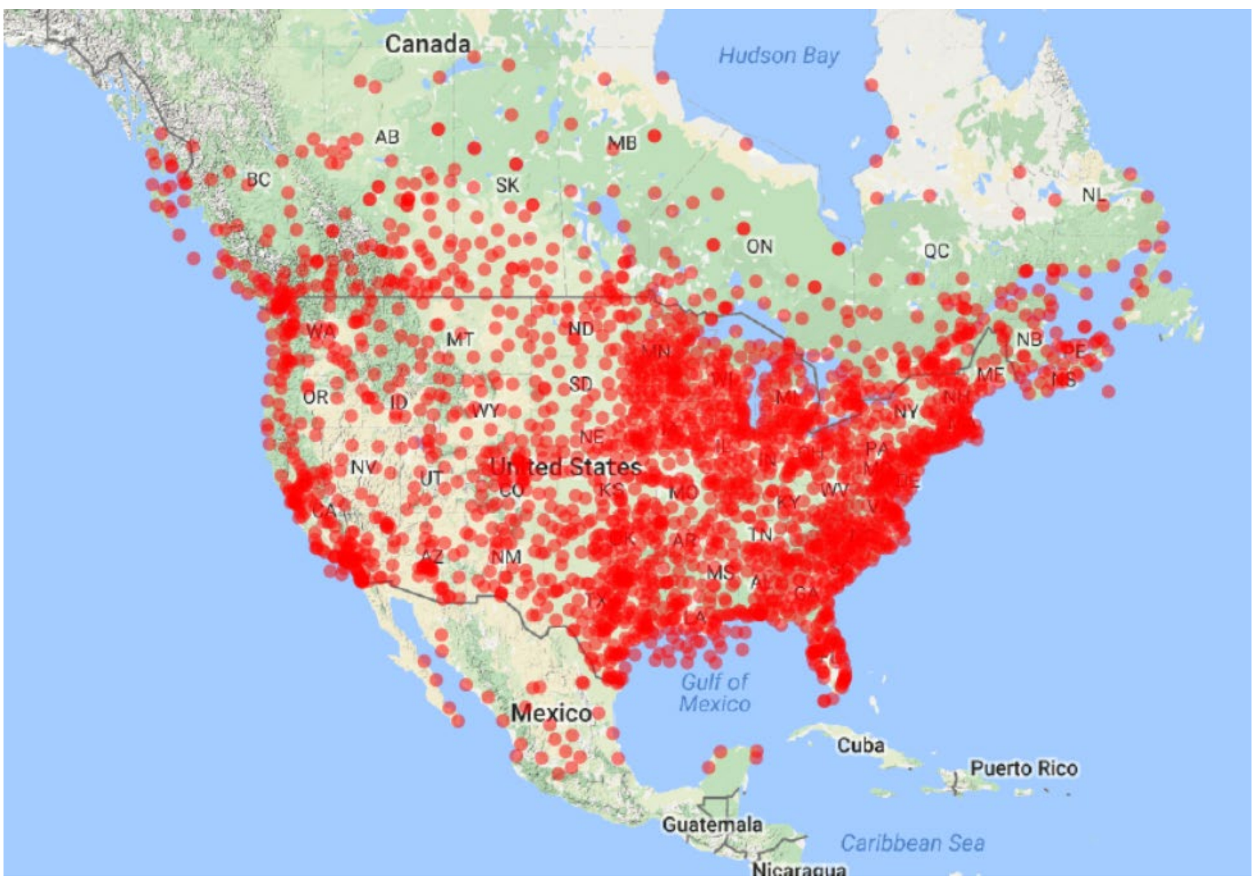

Figure 8-3: All ds472.0 Data Used for Model Validation in the Modeling Domain

Daily performance was evaluated using monthly time series panels comparing hourly modeled and observed data that were averaged across all ds472 sites and sites in a south-central region, as shown in Figure 8-4: *ds472 Sites in the South-Central States* that included Texas and its surrounding states with Class I areas of interest. Statistical performance across the south-central region is reasonable for September 2016.

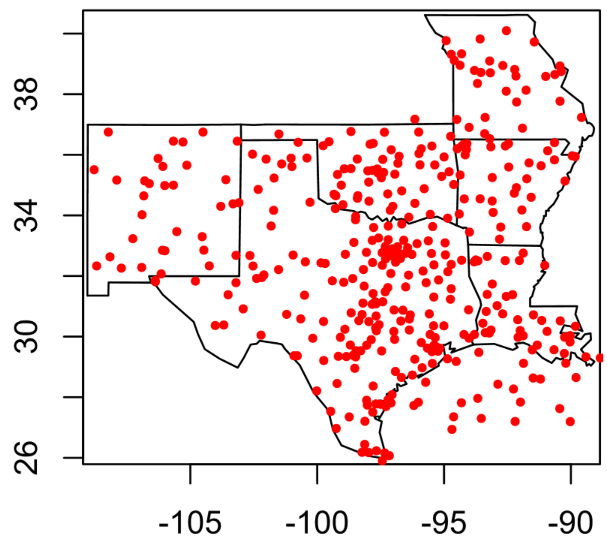

Figure 8-4: ds472 Sites in the South-Central States

Time series for wind speed, wind direction, temperature and humidity were calculated for each month of 2016, and the complete set is provided in Appendix D: *Meteorological Modeling for Regional Haze*. An example of the September 2016 wind speed performance for the entire CONUS is shown in Figure 8-5: *WRF CONUS Wind Performance for September 2016*. The x-axis of the time series panel is the date and time in Central Standard Time (CST) of the modeling episode. The y-axis represents the range of values of the plotted parameter (e.g., wind speed in meters per second (m/s)). The title of the panel indicates the geographic region, meteorological parameter (wind speed, temperature, etc.), and model run name. Diurnal wind speed bias is within about plus or minus 0.5 m/s.

Figure 8-6: *WRF CONUS Temperature Performance for September 2016* shows a diurnal temperature bias that is approximately 1 to 1.5 degrees too warm during evening hours.

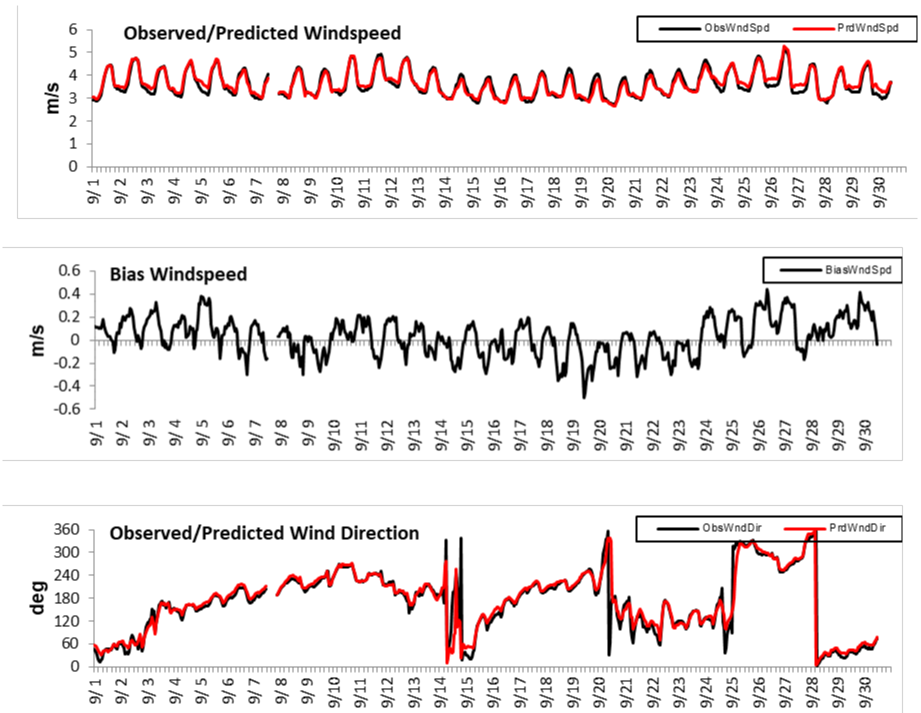

Figure 8-5: WRF CONUS Wind Performance for September 2016

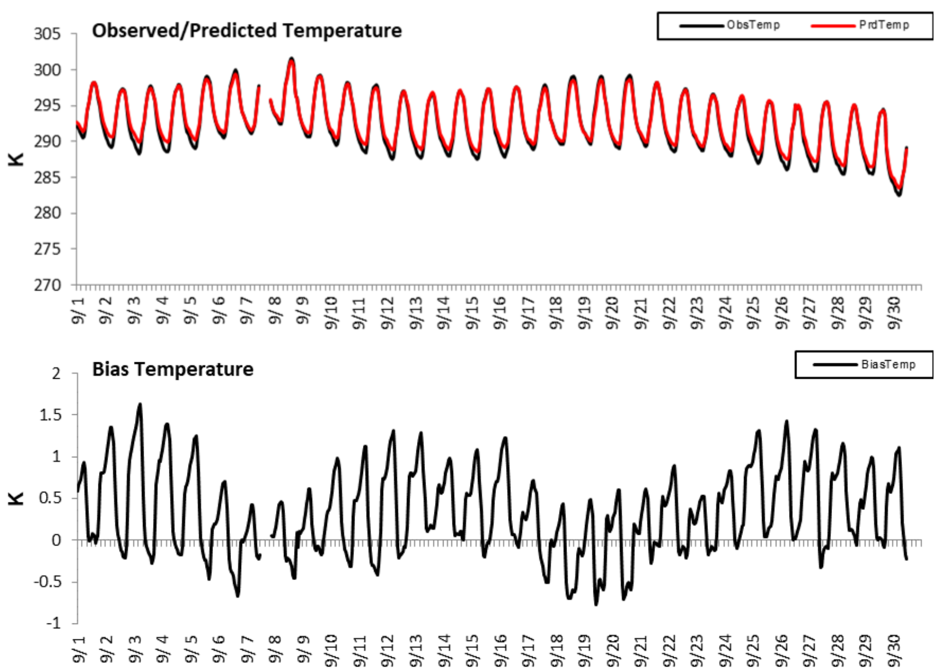

Figure 8-6: WRF CONUS Temperature Performance for September 2016

The predicted humidity, plotted as a mixing ratio of moisture in the air in Figure 8-7: *WRF CONUS Humidity Performance for September 2016*, shows a slight positive bias.

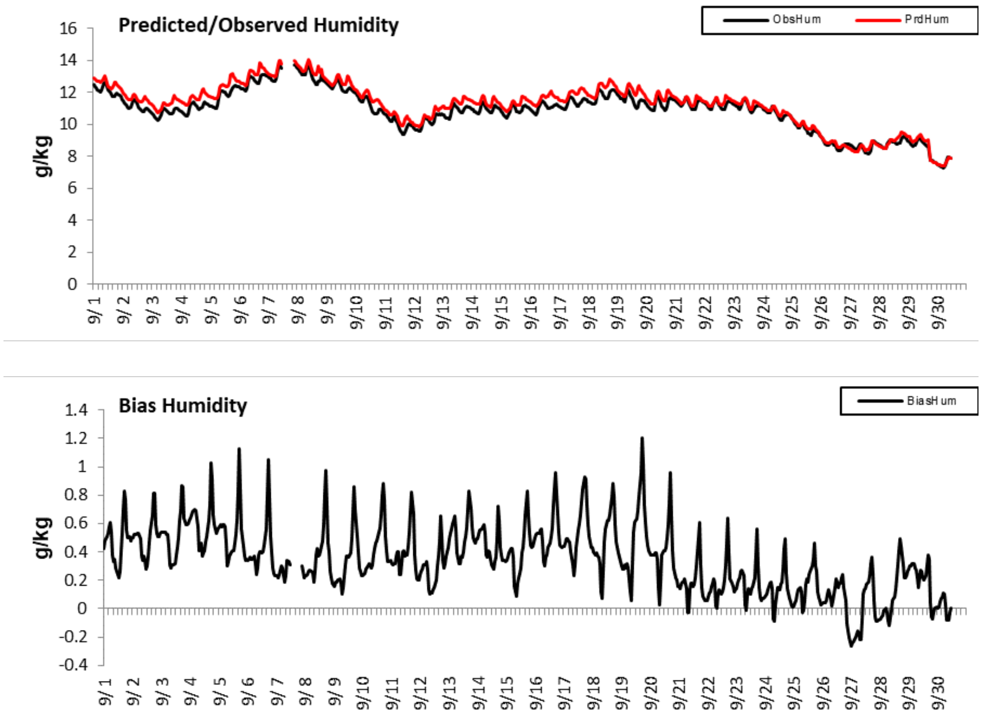

Figure 8-7: WRF CONUS Humidity Performance for September 2016

A set of corresponding plots were created for the south-central region that includes Texas, New Mexico, Oklahoma, Missouri, Arkansas, and Louisiana. The sites are shown in Figure 8-4. Figure 8-8: *WRF South-Central Wind Performance for September 2016*, Figure 8-9: *WRF South-Central Temperature Performance for September 2016*, and Figure 8-10: *WRF South-Central Humidity Performance for September 2016* exhibit the wind, temperature, and humidity performance, respectively, of the south-central region. Statistical performance across the south-central region are reasonable for September 2016.

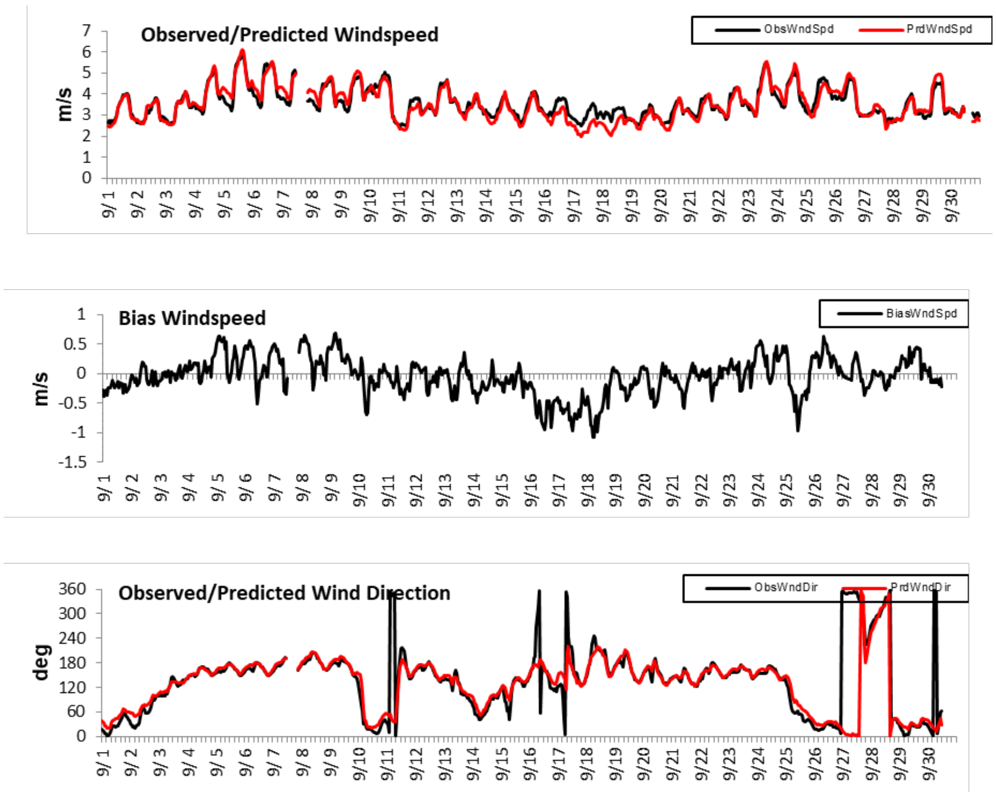

Figure 8-8: WRF South-Central Wind Performance for September 2016

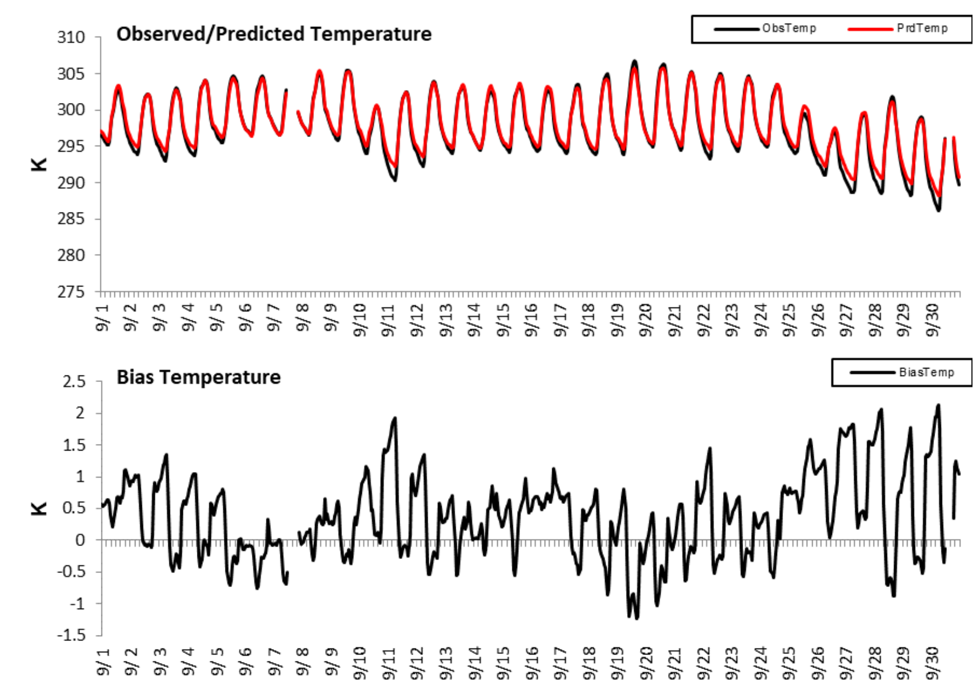

Figure 8-9: WRF South-Central Temperature Performance for September 2016

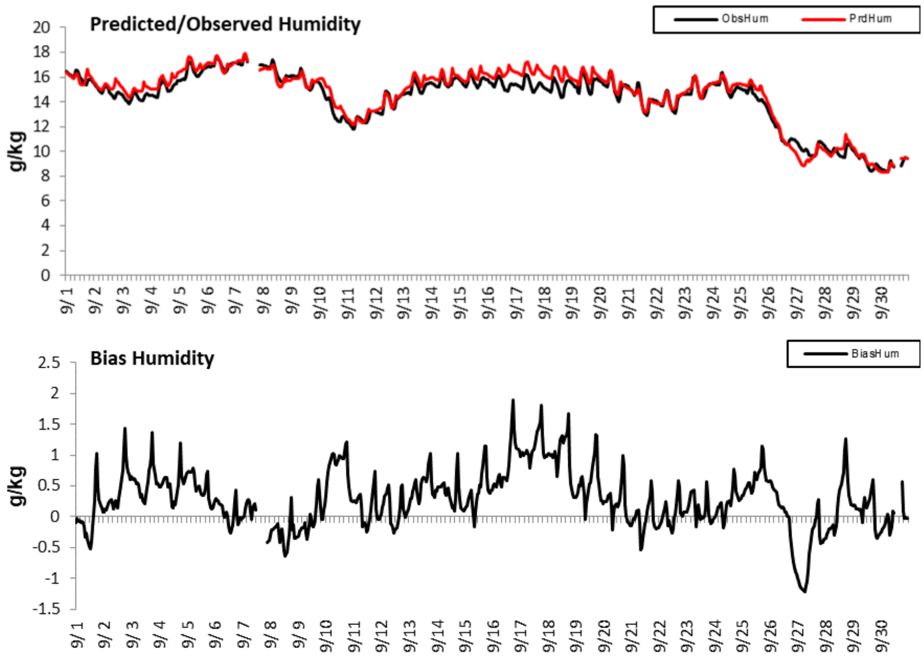

Figure 8-10: WRF South-Central Humidity Performance for September 2016

Alternative ways of aggregating and averaging data provide other performance information. For that reason, WRF monthly mean biases for wind speed, temperature, and humidity are calculated at individual ds472 sites. In Figure 8-11: *WRF Mean Wind Speed Bias for September 2016*, most sites in the central and eastern portion of the United States have a bias within plus or minus 0.5 m/s. However, some sites in Florida and in the western United States show a negative bias. Temperatures throughout Texas and neighboring states look reasonable; however, Figure 8-12: *WRF Mean Bias of Temperature for September 2016* shows high temperature biases in the Rocky Mountains of Colorado. This feature was notable for several of the months evaluated (see Appendix D), but was not likely a concern for neighboring Class I areas due to the distance to neighboring Class I areas of interest. Figure 8-13: *WRF Mean Bias of Mixing Ratio for September 2016* shows a slight underprediction for humidity in north-central Texas and some overprediction along the Rio Grande valley.

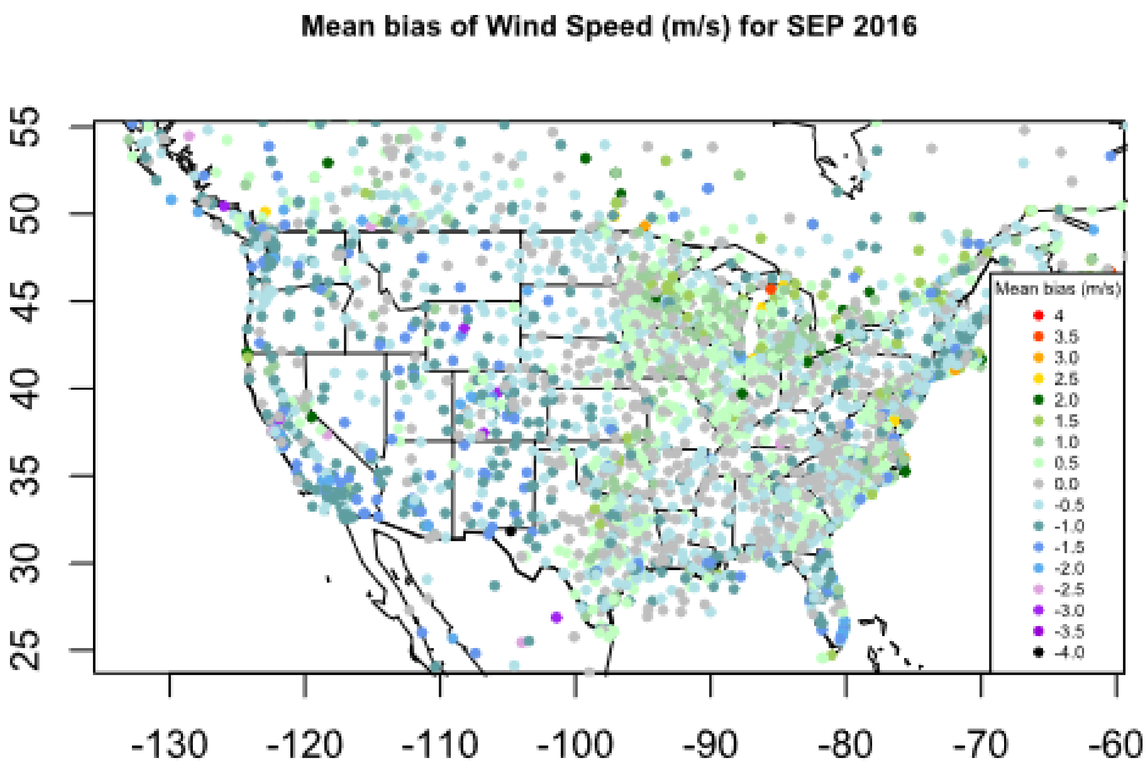

Figure 8-11: WRF Mean Wind Speed Bias for September 2016

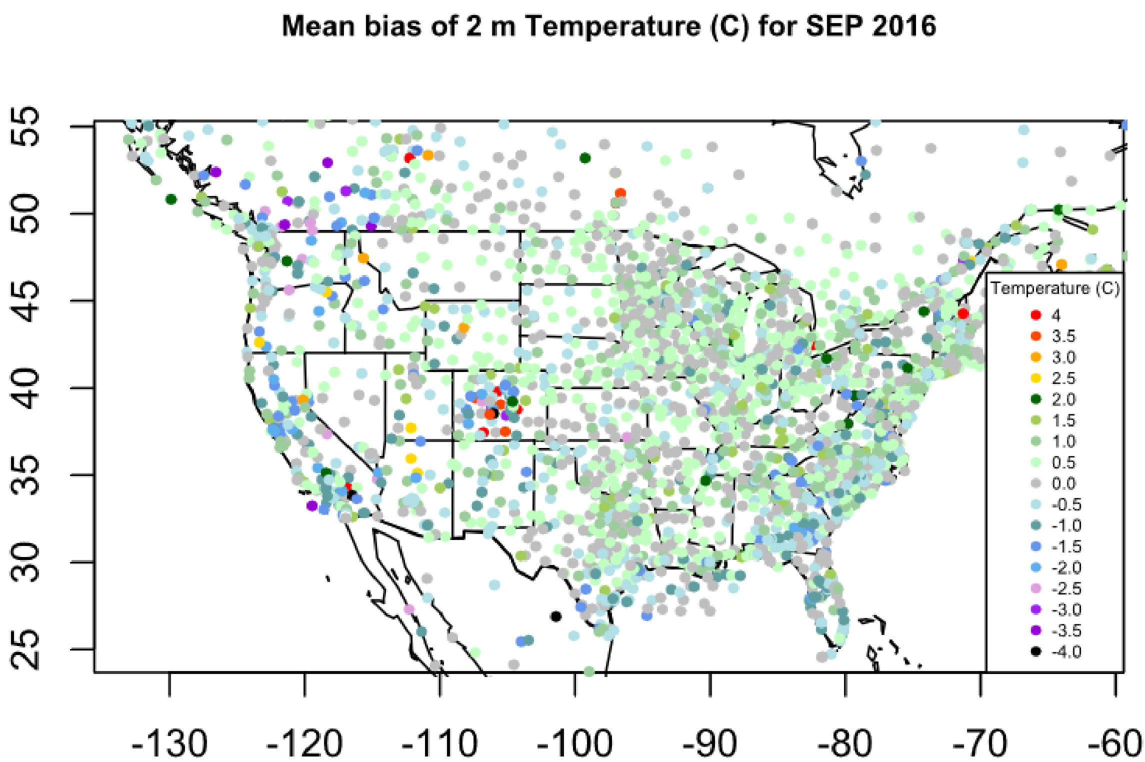

Figure 8-12: WRF Mean Bias of Temperature for September 2016

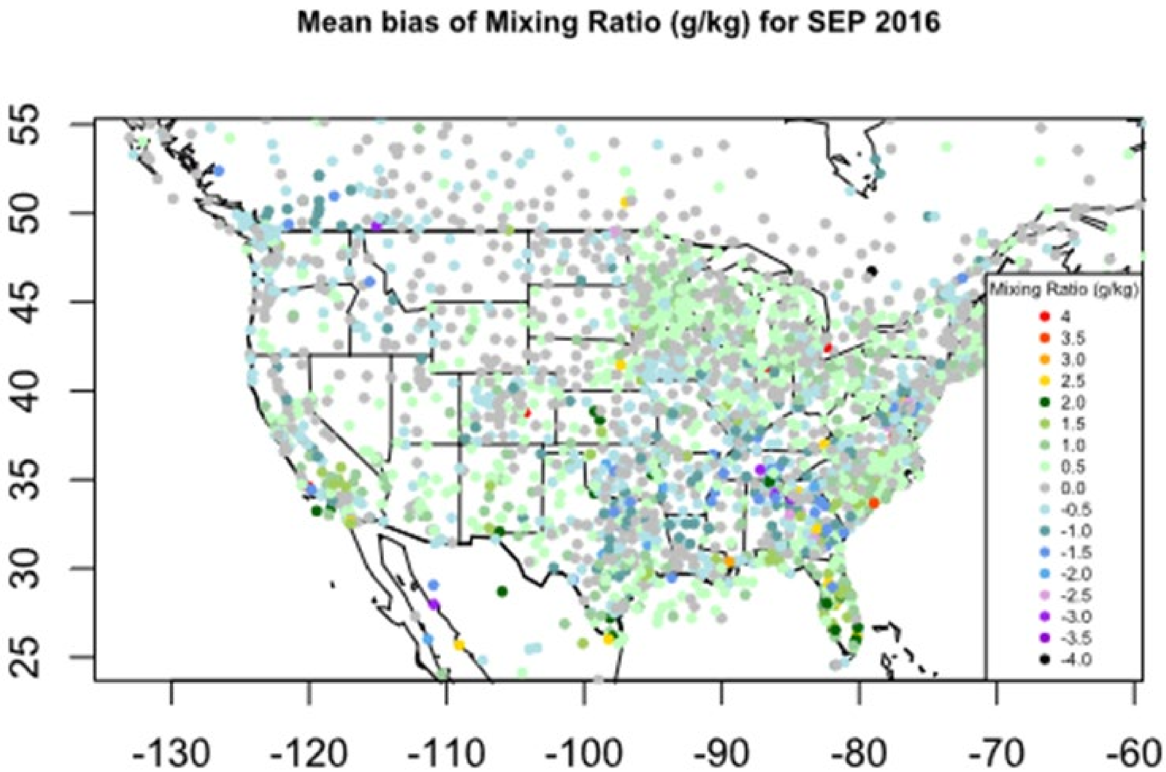

Figure 8-13: WRF Mean Bias of Mixing Ratio for September 2016

Evaluating precipitation performance is important to determine the appropriateness of the overall model configuration for replicating synoptic and mesoscale features. Also, the correct patterns of precipitation are necessary for corrections to deep soil moisture with the land-surface model. Most precipitation is highly variable both in space and time and is difficult for models to predict in absolute time and location. A gridded product suitable for comparison to a gridded model such as WRF is available from the Parameter-elevation Relationships on Independent Slopes Model (PRISM) maintained by Oregon State University. In Figure 8-14: *WRF Accumulated Monthly Precipitation in Inches for September 2016*, the predicted accumulated monthly precipitation for September 2016 can be compared to the PRISM data shown in Figure 8-15: *PRISM Monthly Precipitation for September 2016*. For this month, WRF had more rainfall in the mountains and in southeastern New Mexico than the PRISM data. However, PRISM showed more accumulated precipitation across northeast Texas. Most differences are not large, and the patterns are similar, which indicates acceptable model performance.

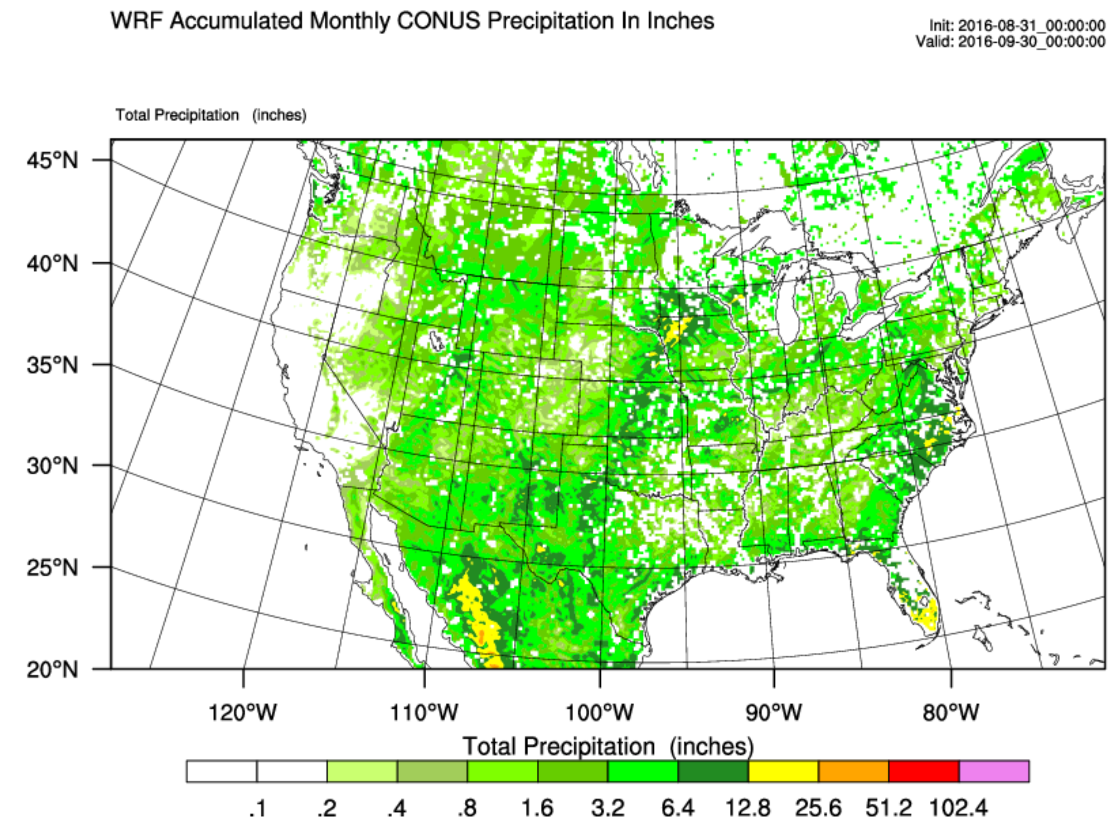

Figure 8-14: WRF Accumulated Monthly Precipitation in Inches for September 2016

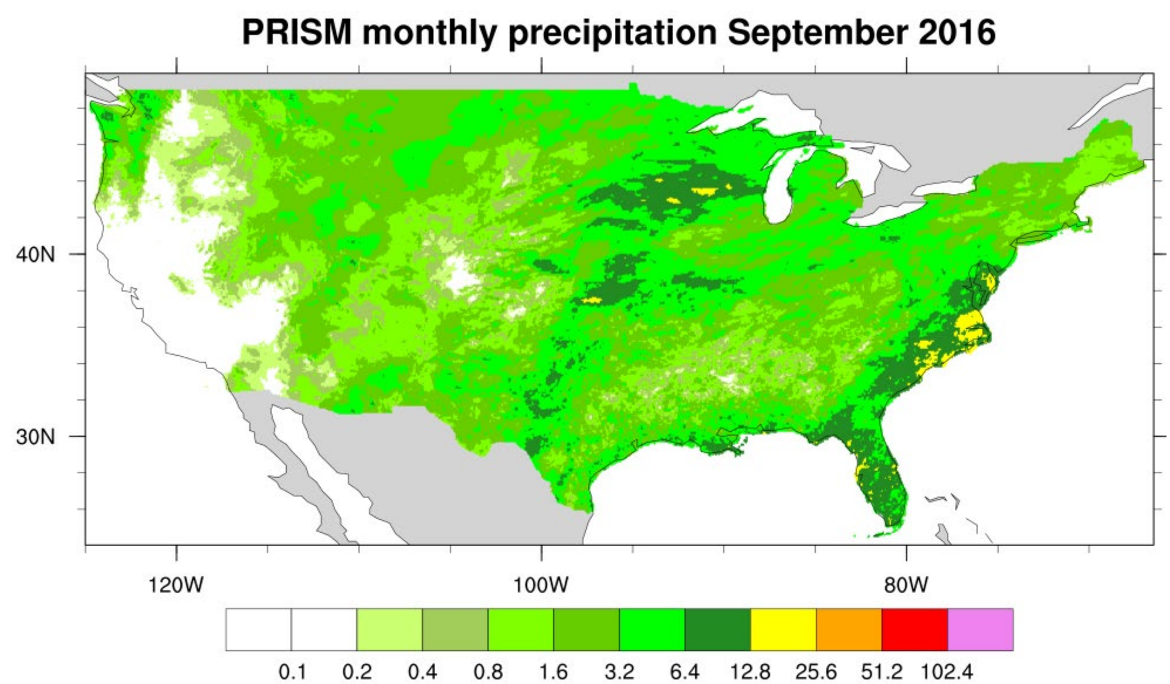

Figure 8-15: PRISM Monthly Precipitation for September 2016

8.3.5 2016 Base Case Modeling Emissions

An overview is provided in this section of the emission inputs used for the 2016 base case. Model-ready emissions were developed for the January through December 2016 period plus a ramp-up period of December 16 through 31 of 2015. Appendix E: *Emissions Modeling* contains more detail on the development and processing of the emissions.

8.3.5.1 Biogenic Emissions

Biogenic sources are trees, shrubs, grasses, and soils that emit NO_x, volatile organic compounds (VOC), and/or aerosols.

To estimate the biogenic source emissions for Texas and the rest of North America, the TCEQ used version 3.61 of the Biogenic Emission Inventory System (BEIS) (Bash, et al., 2016) within the Sparse Matrix Operation Kernel Emissions (SMOKE) System (version 3.7) to generate daily emissions for every day of 2016 in addition to the ramp-up days of December 16 through 31 of 2015 (SMOKE, 2020). The TCEQ WRF model output was used as input for BEIS modeling.

8.3.5.2 Fire Emissions

Agricultural and forest fire emissions for 2016 were created from the Fire Inventory from the National Center for Atmospheric Research, or FINN model, version 1.5, for the entire modeling domain. Fires are treated as point sources for emission processing purposes.

8.3.5.3 Point Sources

Point sources are stationary industrial facilities such as electric generating units (EGU), oil refineries, and cement plants.

Outside Texas

For the non-Texas North American portion of the modeling domains, the TCEQ used the beta version (vβ) inventories from the 2016 NEIC platform (2016ff and 2028fg) for the point sources. The sources are represented by an average weekday and weekend day per month. The 2016 NEIC platform documentation describes development of the 2016 point source emission inventory (NEIC, 2020). For the non-Texas U.S. portion of the modeling domain, hourly NO_x emissions for major EGUs were obtained from the EPA Air Markets Program Database (AMPD) for each day of the 2016 base case year. Canadian and Mexican point source emissions, and emissions for non-EGU point sources in states beyond Texas were obtained from the 2016 NEIC platform vβ 2016ff. Emissions for point sources in the Gulf of Mexico (e.g., oil-and-gas production platforms) were obtained from the 2014 Gulfwide Emissions Inventory (GWEI, 2014) provided by the U.S. Bureau of Ocean Energy Management (BOEM).

Within Texas

Stationary point source emissions data are collected annually from sites that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. To collect the data, the TCEQ provides detailed reporting instructions and tools for completing and submitting an emissions inventory (EI). Companies submit EI data using a web-based system called the Annual Emissions Inventory Report System. Companies are required to report emissions data and to provide sample calculations used to determine the emissions. Information characterizing the process equipment, the abatement units, and the emission points is also required. Per FCAA, §182(a)(3)(B), company representatives certify that reported emissions are true, accurate, and fully represent emissions that occurred during the calendar year to the best of the representative's knowledge.

All data submitted in the EI are reviewed for quality assurance purposes and then stored in the State of Texas Air Reporting System (STARS) database. The TCEQ's Point Source Emissions Inventory webpage (https://www.tceq.texas.gov/airquality/point-source-ei/psei.html) contains guidance documents and historical point source emissions data. Additional information is available upon request from the TCEQ's Air Quality Division.

For this modeling, the TCEQ designated 2018 as the base year for Texas EGUs with emissions from the EPA's AMPD, and 2016 as the base year for all other stationary point sources (non-EGUs) with emissions recorded in the STARS database. Details on the base year for point sources are provided in Section 8.3.3.1: *Episode Selection* and Appendix E.

The TCEQ requested regulated entities submit revisions to the 2016 or 2018 (as appropriate) point source EI by January 4, 2019. The point source emissions used in this modeling incorporate these updates. The TCEQ did not receive 2018 EGU EI revisions. Revised 2016 non-EGU point source emissions in this regional haze SIP revision totaled less than one ton per day each of VOC and NO_X emissions.

Table 8-8: *2016 Average Base Case EGU Emissions Within Texas* provides a summary of the seasonal daily average Texas EGU emissions in tons per day (tpd). The EGU emissions can vary each day based on hourly real-time continuous emissions monitoring data that are reported to the EPA's AMPD. Table 8-9: *2016 Sample Base Case Non-EGU Point Source Emissions Within Texas* provides a summary of average day non-EGU emissions within Texas. Non-EGU point source emissions are calculated based on annual emissions and temporal data that are reported to STARS.

Table 8-8: 2016 Average Base Case EGU Emissions Within Texas

Season	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Winter (Jan-Mar)	212.08	5.27	292.38	451.41	3.15	25.70	31.71
Spring (Apr-Jun)	280.57	7.09	367.97	591.64	3.51	32.75	40.89
Summer (Jul-Sep)	383.70	9.54	548.07	901.51	4.14	44.71	57.08
Fall (Oct-Dec)	283.22	6.30	455.09	720.53	3.05	33.59	43.93

Table 8-9: 2016 Sample Base Case non-EGU Point Source Emissions Within Texas

Sample Day	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Average June Day	399.11	426.01	326.90	223.38	5.50	52.64	75.70

8.3.5.4 On-Road Mobile Sources

On-road mobile sources include cars, trucks, buses, motorcycles, and other vehicles that regularly operate on highways and local roadways.

Outside Texas

For the non-Texas North American portions of the modeling domain, the TCEQ used the 2016 NEIC platform vβ (2016ff) for the on-road mobile sources. Each 2016 day is represented. The 2016 NEIC platform documentation describes development of the 2016 on-road emission inventory[18] (NEIC, 2020).

Within Texas

Texas on-road mobile source emissions for 2016 were developed under contract by the Texas Transportation Institute (TTI) for all Texas counties using the 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model. Vehicle miles traveled (VMT) activity data sets used for the on-road inventory development were based on the Highway Performance Monitoring System that is managed by the Texas Department of Transportation. For each Texas county, on-road emissions were estimated for the four activity day types of weekday (Monday-Thursday average), Friday, Saturday, and Sunday within each of the four seasons of Spring (March, April, and May), Summer (June, July, and August), Fall (September, October, and November), and Winter (December, January, and February).

On-road inventory summaries by season and criteria pollutant are presented in Table 8-10: *2016 Texas On-Road Criteria Pollutant Emissions by Season*.

Table 8-10: 2016 Texas On-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	72,358.74	26,019.80	276,341.16	487.16	1,856.46	2,166.25	4,697.58
Summer	66,573.76	28,373.24	339,198.44	517.10	1,849.80	2,124.67	4,644.80
Fall	71,104.74	26,337.54	305,302.28	520.54	1,849.28	2,133.68	4,655.22
Winter	78,006.06	26,066.48	288,576.63	507.32	1,846.68	2,285.06	4,822.73
Annual	288,043.30	106,797.06	1,209,418.51	2,032.12	7,402.22	8,709.66	18,820.33

8.3.5.5 Non-Road Mobile Sources

Non-road mobile sources include vehicles, engines, and equipment used for construction, agriculture, recreation, and many other purposes.

Outside Texas

For the non-Texas North American portion of the modeling domains, the TCEQ used the 2016 NEIC platform vβ (2016ff) for the non-road mobile sources. The sources are represented by an average weekday and weekend day per month plus holidays. The

[18] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-onroad_15Sep2019.pdf

2016 NEIC platform documentation describes development of the 2016 non-road emission inventory[19] (NEIC, 2020).

Within Texas

Texas non-road mobile source emissions for 2016 were developed using version 2 of the Texas NONROAD (TexN2) model. TexN2 is a customized tool that interfaces with the non-road emissions calculations performed by the MOVES2014a model. For 2016, TexN2 was run by season, with emissions estimates developed for the three activity day types of weekday (Monday-Friday average), Saturday, and Sunday. Non-road emission inventory summaries by season and criteria pollutant for 2016 are presented in Table 8-11: *2016 Texas Non-Road Criteria Pollutant Emissions by Season*.

Table 8-11: 2016 Texas Non-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	28,398.25	16,385.30	183,812.66	43.80	58.66	2,466.17	2,572.15
Summer	30,863.09	23,130.05	228,922.59	51.93	68.60	2,922.21	3,050.79
Fall	22,760.66	18,896.53	222,595.44	62.28	50.32	2,100.75	2,195.24
Winter	19,070.58	10,007.23	131,794.52	48.08	38.25	1,534.56	1,598.64
Annual	101,092.58	68,419.11	767,125.21	206.09	215.83	9,023.69	9,416.82

8.3.5.6 Off-Road Mobile Sources

Off-road mobile sources include locomotives, commercial marine vessels (CMV), plus aircraft and their ground support equipment (GSE) at airports. For Texas and the rest of the U.S., the 2016 NEIC platform emission inventories were used.

Locomotives

The TCEQ used the version one (v1) inventories from the 2016 NEIC platform (2016fh) for the U.S. locomotive sources. The sources are represented by an average day per month. The 2016 NEIC platform documentation describes development of the 2016 locomotive emission inventory[20] according to locomotive operation category (NEIC, 2020).

The 2016 locomotive emissions in Texas by season are summarized in Table 8-12: *2016 Texas Locomotive Criteria Pollutant Emissions by Season*.

Table 8-12: 2016 Texas Locomotive Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,174.94	523.75	2,108.76	7.44	6.60	322.91	332.89
Summer	11,702.37	548.41	2,208.74	7.79	6.91	338.10	348.54
Fall	11,871.47	556.30	2,240.90	7.90	7.01	342.95	353.55

[19] http://views.cira.colostate.edu/wiki/Attachments/Inventory Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad_06Mar2019.pdf

[20] http://views.cira.colostate.edu/wiki/Attachments/Inventory Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1a_mobile-nonroad-rail_Oct2019.pdf

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Winter	11,236.43	526.61	2,120.52	7.48	6.63	324.67	334.70
Annual	45,985.20	2,155.06	8,678.93	30.61	27.15	1,328.62	1,369.68

Commercial Marine Vessels

The TCEQ used the vβ inventories from the 2016 NEIC platform (2016ff) for the class 1 and class 2 (C1C2) CMV. Class 3 (C3) CMV sources are included in the point source inventory. The C1C2 CMV sources are represented by an average day per month. The 2016 NEIC platform documentation describes development of the 2016 C1C2 CMV emission inventory[21] using Automated Identification System (AIS) data (NEIC, 2020).

The 2016 commercial marine emissions in Texas by season are summarized in Table 8-13: *2016 Texas C1C2 CMV Criteria Pollutant Emissions by Season*.

Table 8-13: 2016 Texas C1C2 CMV Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	1,919.61	38.73	605.84	4.84	0.63	29.23	30.13
Summer	1,919.61	38.73	605.84	4.84	0.63	29.23	30.13
Fall	1,898.74	38.31	599.25	4.79	0.62	28.91	29.80
Winter	1,898.74	38.31	599.25	4.79	0.62	28.91	29.80
Annual	7,636.70	154.08	2,410.18	19.25	2.49	116.28	119.87

Airports

Airport sources include aircraft engines, auxiliary power units (APU), and GSE. The TCEQ used the inventories from the 2016 NEIC platform v1 (2016fh) for the U.S. airport sources. The sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform documentation describes development of the 2016 airport emission inventory[22] using the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) version 2d (NEIC, 2020).

The 2016 airport emissions in Texas by season are summarized in Table 8-14: *2016 Texas Airport Criteria Pollutant Emissions by Season*.

Table 8-14: 2016 Texas Airport Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	3951.32	1519.73	14677.33	573.73	0.00	188.08	212.55
Summer	4152.20	1596.99	15423.51	602.90	0.00	197.64	223.35
Fall	3821.38	1469.75	14194.66	554.87	0.00	181.90	205.56

[21] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad-cmv-c1c2_19Sep2019.pdf

[22] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_airports_15Oct2019.pdf

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Winter	3334.12	1282.35	12384.72	342.32	0.00	158.70	179.35
Annual	15259.01	5868.82	56680.22	2073.82	0.00	726.33	820.81

8.3.5.7 Area Sources

Area sources include small stationary sources such as gas stations, residential water heating, and painting operations. Blowing dust from fugitive sources, agricultural activity, and residential wood combustion are also area sources of particulate matter.

The TCEQ used the 2016 NEIC platform inventories for the U.S. area sources, including Texas. Oil-and-gas emissions are included in a separate area source category. The sub-categories of the area sources, the 2016 NEIC platform inventory versions, and the inventory development documentation are shown in Table 8-15: *2016 Area Source Inventory Version and Documentation*.

Table 8-15: 2016 Area Source Inventory Version and Documentation

Area Source Sub-Category	2016 Collaborative Inventory Version	Documentation (Reference)
Non-Point Sources	v1 (2016fh)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint_15Oct2019.pdf
Residential Wood Combustion	vβ (2016ff)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_nonpoint-rwc_31May2019.pdf
Agricultural Activities	v1 (2016fh)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-ag_15Oct2019.pdf
Fugitive Dust (adjusted)	v1 (2016fh)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-afdust_15Oct2019.pdf

The 2016 area source emissions by season in Texas are shown in *Table 8-16: 2016 Base Case Area Source Modeling Emissions for Texas.*

Table 8-16: 2016 Base Case Area Source Modeling Emissions for Texas

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,219.22	74,871.02	54,415.72	1,112.09	106,168.21	27,640.10	149,785.12
Summer	8,185.75	78,139.58	51,721.15	1,078.18	148,829.04	34,609.95	195,141.26
Fall	10,700.05	75,491.02	52,132.60	1,092.64	99,925.09	30,759.79	174,368.98
Winter	15,951.01	75,520.92	74,016.30	873.62	45,472.06	27,346.92	135,961.67
Annual	46,056.03	304,022.54	232,285.77	4,156.54	400,394.39	120,356.76	655,257.04

8.3.5.8 Oil-and-Gas Area Sources

Oil-and-gas sources include equipment for drilling new wells along with the extraction and processing of crude oil, natural gas, and condensate from existing wells. Extraction and processing sources large enough to meet point source reporting requirements are included as point sources.

Outside Texas

For the non-Texas U.S. oil-and-gas sources, the 2016 NEIC platform vβ inventories (2016ff and 2028fg) were used. The sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform documentation describes development of the 2016 oil-and-gas emission inventory[23] (NEIC, 2020).

Within Texas

Texas oil-and-gas emissions estimates for 2016 were developed by the TCEQ based on historical drilling and production data obtained from the Texas Railroad Commission (RRC). For each Texas county where drilling and production occurred in 2016, calculations were performed for each type of equipment associated with oil-and-gas operations. The oil-and-gas summaries by season and criteria pollutant are presented in Table 8-17: *2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Season*.

Table 8-17: 2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Season

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	58,235.27	268,981.01	41,089.14	5,910.27	0.00	816.96	821.06
Summer	57,884.97	268,981.01	41,089.14	5,910.27	0.00	816.96	821.06
Fall	57,469.02	266,057.30	40,642.52	5,846.03	0.00	808.08	812.14
Winter	57,763.04	266,057.30	40,642.52	5,846.03	0.00	808.08	812.14
Annual	231,352.30	1,070,076.62	163,463.32	23,512.60	0.00	3,250.08	3,266.40

Version 3 of the Emissions Processing System (EPS3) was used to prepare the Texas oil-and-gas emission estimates for input to the photochemical model. A speciation step was performed in EPS3 to separate the oil-and-gas emissions into the $PM_{2.5}$ components of POA, PSO4, PNO3, and water (PH_2O). More detail about the oil-and-gas emission inventories and these $PM_{2.5}$ emission components is provided in Appendix E.

8.3.6 2028 Future Case Emissions

An overview is provided in this section of the emission inputs used for the 2028 future case. Model-ready emissions were developed for the January through December 2028 period plus a ramp-up period of December 16 through 31 of 2027. Appendix E contains more detail on the development and processing of the emissions.

[23] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_nonpoint-oilgas_17Sep2019.pdf

8.3.6.1 Biogenic Emissions

Biogenic emissions modeled in 2028 were held constant from 2016, as was the driving meteorology.

8.3.6.2 Fire Emissions

Fire emissions modeled in 2028 were held constant from 2016.

8.3.6.3 Point Sources

Outside Texas

For the non-Texas U.S. portion of the modeling domain, hourly NO_X emissions for major EGUs were obtained from the Eastern Regional Technical Advisory Committee (ERTAC) projection model.[24] Information to create 2028 projections of hourly emissions included 2016 AMPD hourly data, U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO) and North American Electric Reliability Corporation (NERC) growth rates, planned new units and shutdowns, and changes to emission controls.

Canadian and Mexican point source emissions, and emissions for non-EGU point sources in states beyond Texas were obtained from the 2016 NEIC platform vβ 2028fg. Emissions for point sources in the Gulf of Mexico (e.g., oil-and-gas production platforms) were set equal to the base case by using the same 2014 GWEI.

Within Texas

The 2028 future case EGU emission estimates within Texas were based on the 2018 AMPD data, the reasonable progress Best Available Retrofit Technology (BART) Federal Implementation Plan (FIP)[25] for specific EGU SO_2 emissions, and the Cross-State Air Pollution Rule (CSAPR) Update[26] for EGU NO_X emissions. The prescribed budgets were 238,393 SO_2 tons annually and 52,301 NO_X tons for the five-month ozone season of May through September, respectively. Since electricity generation varies based on energy demand (higher emissions during hotter days due to increased demand), operational profiles based on base case year (2016) AMPD data were used to allocate hourly emissions for future year modeling purposes. Future case EGU emission estimates accounted for retirements as well as newly permitted EGUs. More details regarding Texas EGU point sources, the BART FIP and CSAPR can be found in Appendix E.

The 2028 future year non-EGU emissions were projected from the 2016 STARS data considering the effect of all applicable rules, regulations, and expected growth (ERG, 2016). The applicable rules and regulations include the Emissions Banking and Trading programs, the Mass Emissions Cap and Trade (MECT) Program within the eight-county Houston-Galveston-Brazoria (HGB) ozone non-attainment area, and the Highly Reactive Volatile Organic Compounds Emissions Cap and Trade (HECT) Program within Harris County. In addition, emission reduction credits (ERC), discrete emission reduction credits (DERC), and mobile discrete emission reduction credits (MDERC) needed to

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[24] https://marama.org/technical-center/ertac-egu-projection-tool/
[25] https://www.govinfo.gov/content/pkg/FR-2017-10-17/pdf/2017-21947.pdf
[26] https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update

meet program limits and projected growth were considered when determining 2028 future year emissions. More details regarding MECT, HECT, certified credits, and the methodology used to distribute emissions are provided in Appendix E.

Table 8-18: *Average Future Year EGU Emissions Within Texas* provides a summary of the seasonal daily average Texas EGU emissions modeled for the future year. Table 8-19: *Sample Future Year Non-EGU Point Source Emissions Within Texas* provides a summary of the average day non-EGU emissions within Texas modeled for the future year.

Table 8-18: Average Future Year EGU Emissions Within Texas

Season	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Winter (Jan-Mar)	221.24	5.88	228.59	393.80	2.76	21.78	26.58
Spring (Apr-Jun)	269.30	7.99	314.85	577.03	3.32	29.98	36.04
Summer (Jul-Sep)	364.55	10.69	430.76	743.08	4.14	38.41	46.85
Fall (Oct-Dec)	274.88	6.87	322.51	546.90	2.93	27.53	33.59

Table 8-19: Sample Future Year Non-EGU Point Source Emissions Within Texas

Sample Month	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Average June Day	434.09	435.64	347.42	220.60	6.69	57.45	84.20

8.3.6.4 On-Road Mobile Sources

Outside Texas

For the non-Texas North American portions of the modeling domain, the TCEQ used the 2028 projections from the 2016 NEIC platform vβ (2028ff) for the on-road mobile sources. Each 2028 day is represented. The 2016 NEIC platform documentation describes development of the 2016 on-road emission inventory[27] (NEIC, 2020).

Within Texas

Texas on-road mobile source emissions for 2028 were developed under contract by TTI for all Texas counties using the MOVES2014a model.

On-road inventory summaries by season and criteria pollutant are presented in Table 8-20: *2028 Texas On-Road Criteria Pollutant Emissions by Season*. The reduction in on-road emissions from 2016 to 2028 is due primarily to fleet turnover where older higher-emitting vehicles are removed through attrition and replaced by newer lower-emitting ones. The last year when gasoline sulfur levels were required under federal rules to average 30 parts per million (ppm) was 2016. Starting in 2017, a phase-in began that required an average gasoline sulfur content of 10 ppm. The reduction in on-

[27]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-onroad_15Sep2019.pdf

road SO_2 emissions from 2016 to 2028 is primarily the result of this change in gasoline sulfur concentration from 30 ppm to 10 ppm.

Table 8-20: 2028 Texas On-Road Criteria Pollutant Emissions by Season

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	23,630.87	13,045.14	159,503.29	201.80	1,754.39	984.67	3,865.67
Summer	21,476.55	13,861.05	197,115.78	214.01	1,748.55	970.41	3,843.67
Fall	22,658.09	12,745.59	170,943.47	203.52	1,747.58	950.51	3,821.30
Winter	25,516.33	13,057.41	162,790.33	198.32	1,745.11	1,003.16	3,876.02
Annual	93,281.84	52,709.19	690,352.87	817.65	6,995.63	3,908.75	15,406.66

8.3.6.5 Non-Road Mobile Sources

Outside Texas

For the non-Texas North American portion of the modeling domains, the TCEQ used the 2028 inventories from the 2016 NEIC platform vβ (2028ff) for the non-road mobile sources. The sources are represented by an average weekday and weekend day per month plus holidays. The 2016 NEIC platform documentation describes development of the 2028 non-road emission inventory[28] (NEIC, 2020).

Within Texas

Texas non-road mobile source emissions for 2028 were developed using TexN2 model, a customized tool that interfaces with the non-road emissions calculations performed by the MOVES2014a model. For 2028, TexN2 was run by season, with emissions estimates developed for the three activity day types of weekday (Monday-Friday average), Saturday, and Sunday. Non-road emission inventory summaries by season and criteria pollutant for 2028 are presented in Table 8-21: *2028 Texas Non-Road Criteria Pollutant Emissions by Season.* The reduction in non-road emissions from 2016 to 2028 is due primarily to fleet turnover where older higher-emitting equipment is removed through attrition and replaced by newer lower-emitting equipment. As described above for on-road sources, the reduction in non-road SO_2 emissions from 2016 to 2028 is primarily the result of the reduction in gasoline sulfur concentration from 30 ppm to 10 ppm.

Table 8-21: 2028 Texas Non-Road Criteria Pollutant Emissions by Season

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	13,841.90	12,027.42	188,945.22	35.69	68.28	1,003.13	1,063.12
Summer	15,373.27	15,836.59	230,793.53	42.42	79.41	1,179.64	1,249.94
Fall	11,740.58	13,729.27	184,077.36	31.59	58.11	906.22	961.81
Winter	9,620.80	7,518.14	110,056.33	23.05	44.03	617.40	652.66
Annual	50,576.55	49,111.42	713,872.44	132.75	249.83	3,706.39	3,927.53

[28] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad_06Mar2019.pdf

8.3.6.6 Off-Road Mobile Sources

Locomotives

The TCEQ used the 2028 inventories from the 2016 NEIC platform v1 (2028fh) for the U.S. locomotive sources. The sources are represented by an average day per month. The 2016 NEIC platform documentation describes development of the 2016 locomotive emission inventory[29] according to locomotive operation category, (NEIC, 2020).

The 2028 locomotive emissions in Texas by season are summarized in Table 8-22: *2028 Texas Locomotive Criteria Pollutant Emissions by Season*.

Table 8-22: 2028 Texas Locomotive Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,722.73	549.58	2,211.05	7.80	6.92	338.87	349.34
Summer	12,274.88	575.39	2,315.71	8.17	7.25	354.77	365.73
Fall	12,451.61	583.64	2,349.34	8.28	7.35	359.84	370.96
Winter	11,658.56	546.55	2,199.13	7.76	6.88	337.00	347.41
Annual	48,107.77	2,255.16	9,075.23	32.00	28.39	1,390.48	1,433.45

Commercial Marine Vessels

The TCEQ used the 2028 inventories from the 2016 NEIC platform vβ (2028fg) for the class 1 and class 2 (C1C2) CMV. Class 3 (C3) CMV sources are included in the point source inventory. The C1C2 CMV sources are represented by an average day per month. The 2016 NEIC platform documentation describes development of the 2016 C1C2 CMV emission inventory[30] using Automated Identification System (AIS) data (NEIC, 2020).

The 2028 commercial marine emissions in Texas by season are summarized in Table 8-23: *2028 Texas C1C2 CMV Criteria Pollutant Emissions by Season*.

Table 8-23: 2028 Texas C1C2 CMV Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	1,063.29	20.45	607.83	1.65	0.63	16.56	17.07
Summer	1,063.29	20.45	607.83	1.65	0.63	16.56	17.07
Fall	1,051.73	20.22	601.22	1.63	0.62	16.38	16.88
Winter	1,040.18	20.00	594.62	1.61	0.61	16.20	16.70
Annual	4,218.49	81.12	2,411.50	6.55	2.48	65.69	67.72

Airports

Airport sources include aircraft engines, APU, and GSE. The TCEQ used the 2028 inventories from the 2016 NEIC platform v1 (2028fg) for the U.S. airport sources. The

[29] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1a_mobile-nonroad-rail_Oct2019.pdf

[30] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad-cmv-c1c2_19Sep2019.pdf

sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform documentation describes development of the 2016 airport emission inventory[31] using the AEDT version 2d (NEIC, 2020).

The 2028 airport emissions in Texas by season are summarized in Table 8-24: *2028 Texas Airport Criteria Pollutant Emissions by Season*.

Table 8-24: 2028 Texas Airport Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	5,186.52	1,792.08	17,114.50	761.29	0.00	198.56	220.47
Summer	5,450.20	1,883.19	17,984.60	799.99	0.00	208.66	231.68
Fall	5,015.97	1,733.15	16,551.70	736.25	0.00	192.03	213.22
Winter	4,376.38	1,512.15	14,441.22	449.71	0.00	167.55	186.04
Annual	20,029.08	6,920.56	66,092.02	2,747.24	0.00	766.81	851.42

8.3.6.7 Area Sources

The TCEQ used the 2016 NEIC platform inventories for the U.S. area sources, including Texas. Oil-and-gas emissions are not included in this area source category. The sub-categories of the area sources, the 2016 NEIC platform inventory versions, and the inventory development documentation are shown in Table 8-25: *2028 Area Source Inventory Version and Documentation*.

Table 8-25: 2028 Area Source Inventory Version and Documentation

Area Source Sub-Category	2028 Collaborative Inventory Version	Documentation (Reference)
Non-Point Sources	v1 (2028fg)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint_15Oct2019.pdf
Residential Wood Combustion	v1 (2028fg)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_nonpoint-rwc_31May2019.pdf

[31] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_airports_15Oct2019.pdf

Area Source Sub-Category	2028 Collaborative Inventory Version	Documentation (Reference)
Agricultural Activities	v1 (2028fg)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-ag_15Oct2019.pdf
Fugitive Dust (adjusted)	v1 (2028fh)	http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-afdust_15Oct2019.pdf

The 2028 area source emissions by season in Texas are shown in Table 8-26: *2028 Future Case Area Source Modeling Emissions for Texas.*

Table 8-26: 2028 Future Case Area Source Modeling Emissions for Texas

Season	NO_x (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,092.92	80,522.67	55,288.90	1,000.22	111,111.69	28,346.35	151,566.78
Summer	8,156.53	83,362.10	53,385.99	964.63	100,671.43	35,400.57	197,127.83
Fall	10,573.70	81,053.50	53,032.48	982.30	64,364.59	31,526.92	176,403.43
Winter	15,749.95	81,248.99	74,167.59	803.91	35,526.77	27,837.69	136,614.99
Annual	45,573.09	326,187.26	235,874.96	3,751.07	311,674.48	123,111.53	661,713.03

8.3.6.8 Oil-and-Gas Area Sources

Oil-and-gas area sources include equipment for drilling new wells along with the extraction and processing of crude oil, natural gas, and condensate from existing wells. Extraction and processing sources large enough to meet point source reporting requirements are included as point sources.

Outside Texas

For the non-Texas U.S. oil-and-gas sources, the 2016 NEIC platform vβ inventories (2028fg) were used. The sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform documentation describes development of the 2016 Oil-and-Gas emission inventory[32] (NEIC, 2020).

Within Texas

Texas Oil-and-gas sources include equipment for drilling new wells along with the extraction and processing of crude oil, natural gas, and condensate from existing wells. The 2028 oil-and-gas emissions estimates were projected from an inventory based on

[32] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_nonpoint-oilgas_17Sep2019.pdf

2017 historical RRC data. The oil-and-gas summaries by season and criteria pollutant are presented in Table 8-27: *2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Season*.

Table 8-27: 2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	47,782.99	210,659.43	31,548.41	3,896.17	0.00	491.26	491.91
Summer	47,609.98	210,659.43	31,548.41	3,896.17	0.00	491.26	491.91
Fall	47,196.26	208,369.66	31,205.49	3,853.82	0.00	485.92	486.57
Winter	47,343.43	208,369.66	31,205.49	3,853.82	0.00	485.92	486.57
Annual	189,932.66	838,058.18	125,507.80	15,499.98	0.00	1,954.36	1,956.96

EPS3 was used to prepare the Texas oil-and-gas emission estimates for input to the photochemical model. A speciation step was performed in EPS3 to separate the oil-and-gas emissions into the $PM_{2.5}$ components of POA, PSO4, PNO3, and water (PH_2O). More detail about the oil-and-gas emission inventories and these $PM_{2.5}$ emission components is provided in Appendix E.

8.3.7 Photochemical Modeling

8.3.7.1 Modeling Domains and Horizontal Grid Cell Size

The TCEQ used two nested CAMx modeling grids, a 36-km North American grid (na_36km) shown in red, and a smaller 12-km U.S. grid (us_12km), shown in blue in Figure 8-16: *CAMx Modeling Grids*.

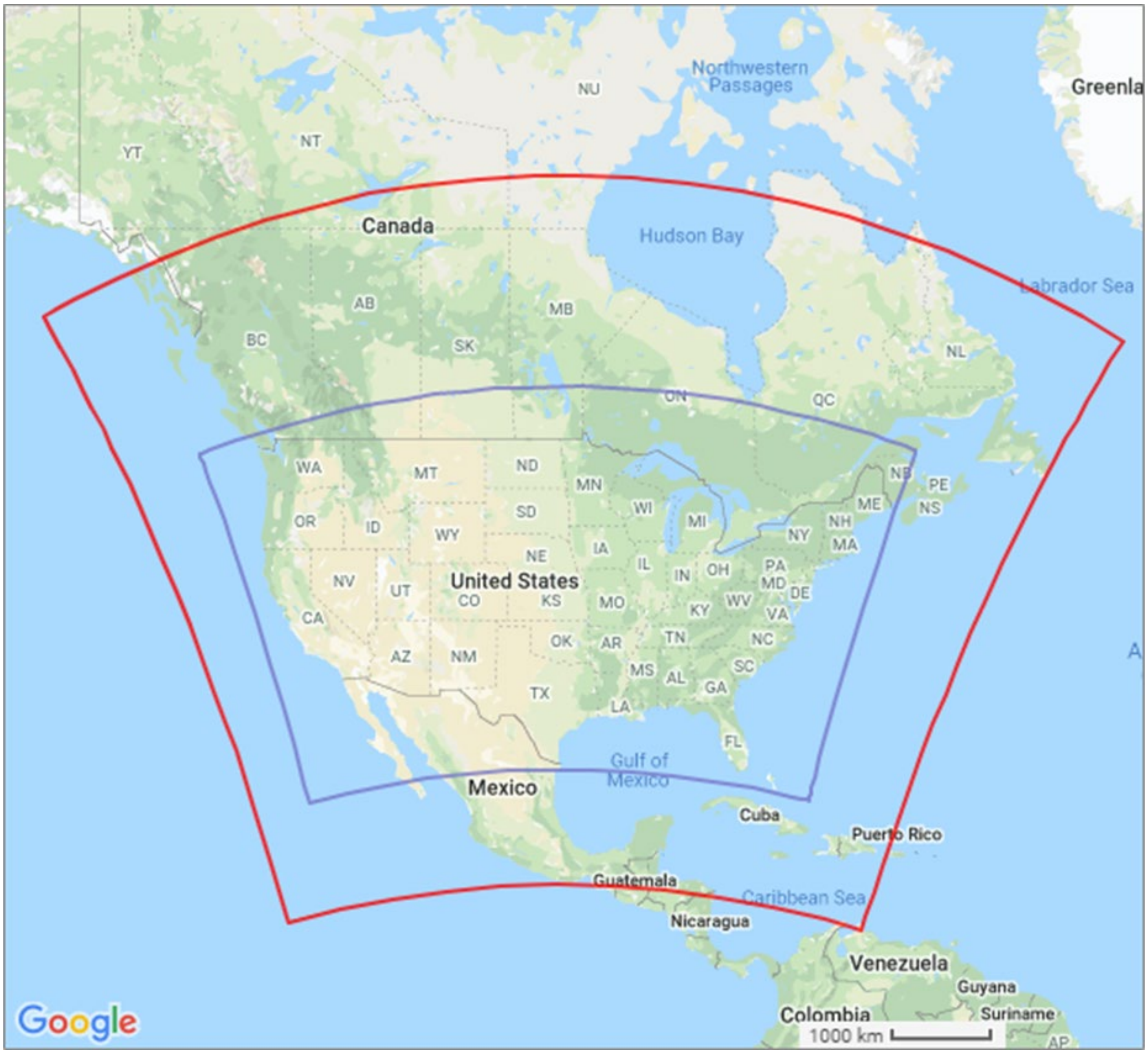

Figure 8-16: CAMx Modeling Grids

The CAMx and WRF model domains are defined on the LCC map projection with parameters shown in Table 8-4.

The 36 km grid has 172 cells east-to-west and 148 cells south-to-north. The 12 km grid has 398 cells east-to-west, and 248 cells south-to-north.

8.3.7.2 Vertical Layer Structure

The vertical structure of the CAMx model includes 29 layers extending from the surface to 18,250 m. The layer depth increases from 34 m at the surface to 3,611 m for the top layer, as shown in Table 8-28: *CAMx Vertical Structure with Layer Dimensions and Boundaries.*

Table 8-28: CAMx Vertical Structure with Layer Dimensions and Boundaries

WRF Layer	CAMx Layer	Top (m AGL)	Center (m AGL)	Thickness (m)
42	29	18250	16445	3611
39	28	14639	13632	2015
37	27	12624	10786	3675
33	26	8949	7891	2115
30	25	6833	6289	1088
28	24	5746	5290	911
26	23	4835	4449	772
24	22	4063	3704	717
22	21	3346	3175	341
21	20	3005	2840	330
20	19	2675	2515	320
19	18	2355	2225	259
18	17	2096	1969	253
17	16	1842	1718	248
16	15	1595	1474	242
15	14	1353	1281	143
14	13	1210	1140	141
13	12	1069	1000	139
12	11	930	861	138
11	10	792	747	91
10	9	702	656	90
9	8	612	567	89
8	7	522	478	89
7	6	433	389	88
6	5	345	302	87
5	4	258	215	87
4	3	171	128	86
3	2	85	60	51
2	1	34	17	34

8.3.7.3 Model Configuration

The TCEQ used the latest public-release version of CAMx, version 6.5. Several sensitivity tests were performed to examine how different model configurations affect model performance, including 1) using the secondary organic aerosol processor (SOAP) scheme with updated terpene chemistry (SOAP v2.2), 2) adding lightning NO_x, and 3) adjusting surface resistance of ammonia in the dry deposition scheme. The best performing model configuration was selected and is summarized in Table 8-29: *CAMx Model Configuration*.

Table 8-29: CAMx Model Configuration

CAMx Option	Choice Used
Version	Version 6.50
Horizontal Grids	36 km with nested 12 km
Vertical Grid	29 Layers
Time Zone	Coordinated Universal Time (UTC)
Chemistry Mechanism	Carbon Bond 6r4 gas-phase mechanism and coarse/fine particulate matter scheme
Photolysis Mechanism	Tropospheric Ultraviolet and Visible (TUV) radiative transfer model, version 4.8, with Total Ozone Mapping Spectrometer (TOMS) ozone column data
Chemistry Solver	Euler-Backward Iterative (EBI)
Secondary Aerosol	Secondary Organic Aerosol Processor (SOAP) v2.2 that will be standard in CAMx Version 7.0
Meteorology	WRF model v3.8.1. See Section 8.3.4.2 for configuration.
Advection Scheme	Piecewise Parabolic Method (PPM)
Planetary Boundary Layer (PBL) Mixing	K-theory
Dry Deposition Scheme	Wesley. Default surface resistance for ammonia (R scale = 1)
Lightning NO_X	CAMx preprocessor
Wind-Blown Dust	CAMx preprocessor
Iodine Emissions	Oceanic iodine emissions computed from saltwater masks

8.3.7.4 MPE

Performance Evaluations Overview

An evaluation of model performance was conducted on two tracks, an operational evaluation that compared modeled base case results to 2016 observations of $PM_{2.5}$ components, and a diagnostic evaluation using CAMx model tools to determine how well the model predicted temporal and spatial variations in modeled parameters.

Operational Evaluations

Ramboll performed an operational MPE under contract from the TCEQ for ozone, $PM_{2.5}$, and $PM_{2.5}$ components within the us_12km domain shown in Figure 8-16. Table 8-20: *Definitions of Statistical Performance Measures and Performance Benchmarks* lists the definitions of statistical performance measures that were used in the MPE. Ramboll compared the Normalized Mean Bias (NMB) and Normalized Mean Error (NME) to numerical “goals” and less stringent “criteria” benchmarks recommended by Emery et al. (2016). Another widely used set of benchmarks was established by the U.S. Regional Planning Organizations (RPOs) based on Fractional Bias (FB) and Fractional Error (FE) (Boylan and Russell, 2006). The purpose of MPE benchmarks is not to give a passing or failing grade to a simulation, but rather to put results into the proper context of previous model applications that establish what level of performance can realistically be expected.

Table 8-30: Definitions of Statistical Performance Measures and Performance Benchmarks

Statistical Measure	Mathematical Expression	Performance Benchmark Goals	Performance Benchmark Criteria
Normalized Mean Bias (%), NMB	$\frac{\sum_{i=1}^{N}(P_i - O_i)}{\sum_{i=1}^{N} O_i}$	MDA8 O_3 <±5% $PM_{2.5}$, SO_4, NH_4 <±10% NO_3 <±15% OA <±15% EC <±20%	MDA8 O_3 <±15% $PM_{2.5}$, SO_4, NH_4 <±30% NO_3 <±65% OA <±50% EC <±40%
Normalized Mean Error (%), NME	$\frac{\sum_{i=1}^{N}\lvert P_i - O_i\rvert}{\sum_{i=1}^{N} O_i}$	MDA8 O_3 <15% $PM_{2.5}$, SO_4, NH_4 <35% NO_3 <65% OA <45% EC <50%	MDA8 O_3 <25% $PM_{2.5}$, SO_4, NH_4 <50% NO_3 <155% OA <65% EC <75%
Fractionalized Bias (%), FB	$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i - O_i}{P_i + O_i}\right)$	24-hr total and speciated $PM_{2.5}$ <±30%	24-hr total and speciated $PM_{2.5}$ <±60%
Fractional Error (%), FE	$\frac{2}{N}\sum_{i=1}^{N}\left\lvert\frac{P_i - O_i}{P_i + O_i}\right\rvert$	24-hr total and speciated $PM_{2.5}$ <50%	24-hr total and speciated $PM_{2.5}$ <75%

The operational model performance evaluation for $PM_{2.5}$ focuses on total $PM_{2.5}$ mass and its key components, including sulfate (SO_4), nitrate (NO_3), elemental carbon (EC), and organic aerosol (OA). $PM_{2.5}$ ambient measurements for 2016 were obtained from the IMPROVE and Chemical Speciation Monitoring Network (CSN) for the sites within the area shown in Figure 8-17 and described in Table 8-31: *Names of IMPROVE Monitors Representing Class I Areas in and Near Texas*. Note that the GUMO1 monitor measures visibility impairment for both Guadalupe Mountains National Park in Texas and Carlsbad Caverns National Park in New Mexico from a monitor in Texas. The IMPROVE and CSN network provide 24-hour average concentrations every 3 days and 3 or 6 days, respectively.

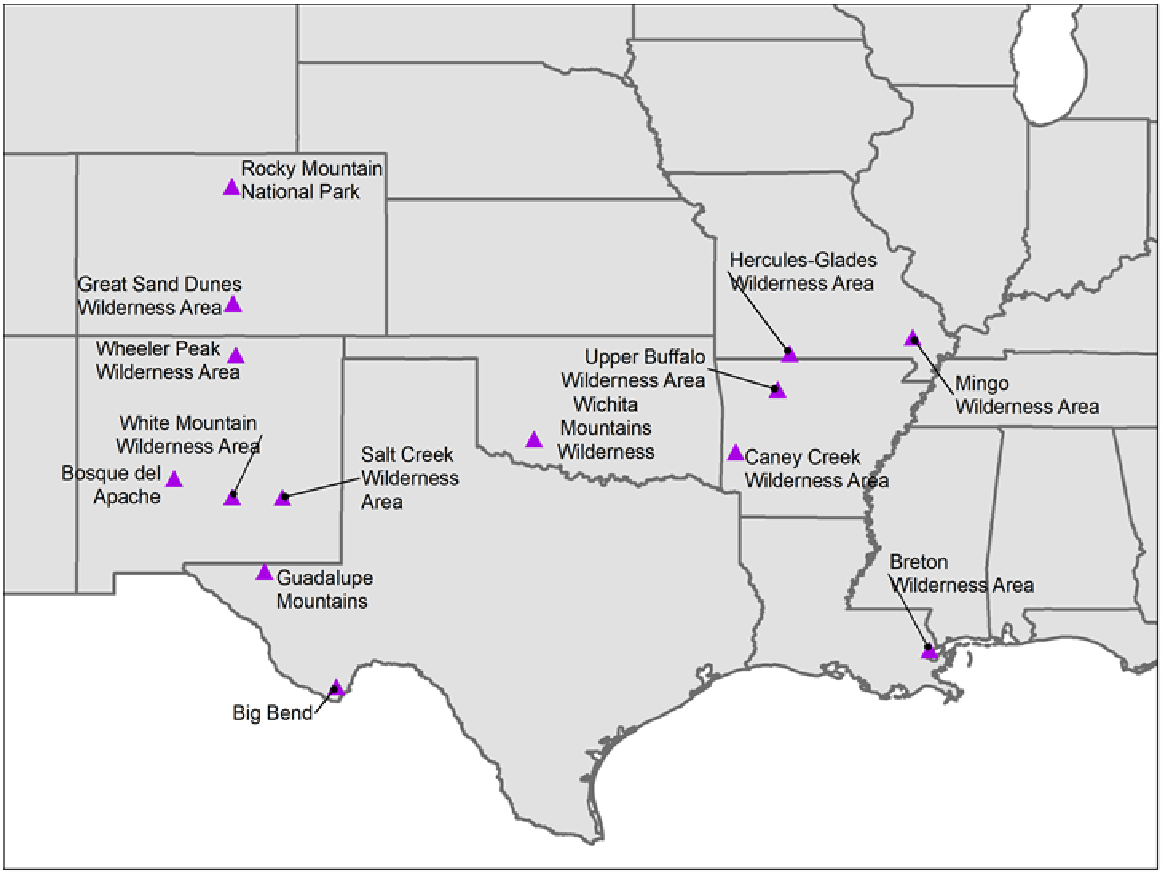

Figure 8-17: Map of IMPROVE Monitors Representing Class I Areas in and Near Texas

Table 8-31: Names of IMPROVE Monitors Representing Class I Areas in and Near Texas

Class I Area Identifier	Class I Area Name	Class I Area State	IMPROVE Monitor Identifier	IMPROVE Monitor State
BIBE	Big Bend National Park	TX	BIBE1	TX
GUMO	Guadalupe Mountains National Park	TX	GUMO1	TX
BOAP	Bosque del Apache Wilderness Area	NM	BOAP1	NM
CAVE	Carlsbad Caverns National Park	NM	GUMO1	TX
SACR	Salt Creek Wilderness Area	NM	SACR1	NM
WHIT	White Mountain Wilderness Area	NM	WHIT1	NM
WHPE	Wheeler Peak Wilderness Area	NM	WHPE1	NM
GRSA	Great Sand Dunes Wilderness Area	CO	GRSA1	CO
ROMO	Rocky Mountain National Park	CO	ROMO1	CO
WIMO	Wichita Mountains Wilderness	OK	WIMO1	OK
HEGL	Hercules-Glades Wilderness Area	MO	HEGL1	MO
MING	Mingo Wilderness Area	MO	MING1	MO
CACR	Caney Creek Wilderness Area	AR	CACR1	AR
UPBU	Upper Buffalo Wilderness Area	AR	UPBU1	AR
BRIS	Breton Wilderness Area	LA	BRIS1	LA

Quarterly evaluation is performed for January/February/March (JFM, Quarter 1 (Q1)), April/May/June (AMJ, Quarter 2 (Q2)), July/August/September (JAS, Quarter 3 (Q3)), and October/November/December (OND, Quarter 4 (Q4)). Spatial plots of $PM_{2.5}$ performance statistics are provided in Appendix F: *Photochemical Modeling*. For total $PM_{2.5}$ mass, the recommended performance goal and criteria for bias are ≤±10% and ≤±30% and for error are ≤35% and ≤50% (Emery et al., 2016). The discussion below focuses on $PM_{2.5}$ performance at IMPROVE monitors.

$PM_{2.5}$ Total

Total $PM_{2.5}$ performance is variable across quarters, as seen in Table 8-32: *Model Performance Metrics for $PM_{2.5}$ at IMPROVE and CSN Sites*. The model has a tendency toward overestimating $PM_{2.5}$ mass in Q1 and Q4 and underestimating it in Q2 and Q3. Annual NMB is 2.5%, which is well within the ±10% bias performance goal. Annual NME is 45%, which achieves the error performance criteria but not the goal. Quarterly NMB achieves or nearly achieves the ±30% bias performance criteria. Weaker performance in Q4 (NMB=31%) is due mainly to overestimated soil.

Table 8-32: Model Performance Metrics for $PM_{2.5}$ at IMPROVE and CSN Sites

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	835	3.3	4.2	27.0	52.1	18.8	43.3	0.70
JFM	CSN	1736	8.9	11.5	28.5	49.6	24.2	43.6	0.51
AMJ	IMPROVE	802	4.6	3.8	-16.8	39.0	-21.5	45.3	0.70
AMJ	CSN	1684	8.9	9.2	3.3	39.6	3.6	37.5	0.29
JAS	IMPROVE	832	5.0	4.1	-17.9	43.3	-38.4	54.6	0.67
JAS	CSN	1610	8.6	10.1	18.3	47.3	14.9	42.2	0.39
OND	IMPROVE	769	4.0	5.2	31.1	49.8	18.5	41.6	0.77
OND	CSN	1744	8.9	13.2	48.7	60.4	37.7	47.2	0.54
Annual	IMPROVE	3238	4.2	4.3	2.5	45.4	-6.0	46.3	0.68
Annual	CSN	6774	8.8	11.0	25.1	49.4	20.3	42.6	0.42

$PM_{2.5}$ SO_4

Better performance is seen in Table 8-33: *Model Performance Metrics for Particulate Sulfate at IMRPOVE and CSN Sites* for $PM_{2.5}$ SO_4 than for total $PM_{2.5}$ mass. Quarterly NMEs are lower than 50% and are comparable across all quarters. Quarterly NMB ranges from −26% to 23%. Like total $PM_{2.5}$ mass, SO_4 is overestimated in Q1 and Q4 and underestimated in Q2 and Q3. The tendency for under prediction during summer is more evident in Texas and New Mexico. See Appendix F for more information.

Table 8-33: Model Performance Metrics for Particulate Sulfate at IMPROVE and CSN Sites

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	835	0.6	0.8	23.0	43.7	27.8	39.4	0.76
JFM	CSN	260	0.9	1.2	36.8	51.1	36.6	46.0	0.68
AMJ	IMPROVE	802	0.8	0.7	-13.1	34.7	-12.9	38.4	0.76
AMJ	CSN	223	1.0	1.2	18.7	38.4	18.5	36.6	0.68
JAS	IMPROVE	829	0.9	0.7	-25.8	42.7	-42.9	57.3	0.74
JAS	CSN	174	1.3	1.4	8.0	45.5	0.1	44.8	0.65
OND	IMPROVE	764	0.7	0.9	22.7	45.5	14.0	40.0	0.77
OND	CSN	131	0.9	1.3	40.1	53.1	36.0	46.6	0.75
Annual	IMPROVE	3230	0.8	0.8	-1.9	41.4	-3.7	43.9	0.72
Annual	CSN	788	1.0	1.3	24.4	46.3	23.3	43.2	0.67

$PM_{2.5}$ NO_3

Model error for $PM_{2.5}$ NO_3 is greater than SO_4 in all quarters with NME ranging from 59% (Q2) to 96% (Q4), as seen in Table 8-34: *Model Performance Metrics for Particulate Nitrate at IMPROVE and CSN Sites*. Simulating NO_3 concentrations is more difficult than SO_4 or $PM_{2.5}$ because the model must correctly simulate both the oxidation of NO_X to nitric acid (HNO_3) and the equilibrium between gaseous HNO_3 and particle NO_3, which depends on environmental and chemical factors. Consequently, the $PM_{2.5}$ NO_3 performance goals and criteria for bias (≤±15% and ≤±65%) and error (≤65% and ≤115%) are more lenient than for $SO_4/PM_{2.5}$ bias (≤±10% and ≤±30%) and error (≤35% and ≤50%). Except for the Q4 bias that has a large overestimation, the quarterly bias and error for the 2016 simulation achieve the NO_3 performance criteria for all quarters. NO_3 is underestimated at the two IMPROVE monitors in Texas (i.e., GUMO1 and BIBE1) in all quarters.

Table 8-34: Model Performance Metrics for Particulate Nitrate at IMPROVE and CSN Sites

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	835	0.6	0.6	-0.4	64.2	-14.8	67.1	0.67
JFM	CSN	259	1.4	1.5	11.5	58.0	20.0	51.6	0.58
AMJ	IMPROVE	802	0.2	0.2	-17.5	59.2	-43.2	75.2	0.78
AMJ	CSN	223	0.4	0.5	7.7	50.2	2.9	47.7	0.77
JAS	IMPROVE	829	0.2	0.1	-16.3	77.6	-65.5	91.4	0.57
JAS	CSN	172	0.3	0.6	130.0	165.0	27.4	69.1	0.37
OND	IMPROVE	764	0.4	0.7	69.7	95.5	30.6	69.4	0.72
OND	CSN	131	1.3	1.9	52.9	75.5	48.8	63.6	0.64
Annual	IMPROVE	3230	0.3	0.4	13.8	73.4	-24.1	75.9	0.69
Annual	CSN	785	0.8	1.1	29.4	68.5	21.6	56.3	0.63

$PM_{2.5}$ OA

The model overestimates OA in Q1 and Q4 (NMB of 45% and 14%, respectively). Details are provided in Table 8-35: *Model Performance Metrics for Organic Aerosol at IMPROVE and CSN Sites*. The overestimation of OA in colder periods, particularly in Q1, is more evident at CSN (urban sites), which suggests overstated combustion emissions (e.g., residential wood burning). Except for the Q1 error due to overestimation, the quarterly bias and error for the 2016 simulation achieve the OA performance criteria for other quarters.

Table 8-35: Model Performance Metrics for Organic Aerosol at IMPROVE and CSN Sites

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	835	1.0	1.5	45.2	69.6	33.6	53.6	0.67
JFM	CSN	254	2.3	4.2	79.3	92.4	63.1	68.5	0.52
AMJ	IMPROVE	804	1.8	1.5	-12.7	47.1	-17.2	48.4	0.63
AMJ	CSN	221	2.5	3.3	35.1	51.4	25.9	42.9	0.71
JAS	IMPROVE	833	1.8	1.8	2.0	51.6	-19.1	49.6	0.61
JAS	CSN	165	2.3	3.4	47.7	61.3	29.4	43.8	0.64
OND	IMPROVE	771	1.6	1.9	14.2	43.5	10.4	41.1	0.71
OND	CSN	126	2.5	4.1	65.2	75.3	59.8	64.4	0.71
Annual	IMPROVE	3243	1.6	1.7	8.4	51.4	1.8	48.3	0.62
Annual	CSN	766	2.4	3.7	57.2	70.7	44.6	55.1	0.60

$PM_{2.5}$ EC

The model also tends to overpredict $PM_{2.5}$ EC concentrations in Q1 and Q4, as seen in Table 8-36: *Model Performance Metrics for Elemental Carbon at IMPROVE and CSN Sites* but their concentrations. at IMPROVE monitors are generally small (observed annual average of 0.15 µg/m^3).

Table 8-36: Model Performance Metrics for Elemental Carbon at IMPROVE and CSN Sites

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	835	0.1	0.2	35.3	60.7	39.8	61.4	0.80
JFM	CSN	254	0.5	0.6	30.1	53.0	34.2	50.2	0.60
AMJ	IMPROVE	804	0.1	0.1	-16.3	44.3	-14.0	50.9	0.74
AMJ	CSN	221	0.5	0.5	-0.4	44.4	13.3	41.8	0.52
JAS	IMPROVE	833	0.1	0.1	-3.7	50.5	-22.9	57.1	0.70
JAS	CSN	165	0.4	0.6	31.1	52.2	26.9	47.4	0.62
OND	IMPROVE	771	0.2	0.2	-3.3	37.3	-6.6	42.6	0.83
OND	CSN	126	0.5	0.7	32.7	53.2	44.4	57.1	0.74
Annual	IMPROVE	3243	0.1	0.1	1.4	47.1	-0.8	53.2	0.75
Annual	CSN	766	0.5	0.6	21.8	50.4	28.3	48.3	0.56

$PM_{2.5}$ Soil

There are inconsistencies in how soil is defined using the IMPROVE measurements versus how it is defined in the model. The IMPROVE measurement data defines fine soil as a linear combination of five measured elements (Al, Si, Ca, Fe and Ti). In the model, fine crustal is defined as $PM_{2.5}$ emissions that are not explicitly speciated into SO_4, NO_3, NH_4, EC or OA, so it represents other fine particulate, which can include more than the five elements in the IMPROVE Soil definition as well as measurement artifacts. Thus, it is difficult to interpret model performance for soil. As seen in Table 8-37:

Model Performance Metrics for Soil at IMPROVE Monitors, the best model performance for soil is in Q2 and Q3, and the worst performance in Q1 and Q4. This may be also due to errors in windblown dust generation, which is dependent upon wind speed and soil moisture, which are lower in Q2 and Q3.

Table 8-37: Model Performance Metrics for Soil at IMPROVE Monitors

Period	Network	Obs	Mean (obs)	Mean (mod)	NMB (%)	NME (%)	FB (%)	FE (%)	Correlation
JFM	IMPROVE	834	0.4	0.7	75.3	144.0	65.4	101.0	0.08
AMJ	IMPROVE	802	0.8	1.0	24.4	91.4	20.6	74.2	0.16
JAS	IMPROVE	832	0.8	1.0	22.6	99.5	13.9	79.5	0.34
OND	IMPROVE	769	0.5	1.2	158.0	195.0	70.0	94.2	0.26
Annual	IMPROVE	3237	0.6	1.0	56.3	122.0	42.2	87.3	0.23

Visibility Evaluation

In this section, the base case simulation is evaluated for visibility extinction. Table 8-2 cross references the PM species measured at the IMPROVE monitors with the CAMx species names. The predicted and observed $PM_{2.5}$ species concentrations at the IMPROVE monitors are converted to light extinction in inverse megameters (Mm^{-1}) using Equation 8-1, with site-specific monthly relative humidity adjustment factors.

Stacked bar charts of predicted and observed visibility impairment on the 20% most impaired and clearest days are shown in Figure 8-18: *Observed (Obs) and Modeled (Mod) Concentrations, left, and Extinction, right, on the Observed 20% Most Impaired and Observed 20% Clearest Days at Big Bend National Park in Texas* and Figure 8-19: *Observed and Modeled Concentrations and Extinction on the Observed 20% Most Impaired and Observed 20% Clearest Days at Guadalupe Mountains National Park in Texas*. The left panel displays concentration ($\mu g/m^3$) and the right panels displays light extinction (Bext in Mm^{-1}) of each PM species. Rayleigh scattering is site specific, does not vary by day, and was not modeled; it is a real phenomenon but is due to scattering from air molecules, not measured particulate concentrations.

Visibility performance is generally comparable to the EPA's 2016 model performance (EPA, 2019a) from which many of the emission inputs were derived. The TCEQ base case simulation generally predicts higher AmmNO3 (attributable to updating the ammonia surface resistance) and shows better agreement with observations at all four sites (HEGL1, MING1, UPBU1, and WIMO1) where observation derived Bext_AmmNO3 makes up more than 20% of total extinction. The TCEQ's coarse mass (CM) estimates are lower than observations and the EPA's estimates at most sites. Coarse Mass has shorter transport distance than $PM_{2.5}$ so much of it is local and influenced by subgrid-scale emissions. Modeling CM, much of which is windblown dust, at regional scale remains a challenge. In order to address this challenge, the TCEQ has initiated a research project to evaluate and improve the modeling of windblown dust in CAMx, using MPE at IMPROVE monitors on the 20% most impaired days as an evaluation metric. The model also tends to underestimate the soil component (except for overestimation bias in Q4). Like CM, most soil is due to crustal species that include windblown dust, road dust and other dust sources. These sources are difficult to characterize and their impacts at monitoring sites can be highly influenced by local sources. However, CM and soil also come from sources that are mostly uncontrolled, or not considered for control, and consequently the CM and soil future year projections remain relatively unchanged from 2016 levels.

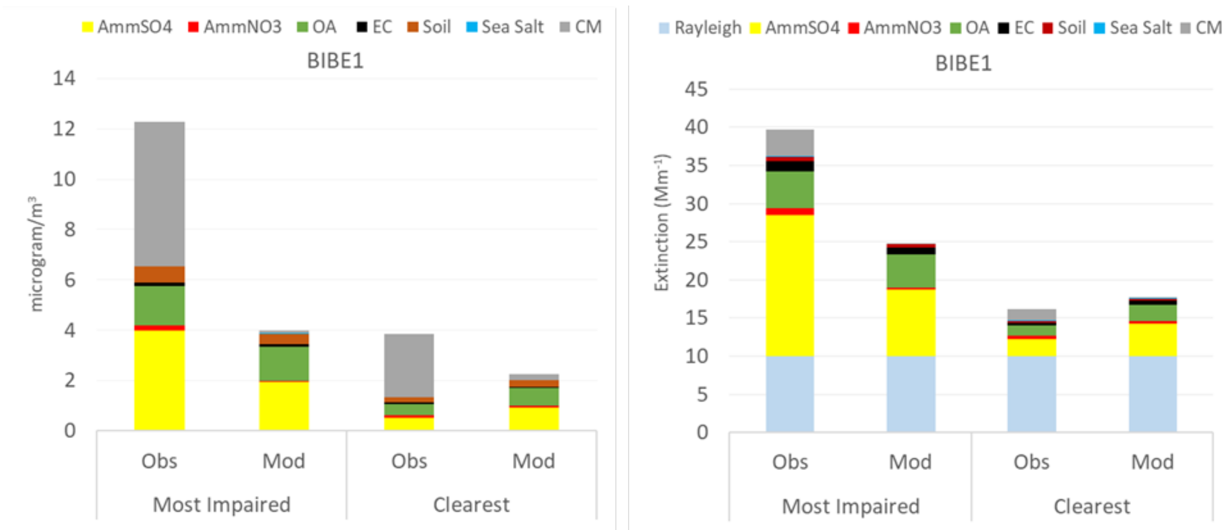

Figure 8-18: Observed (Obs) and Modeled (Mod) Concentrations, left, and Extinction, right, on the Observed 20% Most Impaired and Observed 20% Clearest Days at Big Bend National Park in Texas

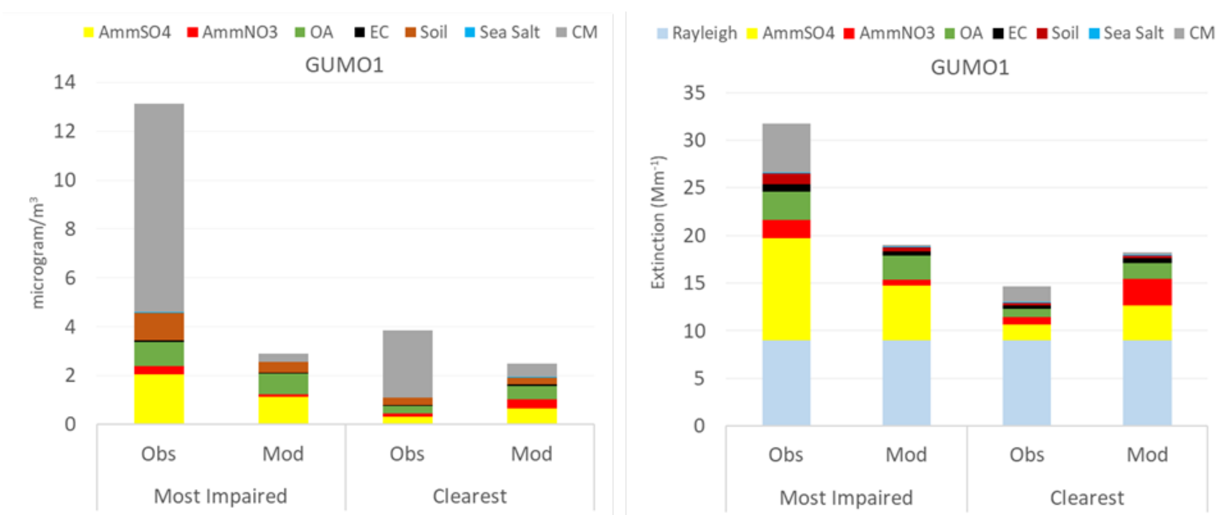

Figure 8-19: Observed and Modeled Concentrations and Extinction on the Observed 20% Most Impaired and Observed 20% Clearest Days at Guadalupe Mountains National Park in Texas

Diagnostic Evaluations

As noted in the operational performance evaluation and shown in Table 8-34, CAMx underpredicts particulate nitrate from January through September at IMPROVE monitors near Texas. To evaluate potential reasons, the TCEQ conducted a test of the RScale model parameter controlling surface resistance of ammonia in the dry deposition scheme. The CAMx Rscale default value for ammonia is 1.0. The TCEQ tested the hypothesis that the Rscale =1.0 value lead to excessive ammonia deposition rather than transition to ammonium sulfate. Results for March, seen in Figure 8-20:

RScale Testing Model Bias and Error for Particulate Nitrate in March show that model bias and error both increase at IMPROVE monitors near Texas when the RScale value is changed from 1.0 to 0. Based on this testing, the TCEQ chose to use an RScale value of 1.0 for ammonia to minimize model error.

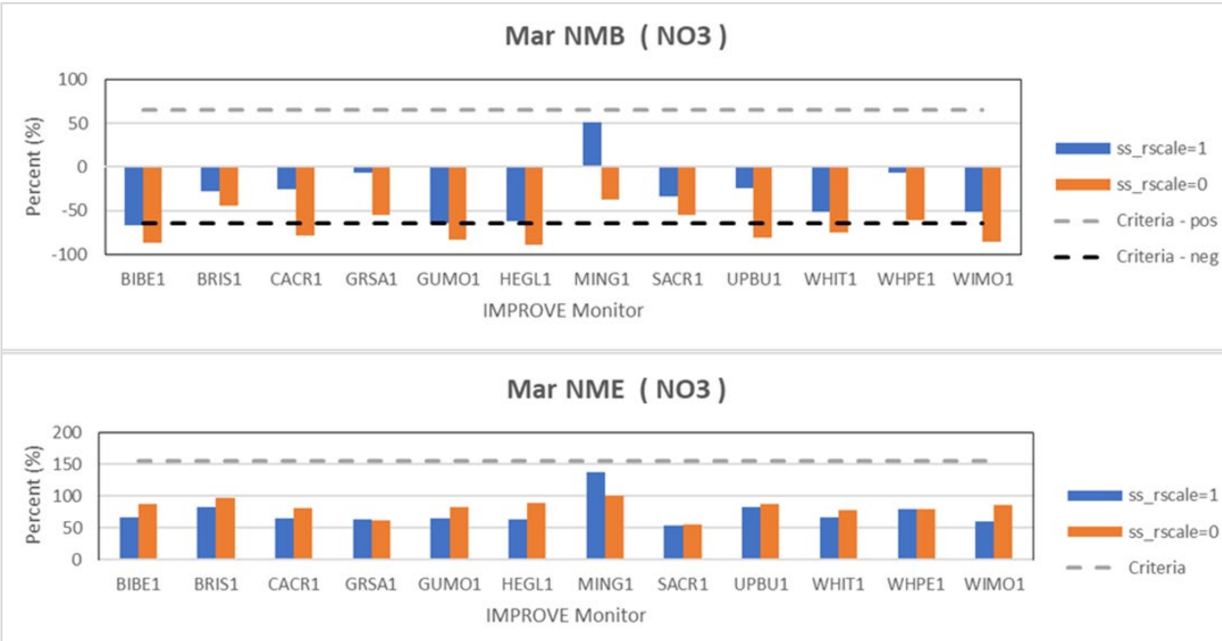

Figure 8-20: RScale Testing Model Bias and Error for Particulate Nitrate in March

Visibility impairment for Regional Haze Rule purposes is calculated according to the IMPROVE visibility equation, Equation 8 1, which assumes that all particulate sulfate is converted to ammonium sulfate, and all particulate nitrate is converted to ammonium nitrate. Both reactions require ammonium. If insufficient ammonium is available, the conversions will not be complete. The modeled particulate ammonium amount on the most impaired days is not enough to convert all the modeled particulate sulfate and particulate nitrate as seen in Table 8-38: *Conversion of Particulate Sulfate and Nitrate to Ammonium Sulfate and Nitrate*. The assumption of complete conversion appears better for inland sites compared to coastal sites, varying from 75% at the Breton Island coastal monitor (BRIS1) to 93% for the Hercules-Glades (HEGL1) inland monitor in Missouri.

Table 8-38: Conversion of Particulate Sulfate and Nitrate to Ammonium Sulfate and Nitrate

Class I Area (IMPROVE ID, State)	Percent of Particulate Sulfate and Particulate Nitrate Converted to Ammonium Sulfate and Ammonium Nitrate
Big Bend N.P. (BIBE, TX)	81.6%
Guadalupe Mountains N.P. (GUMO, TX)	66.6%
Bosque del Apache (BOAP, NM)	91.9%
Salt Creek Wilderness Area (SACR, NM)	92.4%
White Mountain Wilderness Area (WHIT, NM)	83.9%
Wheeler Peak Wilderness Area (WHPE, NM)	89.1%
Great Sand Dunes Wilderness Area (GRSA, CO)	90.5%
Rocky Mountain National Park (ROMO, CO)	92.3%
Wichita Mountains Wilderness (WIMO, OK)	92.8%
Hercules-Glades Wilderness Area (HEGL, MO)	93.2%
Mingo Wilderness Area (MINGO, MO)	90.1%
Caney Creek Wilderness Area (CACR, AR)	90.5%
Upper Buffalo Wilderness Area (UPBU, AR)	91.2%
Breton Wilderness Area (BRIS, LA)	75.4%

8.3.7.5 Particulate Matter Source Apportionment

The CAMx model provides a Particulate Matter Source Apportionment (PSAT) analysis tool that tracks emissions from user-defined source groups and model-generated emissions to determine their influence on modeled particulate matter concentrations. The TCEQ used PSAT to analyze source contributions to modeled PM concentrations at IMPROVE monitors. Version 6.5 of CAMx can apportion the following classes of particulate matter:

- Particulate Sulfate (PSO4)
- Particulate Nitrate (PNO3)
- Particulate Ammonium (PNH4)
- Primary PM (PEC, POA, FCRS, FPRM, CCRS, and CPRM)

Secondary organic aerosol formed from anthropogenic (e.g., aromatics) and biogenic VOC precursors (e.g., isoprene, monoterpene) are obtained from CAMx. The anthropogenic SOA is the sum of CAMx species SOA1, SOA2, and SOPA. The biogenic SOA is the sum of CAMx species SOA3, SOA4, and SOPB.

To determine the influence of emissions of interest originating in Texas and neighboring states, the TCEQ chose the PSAT source categories listed in Table 8-39: *PSAT Emission Source Categories*.

Table 8-39: PSAT Emission Source Categories

Source Category	Category Label	Description or Group
Texas Electric Generating Units (EGU)	TX EGU	Domestic anthropogenic
Texas non-EGU Point	TX non-EGU	Domestic anthropogenic
Texas Oil-and-Gas, area source	TX Oil & Gas	Domestic anthropogenic
Texas on-road mobile	TX on-road	Domestic anthropogenic
Texas other anthropogenic	TX other anthro	Domestic anthropogenic
Non-Texas U.S. anthropogenic; Arkansas, Colorado, Louisiana, Missouri, New Mexico, and Oklahoma are tracked separately	Other U.S. AR, CO, LA, MO, NM, OK	Domestic anthropogenic
Canada and Mexico anthropogenic	Can/Mex anthro	International anthropogenic
Other international anthropogenic including shipping and other Central American countries and islands	Other non-U.S. anthro	International anthropogenic
All fires including agricultural and prescribed burns	Fire	Natural
Other natural sources including biogenic, wind-blown dust, lightning NO_x, ocean sulfates, sea salt	Natural	Natural
Boundary and initial conditions	BC/IC	Mostly international; both anthropogenic and natural
Biogenic SOA	Bio SOA	Natural; obtained directly from CAMx SOA scheme; SOA3 + SOA4 + SOPB
Anthropogenic SOA	Anthro SOA	Anthropogenic; obtained directly from CAMx SOA scheme; SOA1 + SOA2 + SOPA

Several sets of PSAT attribution results are shown in the next three figures. Figure 8-21: *PSAT Light Extinction Influence at Big Bend National Park in Texas* shows the visibility impairment projection at the BIBE1 monitor serving Big Bend National Park in Texas. It shows the relative influence of the emission source categories. The combined Canada/Mexico source group is the most influential source group at nearly 41%. Within this group, the influence of emissions from Mexico are expected to be the vast majority. Within Texas, the other anthropogenic category is the largest source, followed by EGUs, non-EGU point sources, oil-and-gas area sources, and on-road sources.

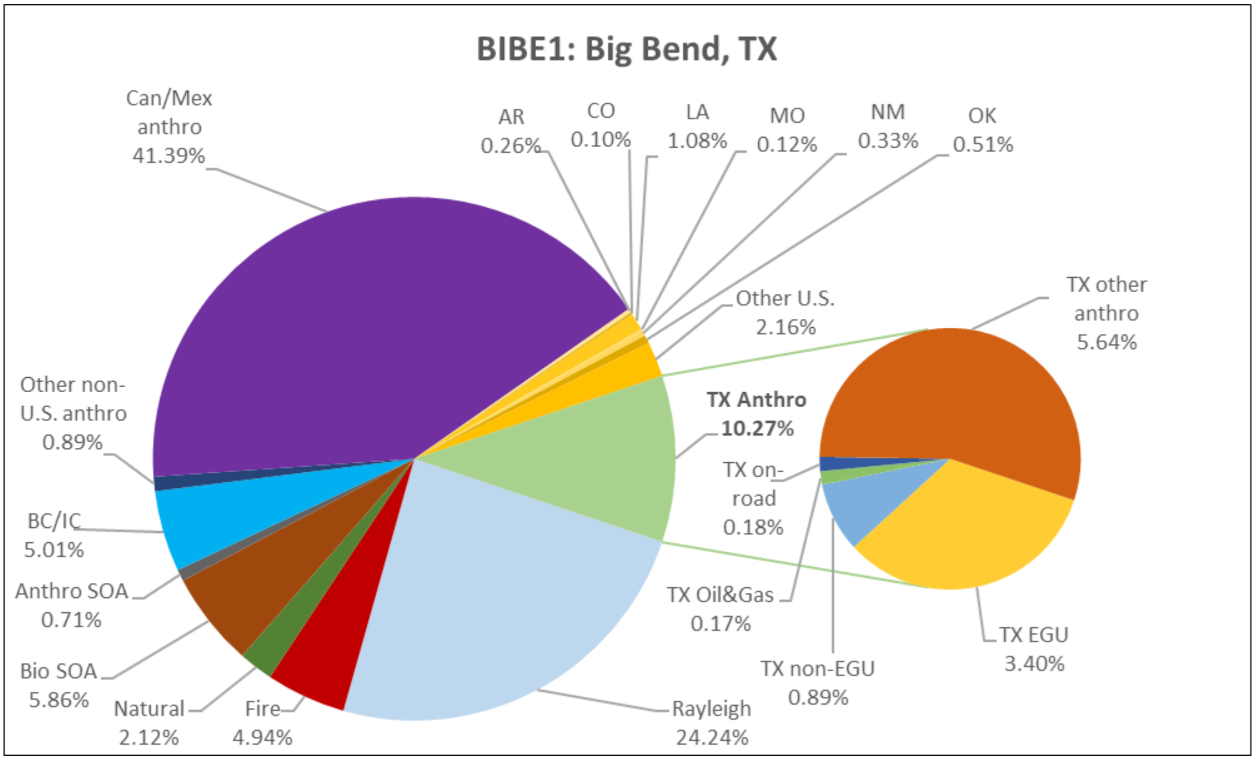

Figure 8-21: PSAT Light Extinction Influence at Big Bend National Park in Texas

Another set of PSAT attribution results is shown in Figure 8-22: *PSAT Light Extinction Influence at Guadalupe Mountains and Carlsbad Caverns*, for the visibility impairment projection at the GUMO1 monitor serving Guadalupe Mountains and Carlsbad Caverns National Parks in Texas and New Mexico. In this case, the ratio of Texas anthropogenic emissions to New Mexico anthropogenic emissions is 2.08, and the combined Canada/Mexico source group is the most influential source group. Within this group, the influence of emissions from Mexico are expected to be the vast majority. Within Texas, the other anthropogenic category is the source category with the single largest influence, followed by EGUs, oil-and-gas area sources, and non-EGU point sources.

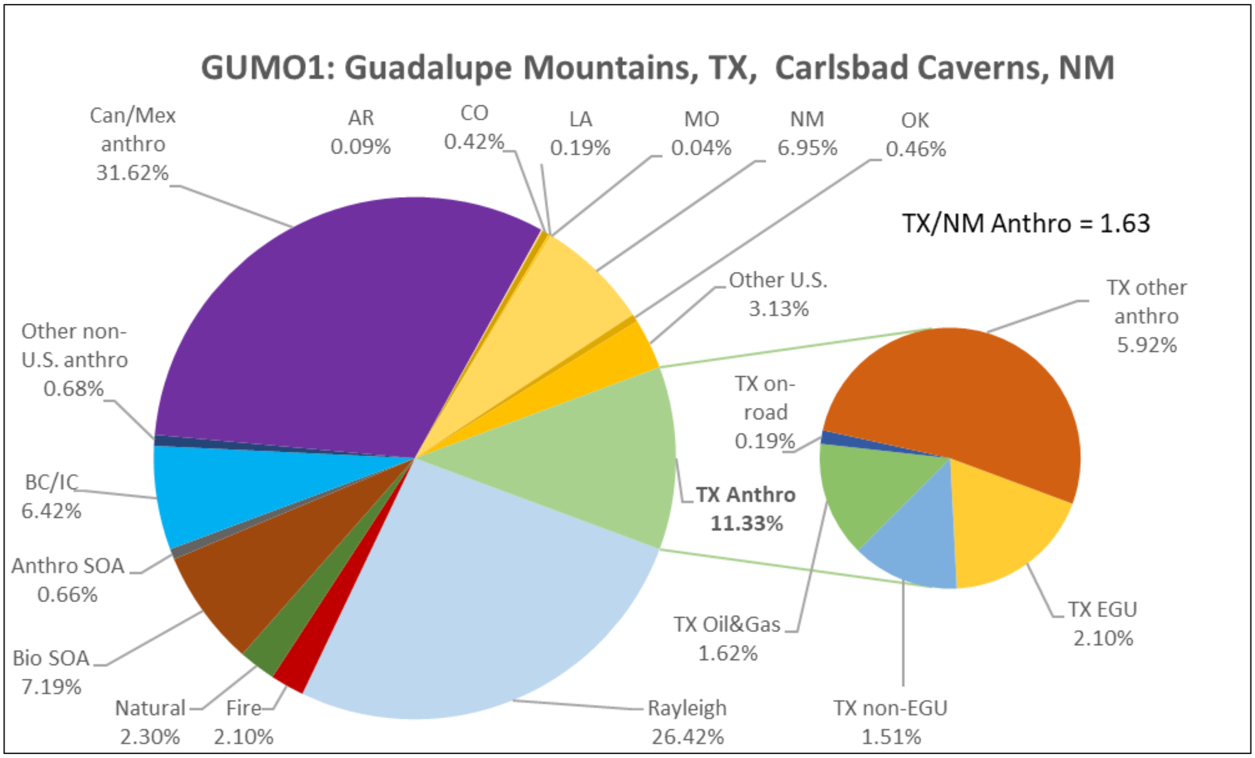

Figure 8-22: PSAT Light Extinction Influence at Guadalupe Mountains and Carlsbad Caverns

PSAT attribution results are shown in Figure 8-23: *PSAT Light Extinction Influence at Wichita Mountains*, for the light extinction projection at the WIMO1 monitor serving Wichita Mountains Wilderness Area in Oklahoma. The ratio of Texas to Oklahoma anthropogenic emissions is 1.22. Within Texas, EGU emissions are the most influential, followed by other anthropogenic sources, non-EGU point sources and oil-and-gas area sources. The EGU emissions are almost half of the Texas total influence. The combined Canada and Mexico influence, at 11.25%, is notably smaller at Wichita Mountains than Guadalupe Mountains, 31.84%, and Big Bend, 39.99%., as the distance from Mexico increases. This trend suggests that most of the Canada/Mexico influence comes from Mexico. Other U.S. anthropogenic sources are notably more influential at Wichita Mountains than Guadalupe Mountains, likely due to the proximity of Wichita Mountains to the rest of the country.

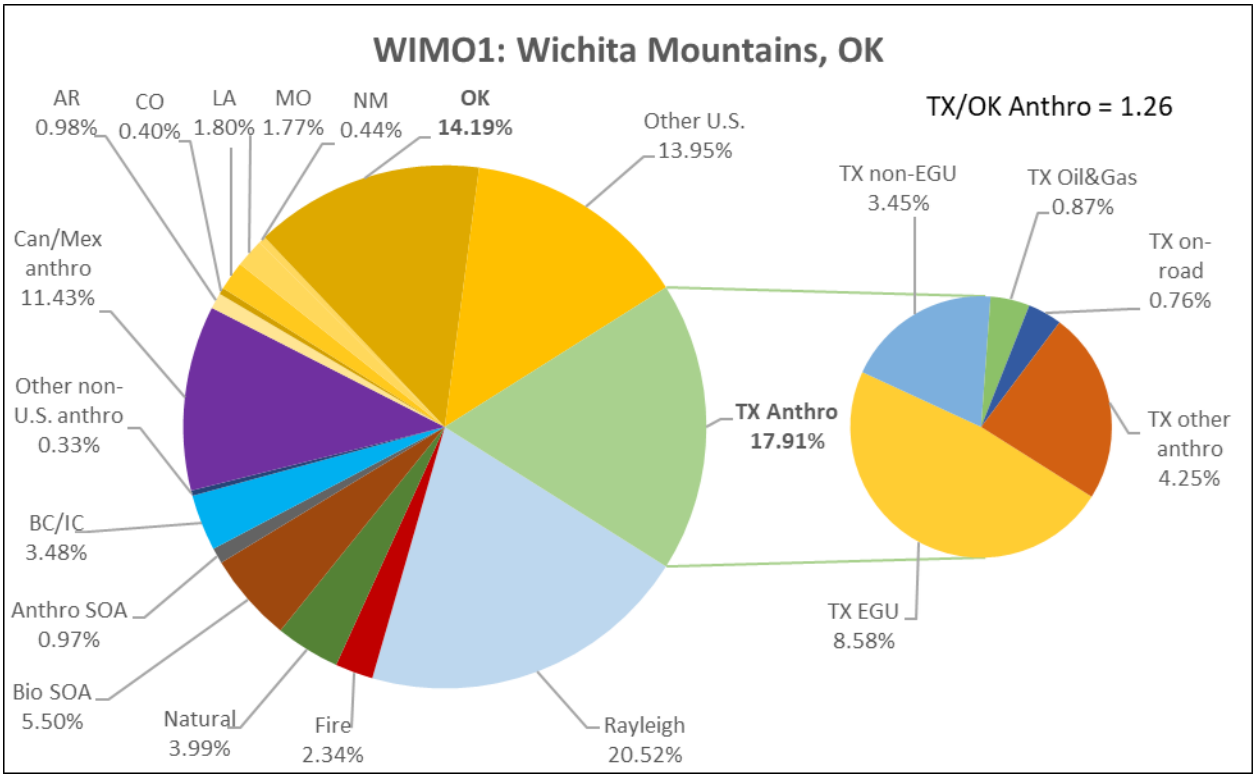

Figure 8-23: PSAT Light Extinction Influence at Wichita Mountains

Light extinction values for the 15 Class I areas in and near Texas are shown in Figure 8-24: *Light Extinction Influence from PSAT Categories at Nearby Class I Areas*. In this figure, the legend entries are in the same order as the plotted PSAT source categories. The influence of emissions from various regions are evident, such as the purple section of Canada/Mexico anthropogenic emissions, which are mostly from Mexico, is clearly seen with larger impairment seen at sites closer to Mexico. Emissions from the monitor home state are usually greater than neighboring states and decrease with distance. Exceptions to this are noted in Table 8-40: *State Ratios of PSAT Light Extinction Influence at Nearby Class I Areas (CIA)*. Except for fire emissions at Big Bend, fire and natural emission sources have greater influence on light extinction at sites east of Texas. The Other U.S. source category increases influence for the farther northeast sites in this comparison and is the largest source category for sites in Missouri and northern Arkansas.

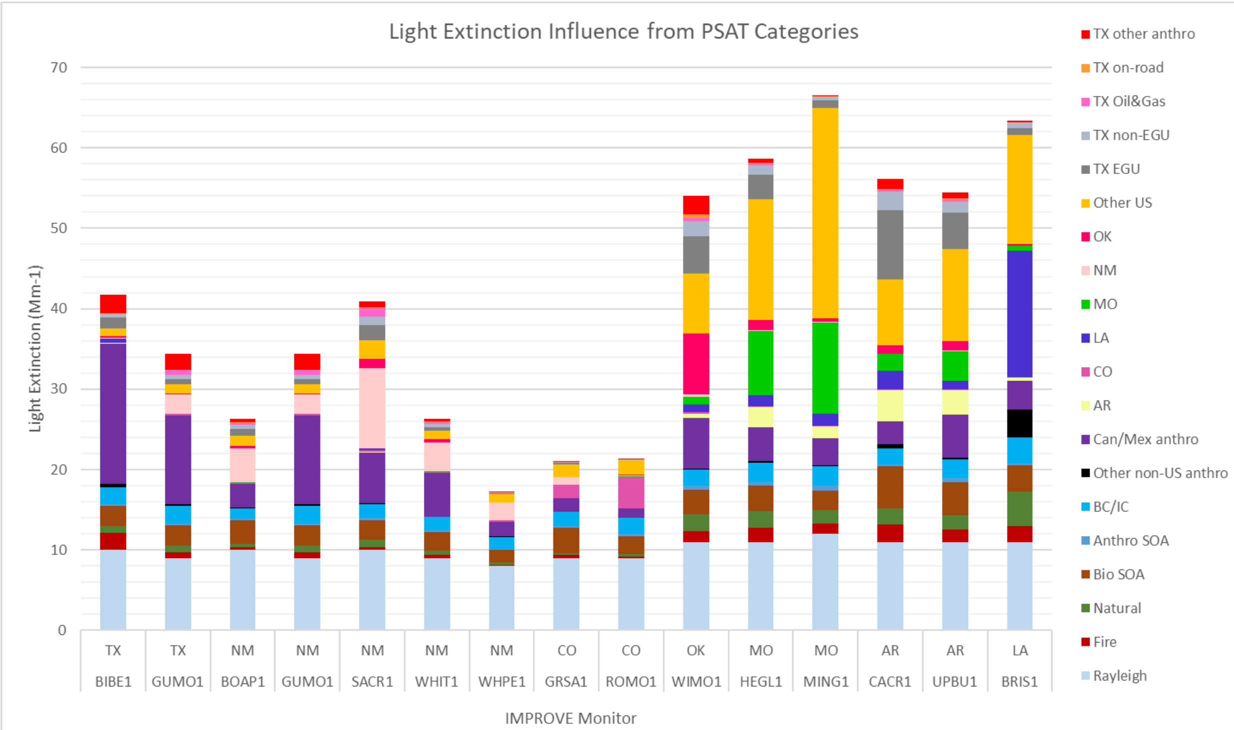

Figure 8-24: Light Extinction Influence from PSAT Categories at Nearby Class I Areas

Light extinction is further analyzed in Table 8-40 by displaying the ratio of each calculated PSAT source state versus the Class I area state. In addition to Carlsbad Caverns (CAVE) and Wichita Mountains mentioned above, Texas has a greater influence on light extinction than the Class I area home state for Caney Creek and Upper Buffalo in Arkansas. Missouri also has a greater influence on light extinction than Arkansas at Upper Buffalo. This fits with the Area of Influence (AOI) maps presented in Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals*. The AOI is calculated to anticipate the visibility impairment from a region, so when an AOI includes substantial portions of other states, the emission sources in those states are anticipated to have a notable impact.

Table 8-40: State Ratios of PSAT Light Extinction Influence at Nearby Class I Areas (CIA)

Class I Area (CIA) Site	CIA State	AR/ CIA State	CO/ CIA State	LA/ CIA State	MO/ CIA State	NM/ CIA State	OK/ CIA State	TX/ CIA State	Other U.S./ CIA State
BIBE	TX	0.0257	0.0097	0.1048	0.0118	0.0324	0.0496	1.0000	0.2103
GUMO	TX	0.0083	0.0372	0.0166	0.0031	0.6135	0.0408	1.0000	0.2763
BOAP	NM	0.0024	0.0253	0.0023	0.0072	1.0000	0.0863	0.4991	0.3069
CAVE	NM	0.0135	0.0606	0.0271	0.0051	1.0000	0.0665	1.6299	0.4504
SACR	NM	0.0037	0.0219	0.0183	0.0084	1.0000	0.1097	0.4854	0.2342
WHIT	NM	0.0033	0.0345	0.0040	0.0102	1.0000	0.1020	0.4137	0.2966
WHPE	NM	0.0003	0.0672	0.0027	0.0011	1.0000	0.0123	0.1123	0.4795
GRSA	CO	0.0006	1.0000	0.0027	0.0023	0.5598	0.0284	0.2366	0.9210
ROMO	CO	0.0003	1.0000	0.0004	0.0018	0.0459	0.0079	0.0375	0.4647
WIMO	OK	0.0690	0.0280	0.1269	0.1249	0.0312	1.0000	1.2626	0.9831
HEGL	MO	0.3111	0.0166	0.1702	1.0000	0.0080	0.1566	0.6349	1.8808
MING	MO	0.1303	0.0070	0.1319	1.0000	0.0022	0.0443	0.1453	2.2876
CACR	AR	1.0000	0.0313	0.5745	0.5372	0.0214	0.2475	3.1947	2.1038
UPBU	AR	1.0000	0.0404	0.3548	1.2054	0.0256	0.4045	2.3228	3.7782
BRIS	LA	0.0266	0.0023	1.0000	0.0347	0.0018	0.0122	0.1070	0.8632

Note: Numbers highlighted in turquoise are light extinction single-state ratios > 1.00.

A more detailed analysis of modeled particulate sulfate concentrations in Figure 8-25: *PSAT Particulate Sulfate Influence at Wichita Mountains* shows a larger ratio of Texas to Oklahoma influence, 4.7, and an increased influence from EGUs in Texas compared with other sources in Texas and elsewhere. Similar detailed analysis of particulate nitrate concentrations in Figure 8-26: *PSAT Particulate Nitrate Influence at Wichita Mountains* shows less influence from Texas, TX/OK is 0.92, a larger influence from other U.S. states, and the largest Texas influence from non-EGU point sources. These results are consistent with the area of influence analysis which showed the Wichita Mountains sulfate visibility area of influence with the major lobe in Texas and the nitrate area with the major lobe extending into states farther north.

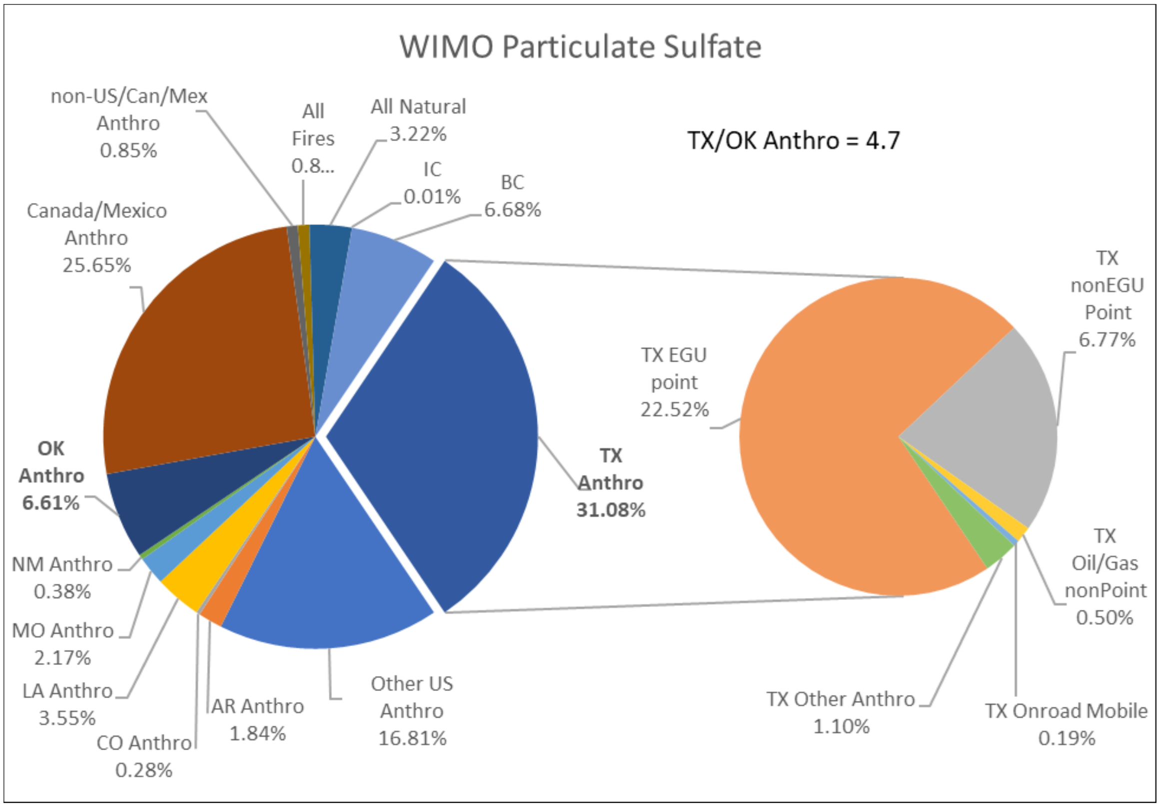

Figure 8-25: PSAT Particulate Sulfate Influence at Wichita Mountains

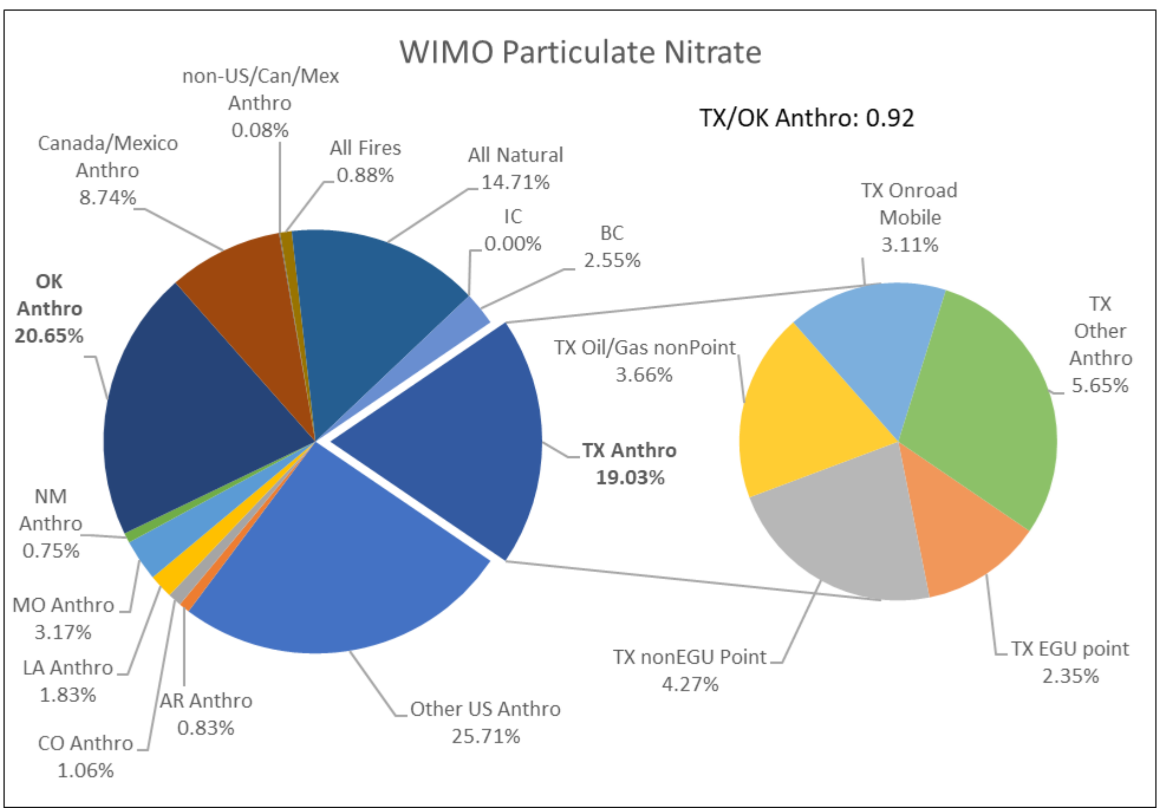

Figure 8-26: PSAT Particulate Nitrate Influence at Wichita Mountains

A summary table of PSAT particulate sulfate and nitrate influence is provided in Table 8-41: *All Sites PSAT Influence for Particulate Sulfate and Nitrate*. The results indicate that for the 13 Class I areas evaluated outside of Texas, the Texas influence for particulate sulfate is greater than the CIA home state influence for nine of the areas, with the largest influence ratio for Caney Creek in Arkansas, at 9.27, as highlighted in yellow in Table 8-41. The Texas influence on particulate nitrate is larger for six sites, with a maximum ratio of 3.45 for Carlsbad Caverns in New Mexico, as highlighted in pink. Six sites have a larger Texas influence for both particulate sulfate and nitrate: Carlsbad Caverns, Bosque del Apache, Salt Creek, and White Mountain in New Mexico; and Caney Creek and Upper Buffalo in Arkansas. Oklahoma also has a greater influence on particulate nitrate than the CIA home state for White Mountain in New Mexico and Upper Buffalo in Arkansas. Similarly, Missouri has a greater influence on particulate sulfate than the CIA home state for Caney Creek and Upper Buffalo in Arkansas, along with a greater influence on particulate nitrate at Upper Buffalo. Louisiana also has a greater influence on particulate sulfate than the CIA home state for Caney Creek. The influence ratio for all other U.S. states is also listed in Table 8-41 indicating that the other 43 states have a larger influence than the home state on particulate sulfate and/or particulate nitrate in most cases. Additional figures similar to Figure 8-25 and Figure 8-26 are presented in Appendix F for other IMPROVE monitors.

Table 8-41: All Sites PSAT Influence for Particulate Sulfate and Nitrate

CIA Site	PM Species	CIA State	AR/ CIA State	CO/ CIA State	LA/ CIA State	MO/ CIA State	NM/ CIA State	OK/ CIA State	TX/ CIA State	Other U.S./ CIA State
BIBE	PS4	TX	0.04	0.00	0.17	0.01	0.01	0.06	1.00	0.03
BIBE	PN3	TX	0.04	0.01	0.20	0.01	0.01	0.09	1.00	0.07
GUMO	PS4	TX	0.02	0.02	0.04	0.01	0.23	0.04	1.00	0.04
GUMO	PN3	TX	0.00	0.07	0.01	0.00	0.29	0.05	1.00	0.14
BOAP	PS4	NM	0.02	0.12	0.03	0.06	1.00	0.48	5.49	2.03
BOAP	PN3	NM	0.01	0.12	0.00	0.02	1.00	0.66	1.88	0.80
CAVE	PS4	NM	0.07	0.08	0.16	0.02	1.00	0.18	4.39	1.09
CAVE	PN3	NM	0.01	0.25	0.02	0.00	1.00	0.16	3.45	0.46
SACR	PS4	NM	0.02	0.05	0.14	0.03	1.00	0.38	2.78	1.02
SACR	PN3	NM	0.01	0.14	0.01	0.04	1.00	0.54	1.52	0.77
WHIT	PS4	NM	0.03	0.15	0.06	0.06	1.00	0.41	4.22	1.78
WHIT	PN3	NM	0.04	0.23	0.01	0.13	1.00	1.79	2.97	1.59
WHPE	PS4	NM	0.00	0.22	0.03	0.01	1.00	0.07	0.97	2.84
WHPE	PN3	NM	0.00	0.48	0.00	0.00	1.00	0.15	0.53	2.11
GRSA	PS4	CO	0.00	1.00	0.03	0.01	0.92	0.11	2.01	5.44
GRSA	PN3	CO	0.00	1.00	0.00	0.00	0.76	0.20	0.54	1.22
ROMO	PS4	CO	0.00	1.00	0.00	0.01	0.10	0.02	0.21	1.36
ROMO	PN3	CO	0.00	1.00	0.00	0.00	0.02	0.01	0.01	0.34
WIMO	PS4	OK	0.28	0.04	0.54	0.33	0.06	1.00	4.70	2.54
WIMO	PN3	OK	0.04	0.05	0.09	0.15	0.04	1.00	0.92	1.24
HEGL	PS4	MO	0.46	0.02	0.46	1.00	0.01	0.25	1.77	3.59
HEGL	PN3	MO	0.21	0.04	0.11	1.00	0.01	0.32	0.48	2.79
MING	PS4	MO	0.14	0.01	0.22	1.00	0.00	0.06	0.31	3.63
MING	PN3	MO	0.35	0.02	0.31	1.00	0.00	0.12	0.20	4.70
CACR	PS4	AR	1.00	0.03	1.54	1.08	0.03	0.36	9.27	4.13
CACR	PN3	AR	1.00	0.16	0.42	0.91	0.06	0.76	1.85	5.25
UPBU	PS4	AR	1.00	0.04	0.85	1.40	0.03	0.66	5.69	6.45
UPBU	PN3	AR	1.00	0.21	0.35	2.38	0.08	1.19	3.04	9.65
BRIS	PS4	LA	0.04	0.00	1.00	0.06	0.00	0.02	0.17	0.93
BRIS	PN3	LA	0.02	0.00	1.00	0.01	0.00	0.01	0.08	1.75

Note: Yellow highlighted numbers are particulate sulfate ratios > 1.00.
Pink highlighted numbers are particulate nitrate ratios > 1.00.

Individual modeled particulate matter species were also evaluated and can inform the analysis of emission impacts. Figure 8-27: *Texas to New Mexico Influence Ratio for Particulate Species at Salt Creek* shows the ratio of Texas to New Mexico influence on eight particulate species. The particulate sulfate and particulate nitrate have the most influence on visibility impairment and are the most common particulate species to show greater influence from outside the monitor state. The orange line at 1.0 in the figure indicates equal contributions between Texas and New Mexico, the IMPROVE monitor home state.

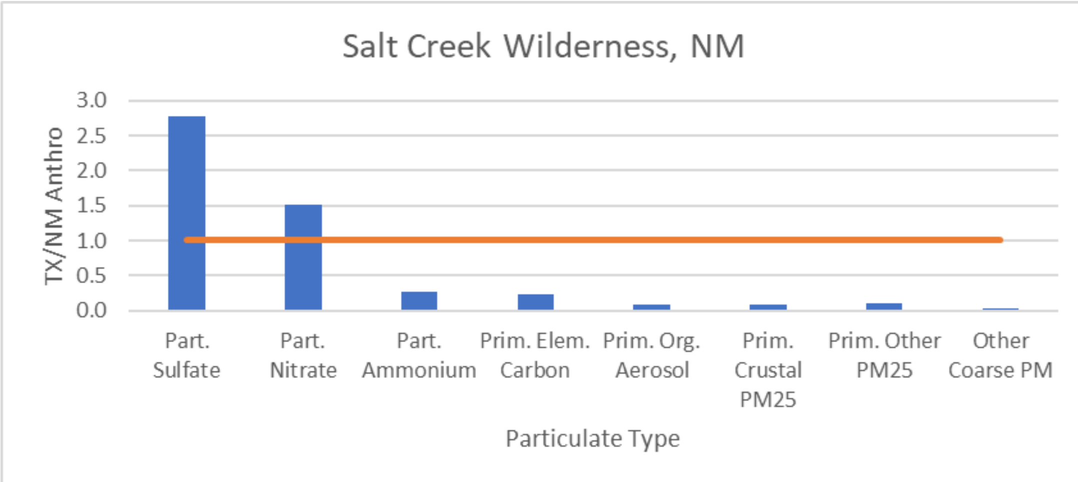

Figure 8-27: Texas to New Mexico Influence Ratio for Particulate Species at Salt Creek

The detailed source attributions determined by PSAT contributing to predicted PM concentrations at other IMPROVE monitors are in Appendix F.

8.4 REASONABLE PROGRESS GOAL STATUS

The required content of Regional Haze Rule SIP revisions for the second planning period and beyond is specified in 40 CFR §51.308(f)(3), which was revised in 2017.[33] The Regional Haze Rule established the concept of reasonable progress goals (RPG) for the 20% most anthropogenically impaired days as a regulatory construct promulgated to implement the statutory requirements for visibility protection. These RPGs reflect the visibility conditions that are projected to be achieved by the end of the applicable implementation period as a result of a state's own and other states' long-term strategies. Chapter 7 describes the long term strategy that reflects emissions reductions from state and federal programs including the federal SO_2 cap and trade program for Texas EGU subject to the Best Available Retrofit Technology (BART) requirements of the Regional Haze Rule, the NO_X trading program under the Cross-State Air Pollution Rule for Texas EGUs subject to BART, and consent decrees requiring SO_2 and NO_X emissions reductions between the EPA and certain refineries and carbon black manufacturing plants. The RPGs were developed after considering and applying the four statutory factors to each source selected for the analysis: 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 the source.

The Regional Haze Rule requires states to determine the rate of improvement in visibility that would need to be maintained during each implementation period in order to reach natural conditions by 2064 for the 20% most impaired days, given the starting point of the 2000 through 2004 baseline visibility condition. The "glidepath," or Uniform Rate of Progress (URP), is the amount of visibility improvement that would be needed to stay on a linear path from the baseline period to natural conditions.

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[33] Final Rule: Amendments to Regulatory Requirements for State Regional Haze Plans. Available online at: https://www.epa.gov/visibility/final-rulemaking-amendments-regulatory-requirements-state-regional-haze-plans

Progress is tracked using ambient concentration measurements from the IMPROVE network expressed in units of deciview (dv), which is proportional to the logarithm of the light extinction (Bext, in units of inverse megameters [Mm^{-1}]). These metrics are referred to as 'visibility monitoring data' although the measured quantity is ambient concentration.

The Regional Haze Rule also requires states to determine the baseline (2000 through 2004) visibility condition for the 20% clearest days and requires that the long-term strategy and RPG ensure no degradation in visibility for the clearest days since the baseline period.

Elements of the glidepath are listed below.

- "Baseline conditions" represent visibility conditions for the most impaired and clearest days for the 2000 to 2004 baseline period, as calculated using visibility monitoring data.
- "Current conditions" represent the most recent 5-year monitoring period for which most recent quality assured visibility monitoring data are available (e.g., 2014 through 2018).
- "Natural conditions" are grouped into two types: episodic and routine. Episodic natural contributions are those that occur relatively infrequently varying from year to year and likely result from extreme events. Routine natural contributions are those that occur on all or most days in a year or season and are more consistent from year to year. For the second planning period SIP, the EPA offered as a starting point a "default" natural visibility target for each Class I area. These default conditions were based on broad regional estimates and data analysis with an expectation that the estimates would be refined over time. Glidepaths based on the EPA's default natural condition estimates are termed 'default glidepaths' in this report.
- Reasonable progress (or interim) goals represent "reasonable progress" towards achieving natural conditions.

The IMPROVE website provides data necessary to develop default glidepaths (IMPROVE, 2020) as seen in Table 8-42: *Data Sources Used in Development of Glidepaths*.

Table 8-42: Data Sources Used in Development of Glidepaths

Element	Metric	Data Source
2000 to 2004 Baseline and Current Conditions	Clearest Days	http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2017/SIA_group_means_5_19.csv
2000 to 2004 Baseline and Current Conditions	Most Impaired Days	http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2017/sia_impairment_group_means_5_19.csv
Natural Conditions	Most Impaired Days	http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/Endpoint/endpoint_2064_imp_g_90_10_18.csv
Daily IMPROVE data (for QA)	Daily	http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2017/sia_impairment_daily_budgets_5_19.csv

The EPA Software for Model Attainment Test-Community Edition (SMAT-CE) version 1.6 was used to calculate 2028 deciview values on the 20% most impaired and 20% clearest days at each IMPROVE monitor. SMAT-CE is an EPA software tool that implements the procedures in the Modeling Guidance to project visibility to a future year. The modeled visibility projections use ambient data from a five-year base period centered about the base modeling year which is 2016 in this case. Therefore, the ambient IMPROVE data should be from the 2014 through 2018 period. However, since 2018 IMPROVE data was not available (as of November 2019) in SMAT, the most recent four-year average 2014 through 2017 was used.

8.4.1 Uniform Rate of Progress (Glidepath) Determination

After a state containing a Class I area projects the visibility conditions for the end of the implementation period, the Regional Haze Rule requires a comparison of these RPGs to the baseline period visibility conditions and to the URP (the glidepath), possibly including adjustment to the glidepath to account for international anthropogenic contribution to visibility impairment. The 2028 RPG for the 20% most anthropogenically impaired days is to be compared to the 2000-2004 baseline period visibility condition for the same set of days and must provide for visibility improvement since the baseline period (40 CFR §51.308(f)(3)). The 2028 RPG for the 20% clearest days is to be compared to the 2000-2004 baseline period visibility condition for the 20% clearest days and must ensure that no visibility degradation from the baseline period is projected (40 CFR §51.308(f)(3)).

Figure 8-28: *Visibility Improvement at Big Bend National Park for 20% Most Impaired Days and 20% Clearest Days* shows the five-year average of the current visibility (2014 through 2017) at Big Bend National Park compared to the five-year average of baseline visibility (2000 through 2004) along with the 2028 RPG established in this regional haze SIP revision.

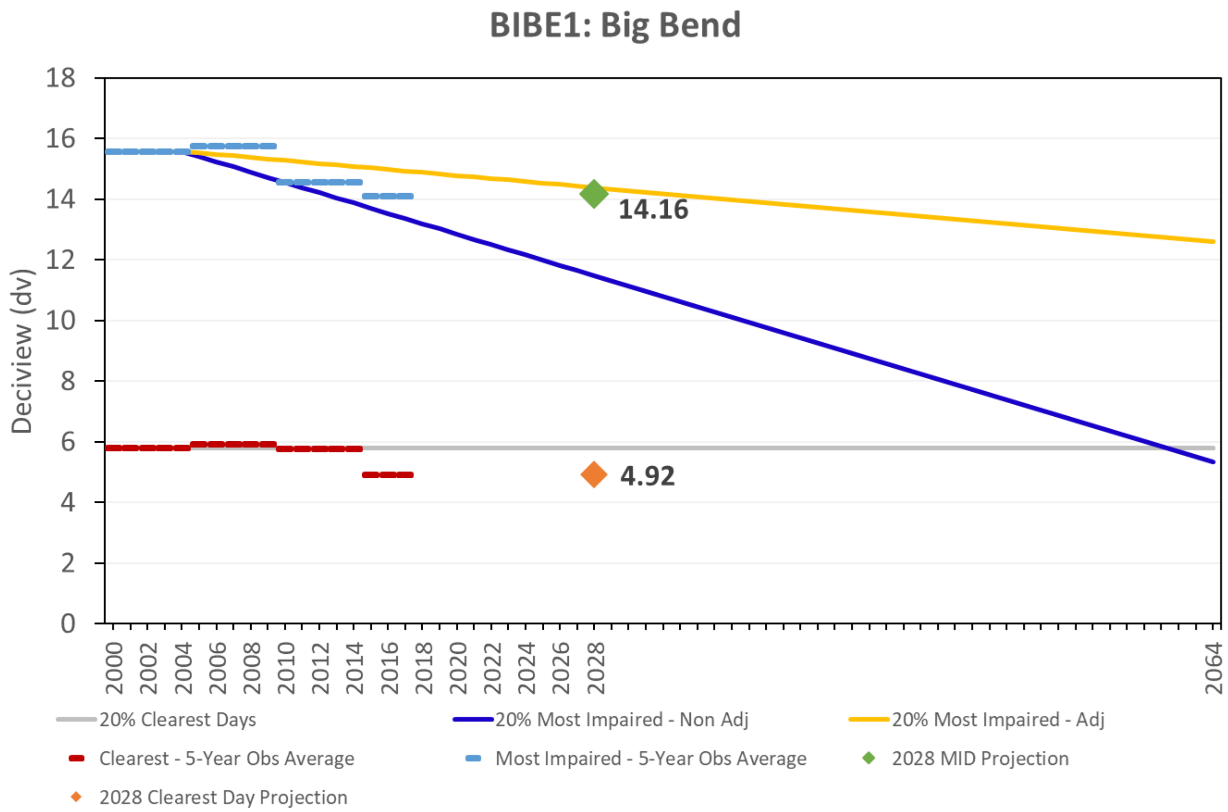

Figure 8-28: Visibility Improvement at Big Bend National Park for 20% Most Impaired Days and 20% Clearest Days

Figure 8-29: *Visibility Improvement at Guadalupe Mountains National Park for 20% Most Impaired Days and 20% Clearest Days* shows the five-year average of the current visibility (2014 through 2017) at Guadalupe Mountains National Park compared to the five-year average of baseline visibility (2000 through 2004) along with the 2028 RPG established in this regional haze SIP revision.

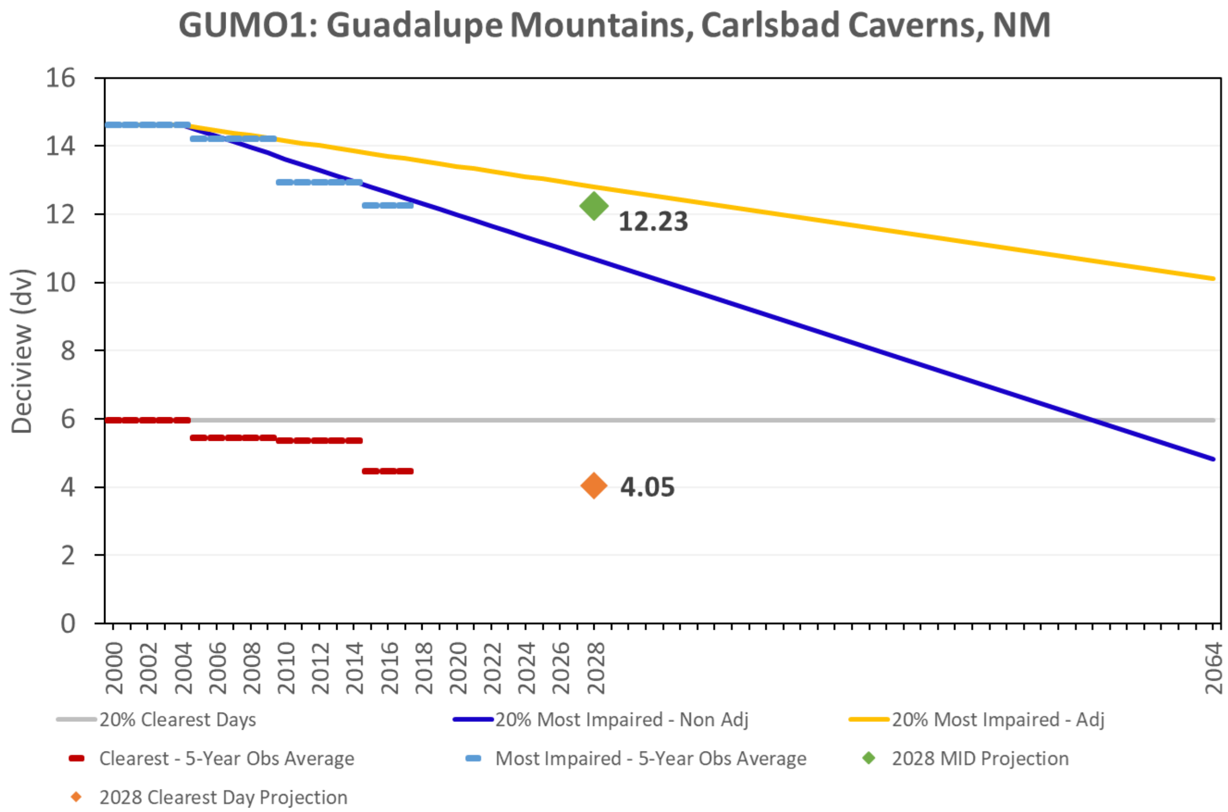

Figure 8-29: Visibility Improvement at Guadalupe Mountains National Park for 20% Most Impaired Days and 20% Clearest Days

Table 8-43: *Visibility for Class I Areas on 20% Most Impaired Days and 20% Clearest Days* presents the IMPROVE data for Texas Class I areas and the nearby Class I areas that Texas' emissions affect.

Table 8-43 shows the 2028 glidepath values at each Class I area, including the data used to calculate the glidepath (the 2000 through 2004 baseline and 2064 endpoints). After adjusting the glidepath endpoint to account for contributions from international anthropogenic emissions, the number of IMPROVE monitors projected to be above the 2028 glidepath decreased from six to one site (Salt Creek, NM) highlighted in pink. The EPA's modeling Technical Support Document (TSD) also had Salt Creek above the adjusted glidepath.[34]

The Regional Haze Rule requires that states assess progress by 2028 per 40 CFR 51.308. There is not a requirement to be on or below the straight line interpolated between the base period (2000 through 2004) and 2028 (the glidepath).

[34] Technical Support Document for the EPA'S Updated 2028 Regional Haze Modeling available at: https://www.epa.gov/visibility/technical-support-document-epas-updated-2028-regional-haze-modeling

Table 8-43: Visibility for Class I Areas on 20% Most Impaired Days and 20% Clearest Days

Class I Area (IMPROVE ID, State)	2014-2017 20% Clearest Days (dv)	Future Year (2028) 20% Clearest Days (dv)	2028 Adjusted Glidepath (dv)	Future Year (2028) 20% Most Impaired Days (dv)
Big Bend National Park (N.P.) (BIBE, TX)	5.2	4.9	14.4	14.2
Bosque del Apache Wilderness Area (W.A.) (BOAP, NM)	4.6	4.2	9.9	9.6
Breton Island W.A. (BRIS, LA)	11.8	11.3	19.8	18.3
Caney Creek W.A. (CACR, AR)	8.2	7.8	18.8	17.1
Great Sand Dunes W.A. (GRSA, CO)	2.9	2.6	8.2	7.3
Guadalupe Mountains N.P. (GUMO, TX)	4.5	4.1	12.8	12.2
Hercules-Glades W.A. (HEGL, MO)	9.8	9.1	19.6	17.4
Mingo W.A. (MINGO, MO)	11.2	10.6	20.2	18.6
Rocky Mountain N.P. (ROMO, CO)	1.3	1.1	9.2	7.3
Salt Creek W.A. (SACR, NM)	6.7	6.2	13.5	13.9
Upper Buffalo W.A. (UPBU, AR)	8.4	7.9	19.2	16.7
White Mountain W.A. (WHIT, NM)	2.6	2.2	10	9.5
Wheeler Peak W.A. (WHPE, NM)	0.3	0.1	6.5	5.3
Wichita Mountains W.A. (WIMO, OK)	8.4	7.7	17.4	16.7

Under 40 CFR 51.308(f)(1)(vi)(B), a state may adjust the glidepath for impacts from international anthropogenic sources and certain prescribed fires on wildland. For both Big Bend National Park and Guadalupe Mountains National Park, the 2028 RPG for the 20% most impaired days is below the adjusted glidepath.

8.4.2 International Contributions

The 2017 Regional Haze Rule includes a provision that allows states to propose an adjustment to the glidepath to account for impacts from anthropogenic sources outside the United States, if the adjustment has been developed through scientifically valid data and methods. The EPA's visibility guidance (EPA, 2018b) states "to calculate the proposed adjustment(s), the State must add the estimated impact(s) to the natural visibility condition and compare the baseline visibility."

The CAMx PSAT analysis described in Section 8.3.7.5: *Particulate Matter Source Apportionment* allows the TCEQ to quantify visibility contributions from various sources on the 20% most impaired days. Consistent with the 2028 visibility projections, the TCEQ calculated the source contributions using projected 2028 data and the percent contribution of each sector to the total modeled impairment in 2028. This approach is described in the EPA's TSD Appendix C: *PSAT Post-Processing Details* and summarized below:

1. Run SMAT using the 2016 and base case 2028 simulations. This creates 2028 projections from species specific Relative Response Factors (RRFs) multiplied by baseline observations at each IMPROVE monitor.

2. Create “sector tag” SMAT input files as the difference between the base case 2028 total concentrations and the concentration from each sector tag group (e.g., 2028 base case minus 2028 sector tag concentrations).
3. Run SMAT using the base case 2028 and each 2028 sector tag SMAT input file. This creates sector tag species specific RRFs that are multiplied by the 2028 forecast extinction from Step 1.
4. Impairment sector contributions are calculated as the differences between Step 3 and Step 1.
5. Calculate percent contributions of each sector to the total modeled impairment in 2028.

Table 8-44: *Source Contributions (%) to the Projected 2028 RPG on the 20% Most Impaired Days at Each Class I Area* presents the estimated percent source contribution to total projected impairment in 2028 on the 20% most impaired days. Non-Texas U.S. anthropogenic sources contribute 5% to 48% and are the largest impairment contribution at 11 of 14 sites when excluding Rayleigh. Mexico anthropogenic sources are the largest impairment contribution at the other three sites (41% at BIBE1, 32% at GUMO1 and 20% at WHIT1). Contributions from outside the continental U.S. via BC range from 3% to 9%. The results for all these sites can also be seen graphically in Figure 8-24, and individually in Appendix F.

Table 8-44: Source Contributions (%) to the Projected 2028 RPG on the 20% Most Impaired Days at Each Class I Area

Class I Area (State)	IMPROVE Monitor	2028 Extinction (Mm^{-1})	Texas Anthro	Non-Texas U.S. Anthro	Mexico/ Canada Anthro	BC	Natural (fire, biogenic)	Others (incl. Rayleigh)
Big Bend N.P. (TX)	BIBE1	41.2	10%	5%	41%	5%	13%	26%
Bosque del Apache W.A. (NM)	BOAP1	26.2	8%	23%	11%	5%	14%	39%
Breton W.A. (LA)	BRIS1	62.5	3%	48%	6%	5%	15%	24%
Caney Creek W.A. (AR)	CACR1	55.4	23%	31%	5%	3%	17%	21%
Great Sand Dunes W.A. (CO)	GRSA1	20.8	2%	20%	8%	8%	18%	45%
Guadalupe Mountains N.P. (TX)	GUMO1	34	11%	11%	32%	6%	12%	28%
Hercules-Glades W.A. (MO)	HEGL1	57.2	9%	48%	7%	4%	12%	20%
Mingo W.A. (MO)	MING1	64.4	3%	61%	5%	4%	8%	20%
Rocky Mountain N.P. (CO)	ROMO1	20.7	1%	27%	6%	9%	12%	45%
Salt Creek W.A. (NM)	SACR1	40.3	12%	34%	16%	4%	9%	26%
Upper Buffalo W.A. (AR)	UPBU1	53.4	13%	38%	10%	4%	14%	22%
White Mountain W.A. (NM)	WHIT1	25.8	6%	20%	20%	6%	12%	36%
Wheeler Peak W.A. (NM)	WHPE	17	2%	20%	11%	9%	11%	48%
Wichita Mountains W.A. (OK)	WIMO1	53.2	18%	33%	12%	4%	12%	22%

8.5 SENSITIVITY SCENARIOS

8.5.1 Emission Changes

As part of this SIP revision, three sensitivity analysis scenarios were conducted to estimate the impact of potential NO_X and SO_2 reductions in Texas on the future year visibility at Class I areas. The sensitivities were conducted by reducing NO_X and/or SO_2 emissions at specific EGU and non-EGU sources. The non-EGU sources include cement manufacturing, flat glass manufacturing, natural gas compression station, paper mill, and packaging materials sites. The details of the three scenarios include:

- Scenario 1: Removal of the Oklaunion Power Station as its owners have announced its retirement in 2020 (ERCOT, 2020). This scenario is labeled ZeroOKU.
- Scenario 2: In addition to Scenario 1, SO_2 reductions at specific sources in several of the sites described above. This scenario is labeled ZeroOKU&SO2.
- Scenario 3: In addition to Scenario 2, NO_X reductions at specific sources several of the sites described above. This scenario is labeled ZeroOKU&SO2&NOX.

Table 8-45 *Modeled Texas Emissions of NO_X and SO_2 for June 14, 2028 for Sensitivity Analysis Scenarios* summarizes the modeled emissions of NO_X and SO_2 tons per day (tpd) for a sample June day for the 2028 future year and each of the three sensitivity scenarios and the differences between these runs and the 2028 future case without additional controls (2028NoControl).

Table 8-45: Modeled Texas Emissions of NO_X and SO_2 for June 14, 2028 for Sensitivity Analysis Scenarios

Scenario	Non-EGU NO_X (tpd)	Non-EGU SO_2 (tpd)	EGU NO_X (tpd)	EGU SO_2 (tpd)	Total NO_X (tpd)	Total SO_2 (tpd)
2028NoControls	434.1	220.6	346.1	748.1	780.2	968.7
Scenario 1 (ZeroOKU)	434.1	220.6	323.0	740.2	757.1	960.8
Reduction from 2028NoControls	0.0	0.0	23.1	7.9	23.1	7.9
Scenario 2 (ZeroOKU&SO2)	434.1	217.1	323.0	502.8	757.1	719.9
Reduction from 2028NoControls	0.0	3.5	23.1	245.3	23.1	248.8
Reduction from ZeroOKU	0.0	3.5	0.0	237.4	0.0	240.9
Scenario 3 (ZeroOKU&SO2&NOX)	423.0	217.1	323.0	502.8	746.0	719.9
Reduction from 2028NoControls	11.1	3.5	23.1	245.3	34.2	248.8
Reduction from ZeroOKU&SO2	11.1	0.0	0.0	0.0	11.1	0.0

8.5.2 Visibility Impairment Changes

The visibility impairment effect of the ZeroOKU scenario can be seen in Figure 8-30: *Total Visibility Impairment Change Between the ZeroOKU Sensitivity and the 2028NoControls Case* where the difference between the 2028 visibility impairment value at 14 IMPROVE monitors in and around Texas is displayed in units of deciviews. A change of 0.01 deciviews, is seen at the WIMO1 monitor serving the Wichita Mountains Wilderness Area in Oklahoma. This monitor is the closest to the Oklaunion Power Station where the reductions occur. Additional improvement of 0.02 deciviews is seen at SACR1 and an improvement 0.01 deciviews is seen at BOAP1 and WHIT1.

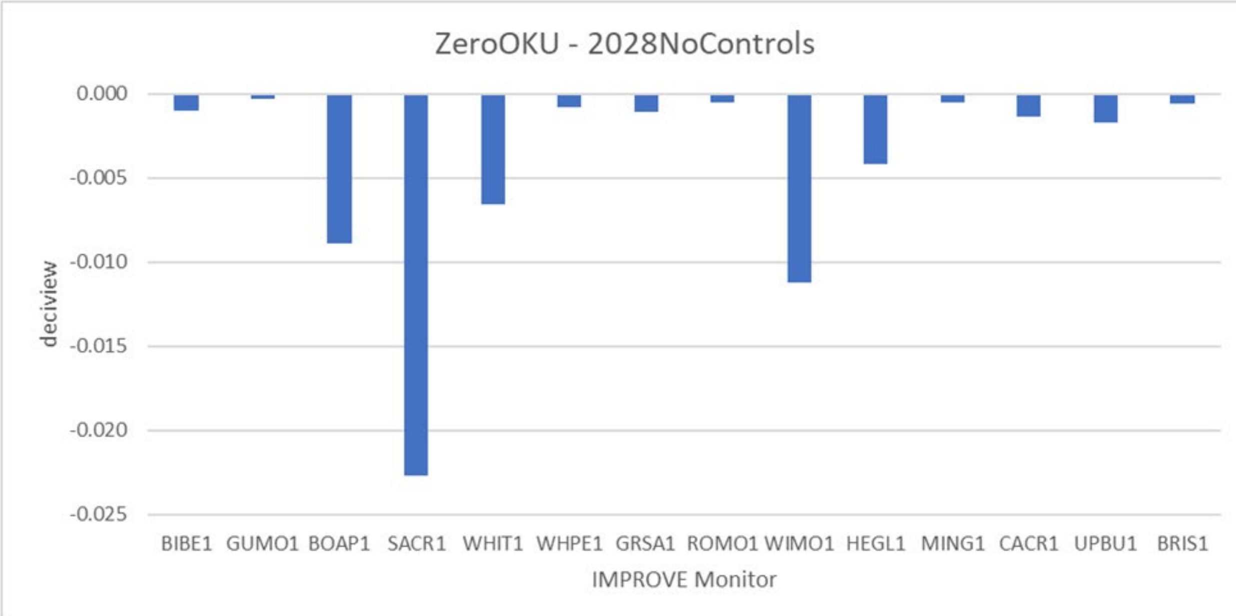

Figure 8-30: Total Visibility Impairment Change Between the ZeroOKU Sensitivity and the 2028NoControls Case

The effect of additional SO_2 control in addition to the NO_x and SO_2 reductions from the ZeroOKU scenario can be seen in Figure 8-31: *Total Visibility Impairment Change Between the ZeroOKU&SO2 Sensitivity and the ZeroOKU Sensitivity*. The additional 240.9 tpd SO_2 reduction on the sample June day is mostly from east Texas and the visibility improvement is seen most at the IMPROVE monitors north and northeast of Texas, with the largest improvement, 0.56 deciviews, at the CACR1 monitor serving Caney Creek in Arkansas. The next highest deciview improvements are seen at UPBU1 serving Upper Buffalo Wilderness Area in Arkansas, which is north of Caney Creek with less improvement seen at the HEGL1 monitor serving Hercules-Glades Wilderness Area in Missouri. HEGL1 is farther downwind on a trajectory past Caney Creek on the 20% most sulfate-impaired days. Visibility improvement is also seen at Wichita Mountains, which is downwind from the sites of SO_2 reductions in east and northcentral Texas on the 20% most sulfate-impaired days. See the AOI analysis in Section 7.2.1: *Area of Influence and Q/d Analysis for Source Selection* for additional information on the areas of influence. Some of the SO_2 reductions modeled were selected for their likely impact on the SACR1 monitor serving the Salt Creek Wilderness Area and the GUMO1 monitor serving Guadalupe Mountain National Park. The results also show visibility improvement at these monitors in addition to nearby BIBE1 (0.07 deciviews), BOAP1 (0.01 deciviews), SACR1 (0.04 deciviews), and WHIT1 (0.01 deciviews) monitors.

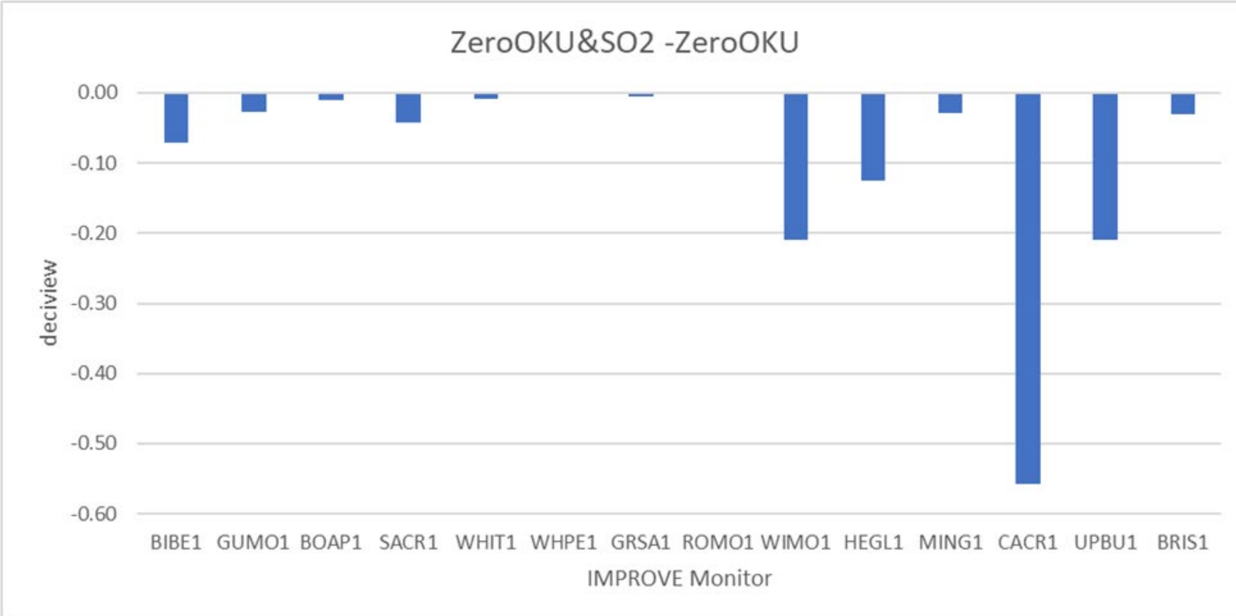

Figure 8-31: Total Visibility Impairment Change Between the ZeroOKU&SO2 Sensitivity and the ZeroOKU Sensitivity

When additional NO_x control is added to the controls of the ZeroOKU&SO2 scenario, some additional visibility improvement is seen. The most improvement is seen at WIMO1, which showed an improvement less than 0.01 deciviews.

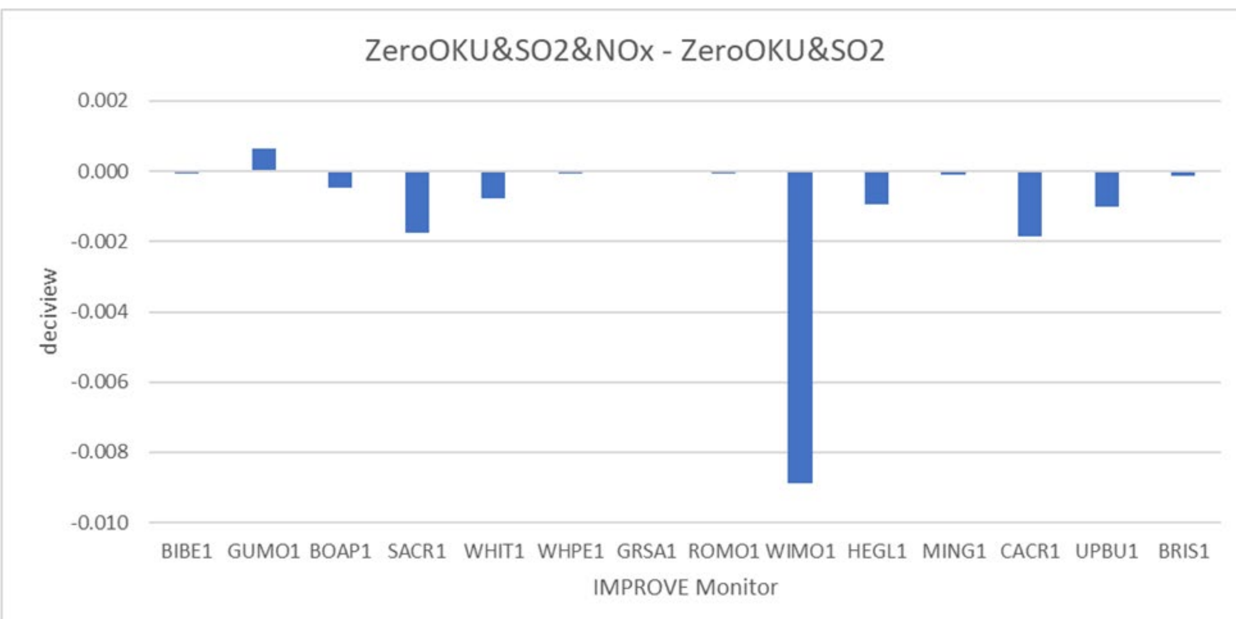

Figure 8-32: Total Visibility Impairment Change Between the ZeroOKU&SO2&NOX Sensitivity and the ZeroOKU&SO2 Sensitivity

The visibility improvement from each of the three scenarios compared with the 2028NoControls case is seen in Figure 8-33: *Visibility Impairment Reduction for ZeroOKU, ZeroOKU&SO2, and ZeroOKU&SO2&NOx Sensitivities,* with comparisons between the scenarios. The maximum visibility improvement at each monitor is seen in the ZeroOKU&SO2&NOx scenario.

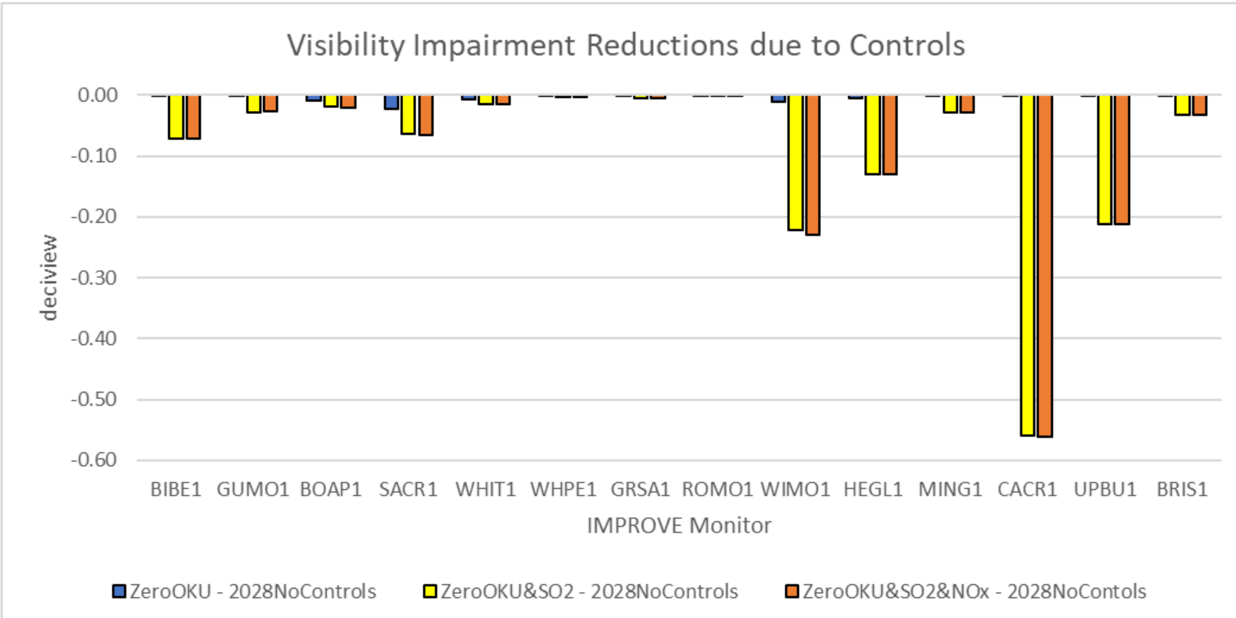

Figure 8-33: Visibility Impairment Reduction for ZeroOKU, ZeroOKU&SO2, and ZeroOKU&SO2&NOx Sensitivities

Figure 8-34: *Visibility Impairment Reduction for ZeroOKU&SO2&NOx from 2028NoControls* shows the visibility improvement from the ZeroOKU&SO2&NOx scenario with total visibility improvement for each monitor listed in deciviews. The maximum improvement is at Caney Creek with 0.56 deciviews. All monitors show a small degree of improvement in visibility. This includes the Salt Creek monitor, SACR1, which is over the adjusted glidepath, showing 0.07 deciviews improvement.

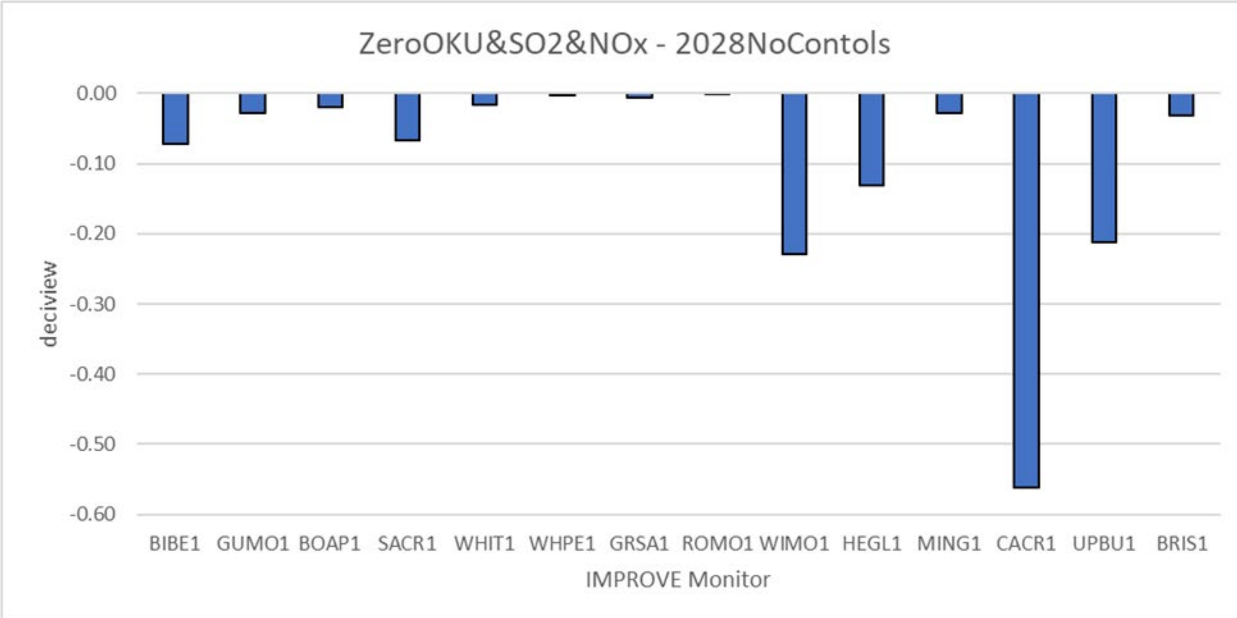

Figure 8-34: Visibility Impairment Reduction for ZeroOKU&SO2&NOx from 2028NoControls

Table 8-46: *Sensitivity Run 2028 Visibility Impairment on 20% Most Impaired Days and Adjusted Glidepath* shows the modeled 2028 visibility impairment on the 20% most impaired days for the 2028NoControls, ZeroOKU, ZeroOKU&SO2, and ZeroOKU&SO2&NOx compared with the URP or glidepath. The Salt Creek monitor is above the adjusted glidepath in all scenarios, highlighted in pink, and all other monitors are below the adjusted glidepath.

Table 8-46: Sensitivity Run 2028 Visibility Impairment on 20% Most Impaired Days and Adjusted Glidepath

Class I Area (IMPROVE ID, State)	2028 Adjusted Glidepath (dv)	2028 NoControls (dv)	2028 ZeroOKU (dv)	2028 ZeroOKU & SO_2 (dv)	2028 ZeroOKU & SO_2 & NO_x (dv)
Big Bend N.P. (BIBE, TX)	14.38	14.16	14.16	14.09	14.09
Guadalupe Mountains N.P. (GUMO, TX)	12.81	12.23	12.23	12.2	12.2
Bosque del Apache W.A. (BOAP, NM)	9.9	9.63	9.62	9.61	9.61
Salt Creek W.A. (SACR, NM)	13.49	13.94	13.92	13.87	13.87
White Mountain W.A. (WHIT, NM)	6.49	9.47	9.46	9.45	9.45
Wheeler Peak W.A. (WHPE, NM)	10	5.3	5.3	5.3	5.3
Great Sand Dunes W. A. (GRSA, CO)	8.21	7.32	7.32	7.32	7.32
Rocky Mountain N. P. (ROMO, CO)	9.19	7.28	7.28	7.28	7.28
Wichita Mountains W. A. (WIMO, OK)	17.38	16.71	16.7	16.49	16.48
Hercules-Glades W.A. (HEGL, MO)	19.64	17.45	17.44	17.32	17.32
Mingo W.A. (MINGO, MO)	20.19	18.63	18.63	18.6	18.6
Caney Creek W. A. (CACR, AR)	18.81	17.13	17.12	16.57	16.57
Upper Buffalo W.A. (UPBU, AR)	19.23	16.75	16.75	16.54	16.54
Breton W.A. (BRIS, LA)	19.84	18.33	18.33	18.29	18.29

Note: The Salt Creek monitor, highlighted in pink, is above the adjusted glidepath in all scenarios.

8.6 SUMMARY AND CONCLUSIONS

8.6.1 Summary

Future visibility was evaluated at individual Class I areas in or near Texas. For all sites evaluated, visibility on the 20% clearest days is projected to be below the baseline (2000 through 2004) visibility condition, meaning that no degradation on these days is anticipated.

Visibility on the 20% most anthropogenically impaired days is projected to be above the unadjusted glidepath in 2028 at six sites (Big Bend, Bosque del Apache, Guadalupe Mountains, Salt Creek, White Mountains, and Wichita Mountains). After adjusting the glidepath endpoint to account for international anthropogenic contributions, only Salt Creek has a 2028 projection above the 2028 adjusted glidepath. The CAMx PSAT results suggest that Texas, Mexico/Canada, and New Mexico anthropogenic source sectors contribute 12%, 15%, and 25%, respectively, to visibility impairment on the 20% most anthropogenically impaired days at Salt Creek.

8.6.2 Conclusions

To establish RPGs and estimate visibility at the end of the second planning period, the TCEQ conducted air quality modeling using the CAMx chemical transport model. Based on currently available information, this modeling provides an estimate of visibility improvement that could be expected in 2028 through the long-term strategy described in Chapter 7.

As shown in Figure 8-28 and Figure 8-29 for Big Bend and Guadalupe Mountains National Parks, the two Class I areas in Texas are expected to achieve sufficient visibility improvement by 2028 to meet or exceed the minimum improvements to achieve the URP. Based on this analysis, Texas meets its obligations under 40 CFR §51.308(f)(3) for reasonable progress goals, including modeling.

CHAPTER 9: REQUIREMENTS FOR PERIODIC REPORTS

9.1 INTRODUCTION

The 2017 amendments to the Regional Haze Rule changed the five-year reporting guidelines. In accordance with 40 Code of Federal Regulations (CFR) §51.308(f)(5), this second planning period state implementation plan (SIP) revision will serve also as the five-year report on reasonable progress addressing the period since submission of the progress report for the first implementation period submitted March 2009. The following chapters and sections this SIP revision describe how the progress report requirements of 40 CFR §51.308(g)(1) through (5) have been addressed.

1) The rule requires a description of the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals for Class I areas both within and outside the state.

Control measures to reduce emission within and outside the state are found in Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals*, Section 7.4: *Federal Programs that Reduce Stationary Source Emissions*, Section 7.5: *Federal Programs that Reduce Mobile Source Emissions*. Section 7.6: *State Air Pollution Control Programs*. Control measures in the state includes Section 7.6: *State Air Pollution Control Programs*, which discusses both state stationary and mobile source emissions control measures; Section 7.6.2: *Best Available Control Technology (BACT) Requirements*, which discusses air permitting requirements for new and modified sources of air pollution; and finally Section 7.6.3: *Additional Measures*, which discusses other measures addressing air pollution from mobile sources, construction activities, and fires, and measures addressing energy efficiency.

2) The rule requires a summary of the emissions reductions achieved throughout the state through implementation of the measures described in paragraph (g)(1).

Emissions reductions are found in Chapter 6: *Emissions Inventory*, Section 6.8: *NO_X and SO_2 Emissions Trends*, Table 6 4: *Anthropogenic NO_X Emissions by Source Type*, and Table 6 5: *Anthropogenic SO_2 Emissions by Source Type.*

Emissions reductions achieved throughout the state through existing control measures are found in Chapter 7: Section 7.4: *Federal Programs that Reduce Stationary Source Emissions*; Section 7.5: *Federal Programs that Reduce Mobile Source Emissions*; Section 7.6: *State Air Pollution Control Programs*, discussing both state stationary and mobile source emissions control measures; Section 7.6.2: *Best Available Control Technology (BACT) Requirements*, discussing air permitting requirements for new and modified sources of air pollution; and finally Section 7.6.3: *Additional Measures*, discussing other measures addressing air pollution from mobile sources, construction activities, and fires, and measures addressing energy efficiency.

3) The rule requires for each Class I 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 five-year averages of these annual values.

Visibility conditions are found in Chapter 4: *Assessment of Baseline and Current Conditions and Estimate of Natural Conditions in Class I Areas*, Section 4.2: *Baseline Visibility Conditions*, Section 4.3: *Natural Visibility Conditions*.

4) The rule requires analysis tracking the change over the period since 2009 and 2014 regional haze SIP revisions, emissions of pollutants contributing to visibility impairment from all sources and activities within the state, and emissions changes identified by type of source or activity.

Emission trends for reasonable progress for this 2021 Regional Haze SIP Revision are found in Chapter 6: *Emissions Inventory,* Section 6.7: *Emissions Summaries*, Table 6.1: *2011 Statewide Pollutant Summary by Source Category*, Table 6 2: *2014 Statewide Pollutant Summary by Source Category*, Table 6.3: *2017 Statewide Pollutant Summary by Source Category*, Table 6 4: *Anthropogenic NO_X Emissions by Source Type*, Table 6 5: *Anthropogenic SO_2 Emissions by Source Type* and in the 2014 Five-Year Regional Haze SIP Revision submitted previously in 2014 but not evaluated by EPA as of July 2020.

5) The rule requires 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.

Since the 2009 and 2014 regional haze SIP revisions, reductions in anthropogenic emissions within and outside the state have occurred from the following:

- ongoing rules and regulations for nonattainment areas in Texas (see Chapter 7: *Long-Term Strategy to Establish Reasonable Progress Goals*, Section 7.7: *State Air Pollution Control Programs*);
- closing several major coal-fired plants in Texas have permanently reduced emissions (see Chapter 7, Section 7.7.3.7: *Potential Effects of Economically Driven Coal Burning Power Plant Closures*);
- continuing reductions in mobile emissions through the incentives like Texas Emissions Reduction Plan (TERP) (see Chapter 7, Section 7.7.3.8: *Texas Emissions Reduction Plan*); and
- ongoing energy efficiency state-wide has continued to increase (see Chapter 7, Section 7.6.3.3: *Energy-Efficiency (EE) Programs and Renewable Energy (RE) Measures*); and others in Chapter 7.

The Regional Haze Rule amendments also changed the five-year report from states to the EPA. For this second planning period only, the five-year report is required by 40 CFR §51.308(g) to be submitted by July 31, 2025. The five-year report will be examined by the EPA, but the EPA will not formally approve or disapprove them. In the future, the SIP process will not be required for the five-year report, but Federal Land Manager consultation and public comments are still required.

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Appendices Available Upon Request

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