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Submitted via electronic mail

October 30, 2020

Daniel Czecholinski
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Arizona Department of Environmental Quality
1110 W. Washington St.
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RE: Irvington Generating Station Visibility Modeling Report
Follow up to TEP's *Irvington Generating Station Four-Factor Analysis Report*

Dear Mr. Czecholinski:

Tucson Electric Power Company (TEP) respectfully submits the attached *Assessing the Visibility Impacts of the Sundt* (Irvington) *Generating Station*, to the Arizona Department of Environmental Quality (ADEQ). TEP owns and operates the H. Wilson Sundt Generating Station, also known as the Irvington Generating Station (IGS), which is located in Tucson, Arizona.

The attached report details the results of a photochemical grid modeling (CAMx) analysis performed by Ramboll US Corporation. Modeling of a hypothetical nitrogen oxides (NO_X) emission reduction of 130 tons per year at Sundt Unit 3 yields a predicted visibility improvement of 0.0097 deciviews on the most anthropogenically impaired days at Saguaro Wilderness Area and lesser improvements at other Class I areas. This is the difference between a total contribution of 0.00317 deciviews from Unit 3 to impairment at Saguaro without additional control measures and a predicted total contribution of 0.00220 deciviews with NO_X controls. Even without additional controls, the visibility impairment attributable to emissions from this unit is negligible. For the same hypothetical NO_X emission reduction, the total predicted visibility improvement at all 25 Class I Areas evaluated is 0.0016 deciviews.

As noted in Section 4.1 of TEP's *Irvington Generating Station Four-Factor Analysis Report* for IGS Unit 3 ("TEP Report", dated March 2020), the total annual cost of combustion controls at this unit is $0.36 million. This value is conservative because the capital recovery cost component is based on a 20-year project life, whereas TEP expects to retire the unit permanently by 2032. Even if this NO_X emission control measure were reasonably cost effective on a $/ton basis, which it is not, these costs cannot be considered reasonable in relation to the negligible visibility benefits that would result. In

particular, if the annual costs are considered in relation to the predicted visibility improvement of 0.00097 deciviews on the most anthropogenically impaired days at Saguaro Wilderness Area, the cost effectiveness in terms of visibility improvement is $370 million per deciview. As noted in footnote 49 of the TEP Report, EPA has routinely approved state decisions to reject controls under the Regional Haze rules, even where such controls may reasonably be considered cost effective on a $/ton basis, where the predicted visibility improvements are negligible, and the cost effectiveness in relation to visibility is similar to that calculated here.

TEP provides this report for ADEQ's use in developing a revised State Implementation Plan for the second planning period under the federal Regional Haze program.

If you have any questions regarding these submittals, please feel free to contact me.

Sincerely,

Megan E. Garvey

Megan E. Garvey
Director, Environmental Services and Sustainability

cc: Rupesh Patel, Pima County Department of Environmental Quality
Catherine Schladweiler, TEP

Prepared for:

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October 27, 2020

ASSESSING THE VISIBILITY IMPACTS OF THE SUNDT GENERATING STATION – FINAL REPORT

RAMBOLL Bright ideas. Sustainable change.

Assessing the Visibility Impacts of the Sundt Generating Station – Final Report

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1.0 INTRODUCTION

RTP Environmental Associates, Inc. (RTP) has retained Ramboll US Consulting, Inc. (Ramboll) on behalf of their client Tucson Electric Power Company (TEP) to conduct preliminary visibility modeling of the Sundt Generating Station (SundtGS), formerly called the Irvington Generating Station. The Arizona Department of Environmental Quality (ADEQ) is developing the second-round regional haze State Implementation Plan (SIP) that is due to the U.S. Environmental Protection Agency (EPA) by July 31, 2021. ADEQ is working with the Western Regional Air Partnership (WRAP) who are assisting the 13 western states with the development of their regional haze SIPs. One important component of the regional haze SIP is conducting a four-factor analysis for sources to determine whether additional reasonable progress controls should be included in the SIP. The four-factors are: (1) costs of compliance; (2) time necessary for compliance; (3) energy and non-air quality environmental impacts of compliance; and (4) remaining useful life. In addition to the four factors, states may take the visibility impacts of a source and the visibility benefits of feasible control options into account when assessing what may be required for reasonable progress. The TEP SundtGS Unit #3 is a source that may undergo review for reasonable progress controls in the next ADEQ regional haze SIP.

1.1 Purpose

This document summarizes the procedures and results for conducting preliminary visibility modeling of the SundtGS for a base case emissions scenario and a NOx sensitivity case emissions scenario.

1.2 Modeling Approach

The SundtGS modeling approach mirrors the approach from “Assessing the Visibility Impacts of the Springerville Generating Station” (Ramboll, 2020). SundtGS visibility modeling was performed with the Comprehensive Air-quality Model with extensions (CAMx) photochemical grid model using EPA’s 2016 beta (2016b) modeling platform. CAMx is a state-of-the-science photochemical grid model that comprises a "one-atmosphere" treatment of tropospheric air pollution over spatial scales ranging from neighborhoods to continents. Visibility impacts of the SundtGS were estimated at nearby Class I Areas for two SundtGS 2028 emission scenarios that are described below.

EPA’s 2016 beta (2016b) CAMx modeling platform was adapted for the visibility modeling. A 12-km resolution southwest U.S. domain (12SW2) was extracted (windowed) from the EPA’s 12-km (12US2) continental U.S. modeling domain. Boundary Conditions (BCs) for the 12SW2 domain were obtained from three-dimensional concentrations from a CAMx simulation of the 12US2 domain.

A CAMx 2016 12SW2 actual base case simulation was conducted using actual SundtGS emissions based on measured hourly Continuous Emissions Monitoring System (CEMS) data from 2016. The CAMx 2016 actual base case was subjected to a model performance evaluation with a focus on PM performance at IMPROVE monitoring sites.

1.3 Overview of SundtGS 2028 Scenarios

Two 2028 CAMx simulations were performed that varied emissions from the SundtGS Unit #3:

1. <u>2028 Base Case Simulation</u>: Base case NO_X emissions from Sundt Unit #3 are 251 tons per year (TPY) (2,424,037 MMBtu/yr × 0.2072 lb/MMBtu) based on emissions information TEP provided to ADEQ.

2. 2028 control scenario: The control scenario is a reduction in SundtGS Unit #3 NO_X emissions of 51.8%, or 130 TPY, to a controlled rate of 121 TPY (2,424,037 MMBtu/yr × 0.1000 lb/MMBtu).

1.4 Visibility Impact Assessment Approach

The contributions of the two SundtGS emission scenarios to visibility impairment at Class I Areas (CIAs) were examined using the Software for Modeled Attainment Test – Community Edition (SMAT[1]). SMAT uses the visibility projection technique outlined in EPAs latest (EPA, 2018a) regional haze modeling guidance[2] that uses the modeling results in a relative fashion to scale observed visibility for the 20% most impaired days (MID) and 20% clearest days. The Sundt contributions are calculated by taking the difference between SMAT visibility projections that include the contribution of Sundt Unit #3 emissions and SMAT visibility projection without the contribution of Sundt Unit #3 emissions.

[1] https://www.epa.gov/scram/photochemical-modeling-tools
[2] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

2.0 EPA REGIONAL HAZE GUIDANCE

To assist states with the preparation of regional haze state implementation plans (SIPs) for the second implementation period (due to EPA by July 31, 2021), EPA has provided a "*Guidance on Regional Haze State Implementation Plans for the Second Implementation Period,*" which was distributed on August 20, 2019 (EPA, 2019a). It replaces the 2016 draft regional haze guidance. One important revision (compared to the first implementation period) is the usage of the new Most Impaired Days (MID) visibility tracking metric, which focuses attention on days when anthropogenic emissions impair visibility instead of days when wildfires and natural dust storms are the greatest contributors to reduced visibility for the Worst 20% days metric that was used in the previous regional haze SIPs.

2.1 EPA Final Guidance for Evaluating Single-Source Visibility Impacts

When evaluating a single-source's visibility impacts at a Class I area, EPA's guidance (EPA, 2019a) recommends using light extinction (in inverse megameters or Mm^{-1}; EPA, 2019a, pp. 16), rather than deciviews that have been used in the past, for comparing the Reasonable Progress Goals (RPGs) to the URP. However, EPA guidance recognizes that the deciview metric may also be used, especially when comparing to past work based on deciviews (e.g., visibility benefits per cost has used the deciview metric) and in this report results for both light extinction and deciview are presented. Light extinction (Bext) is related to Deciview Haze Index (dv) as follows:

$$dv = 10 \ln(Bext/10)$$

EPA recommends that single-source modeling of visibility impacts uses estimates of actual 2028 emissions accounting for any controls or changes in operation that occur between now and 2028 (EPA, 2019a, pp. 17). EPA does not recommend any specific visibility metric or procedure for evaluating which alternative control measure provides greater visibility benefits.

EPA's modeling guidance for making regional haze projections (EPA, 2018b)[3] recommends using the modeling results in a relative fashion to scale the observed visibility on the 20% MID to project 2028 future year 20% MID visibility levels. EPA provides the Software for the Modeled Attainment Test (SMAT[4]) tool to make future year 20% MID visibility projections using base year and future year modeling results and observed visibility conditions. Thus, for this analysis we are using the 20% MID visibility metric at IMPROVE monitoring sites that represent CIAs to evaluate the effects that the alternative control scenarios for the SundtGS would have on visibility impairment at CIAs. We also report the modeling results for the 20% cleanest visibility days at IMPROVE sites representing CIAs.

[3] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf
[4] https://www.epa.gov/scram/photochemical-modeling-tools

3.0 EPA'S 2016 MODELING PLATFORM AND 2016 BASE CASE MODELING

3.1 EPA's 2016 Modeling Platform

EPA routinely develops national photochemical grid model (PGM) modeling platforms that are used to evaluate air quality impacts of national rules, such as the Cross-State Air Pollution Rule (CSAPR[5]). National PGM modeling platforms typically coincide with the triennial National Emission Inventory (NEI[6]) years (e.g., 2008, 2011, 2014, 2017). The EPA PGM modeling platform that was used for the "Assessing the Visibility Impacts of the Springerville Generating Station" (Ramboll, 2020) project was the EPA 2016 beta (2016b) modeling platform, which is the modeling platform used for the SundtGS visibility modeling as well.

2016 Modeling Platform: The EPA and Multi-Jurisdictional Organizations (MJO) performed a joint 2016 inventory collaborative study[7] to develop a 2016 emissions inventory of comparable quality to the NEI. EPA used the EPA/MJO 2016 emissions to develop a 2016 PGM modeling platform. The 2016 Beta platform was released in April 2019 and is available[8] on the Intermountain West Data Warehouse (IWDW). The first full version of the 2016 platform (2016v1) became available later in 2019 and the full version includes future year emissions including 2028, but since this study is based on the Springerville study the older EPA 2016 beta modeling platform was used. The EPA 2016 platform uses the 12-km 12US2 domain embedded in a North America 36-km 36US3 domain that are shown in Figure 3-1.

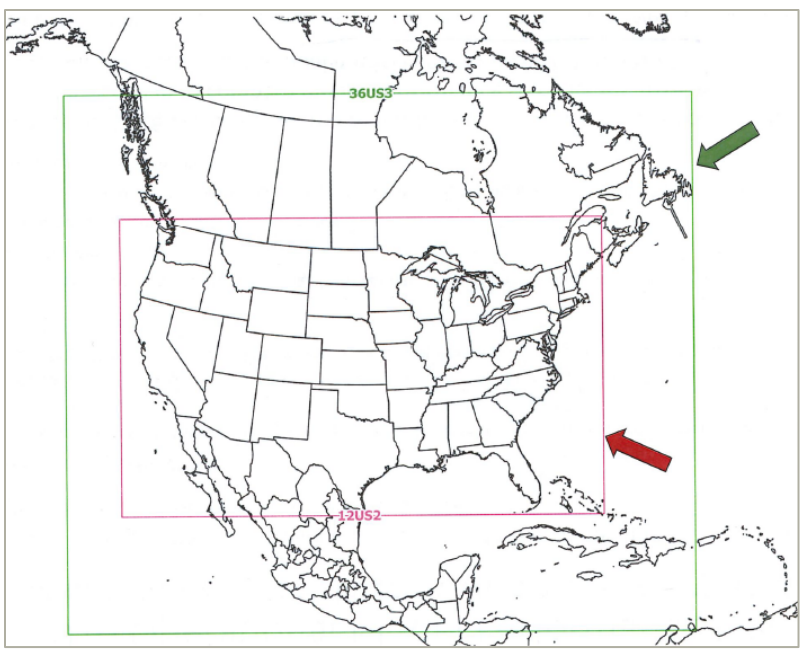

Figure 3-1. 12-km grid resolution 12US2 domain (red) and 36-km grid resolution 36US3 domain (green) used in the EPA's 2016b modeling platform.

[5] https://www.epa.gov/csapr
[6] https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei
[7] https://views.cira.colostate.edu/wiki/wiki/9169#Overview
[8] https://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016

3.2 2016 Southwestern U.S. Domain Modeling Platform

As previously mentioned, the SundtGS modeling approach mirrors the approach from "Assessing the Visibility Impacts of the Springerville Generating Station" (Ramboll, 2020). For the Springerville visibility modeling, the size of the EPA 2016 12-km 12US2 modeling domain was reduced to cover just the southwest U.S. so that the CAMx visibility simulations were more computationally efficient[9] with no loss of accuracy or technical rigor. Figure 3-2 displays the EPA 2016 modeling platform 12-km 12US2 modeling domain (same as red domain in Figure 3-1) and the 12-km 12SW2 modeling domain used in the Springerville (Ramboll, 2020) and the SundtGS visibility modeling assessments with the parameters for the definitions of the two domains given in Table 3-1. Additional steps that were performed to develop the CAMx 2016 12-km 12SW2 domain database for were as follows:

- Conducted CAMx 2016 beta 12-km 12US2 domain simulation for 2016 calendar year plus spin-up days to obtain 3-D output files of hourly concentrations that were used to generate Boundary Conditions (BC) for the smaller 12-km 12SW2 domain.
- Processed the CAMx 2016 12-km 12US2 domain 3-D output to generate hourly BC inputs for the 12-km 12SW2 southwest domain and the 2016 year.
- Windowed out CAMx meteorological, emissions and other gridded inputs from the 12-km 12US to the 12-km 12SW2 domain.
- Developed other CAMx ancillary inputs (e.g., photolysis rates, ozone column, etc.) for 2016 and the 12SW2 domain.
- Conducted a CAMx 12-km 12SW2 southwest modeling domain 2016 base case simulation.
- Performed a model performance evaluation with the Atmospheric Model Evaluation Tool (AMET) focusing on the performance of particulate matter (PM) species concentrations at IMPROVE sites for the CAMx 12-km 12SW2 2016 base case simulation.
- Compared the Springerville CAMx visibility 2016 base case modeling simulation with EPA's CAMx 2016 beta modeling which is documented in the "Technical Support Document for EPA's Updated 2028 Regional Haze Modeling" (EPA 2019). The comparison focused on spatial plots of NMB (%) and NME (%) for $PM_{2.5}$ nitrate and $PM_{2.5}$ sulfate at IMPROVE sites and showed that these two CAMx simulations had very similar model performance statistics, which was to be expected since they are based on the same modeling platform.

Table 3-2 presents a comparison of the model configurations for the EPA 2016 Beta CAMx simulation and the SundtGS CAMx simulation.

[9] The CAMx simulations using the 12SW2 domain will run almost 6 times faster than if the original 12US2 domain was used.

Table 3-1. Definitions of the EPA 12US2 continental and 12SW2 southwest 12-km modeling domains.

Grid	Origin (SW, km)	Extent (NE, km)	NX	NY
12US2	(-2412, -1620)	(2340, 1332)	396	246
12SW2	(-2256, -996)	(-408, 324)	154	110

LCC projection with 33 and 45 N True Latitudes and -97 W and 40 N Central Longitude and Latitude.

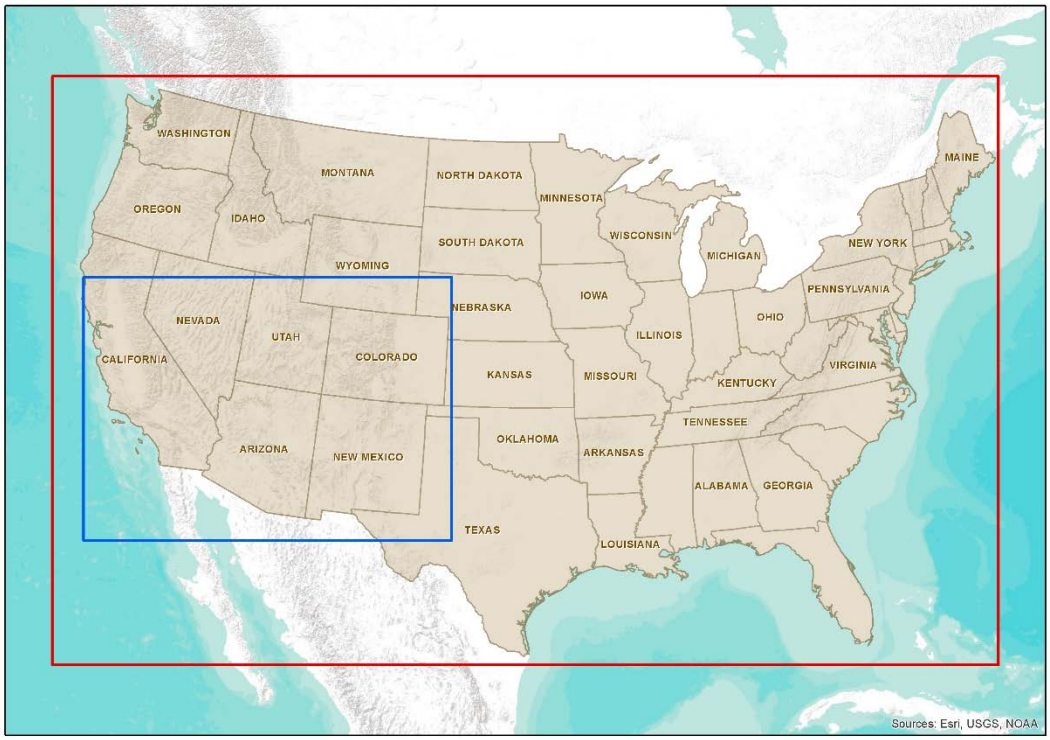

Figure 3-2. EPA 12-km 12US2 continental U.S. modeling domain (red) and 12-km 12SW2 southwest U.S. modeling domain (blue).

Table 3-2. CAMx model configurations used for the EPA 2016 beta CAMx modeling and the SundtGS visibility modeling (which was identical to the Springerville (Ramboll, 2020).

Science Options	EPA 2016 Beta CAMx	Springerville and SundtGS 2016 CAMx	Comment
Model Codes	CAMx V6.5 - Apr 2018	CAMx v6.5 - Apr 2018	CAMx v7.0 released /May 2020
Horizontal Grid Mesh	36/12-km	12-km	LCC Projection
36 km grid	36US3: 172 x 148 cells	None	36US3 Domain
12 km grid	12US2: 396 x 246 cells	12SW2: 154 x 110 cells	6x faster on 12SW2 than 12US1
Vertical Grid Mesh	35 vertical layers	35 vertical layers	Layer 1 thickness 20 m. Model top at ~19 km AGL
Grid Interaction	36/12-km one-way nesting	Just 12-km 12SW2 domain	One-way nesting between 12US2 and 12SW2 domains
Initial Conditions	10-day spin-up	5-day spin-up	
Boundary Conditions	2016 HCMAQ for 36US2	From CAMx 2016 12US2 simulation	CAMx 12US2 used CAMx 36US BCs that used HCMAQ BCs
Emissions			
Baseline Emissions	SMOKE, SMOKE-MOVES2014, BEIS	SMOKE, SMOKE-MOVES2014, BEIS	EPA 2016 Beta Emissions
Sub-grid Plumes	No Plume-in-Grid	No Plume-in-Grid	
Chemistry			
Gas Phase Chemistry	CB6r2h	CB6r2h	(Yarwood et al., 2010)
Meteorological Processor	WRFCAMx	WRFCAMx	Compatible with CAMx V6.5
Horizontal Diffusion	Spatially varying	Spatially varying	K-theory with Kh grid size dependence
Vertical Diffusion	CMAQ-like Kv	CMAQ-like Kv	Minimum Kv 0.1 to 1.0 m^2/s
Diffusivity Lower Limit	Kz-min = 0.1 to 1.0 m^2/s or 2.0 m^2/s	Kz-min = 0.1 to 1.0 m^2/s or 2.0 m^2/s	Depends on fraction of urban land use fraction
Deposition Schemes			
Dry Deposition	Zhang dry deposition	Zhang dry deposition	(Zhang et. al, 2001; 2003)
Wet Deposition	CAMx -specific formulation	CAMx -specific formulation	rain/snow/graupel
Numerics			
Gas Phase Chemistry	Euler Backward Iterative(EBI)	Euler Backward Iterative(EBI)	EBI fast and accurate solver
Vertical Advection	Implicit scheme w/ vertical velocity update	Implicit scheme w/ vertical velocity update	Emery et al., (2009a,b; 2011)
Horizontal Advection	Piecewise Parabolic Method (PPM) scheme	Piecewise Parabolic Method (PPM) scheme	Colella and Woodward (1984)
Integration Time Step	Wind speed dependent	Wind speed dependent	~0.5-1 min (4-km), 1-5 min (12-km), 5-15 min (36-km)
Simulation Strategy			
MPI/OpenMP	8/3	8/3	Each run segment using 24 cores
Run Segments	4-Segments (~3 months each)	4-Segments (~3 months each)	4 run-segments run at the same time
CPU	DQUAD 1.6 GHz	DHEX	

4.0 2028 EMISSIONS SCENARIOS

Two 2028 CAMx simulations were performed that varied emissions from the SundtGS Unit #3:

1. 2028 Base Case Simulation: Base case NO_X emissions from Sundt Unit #3 are 251 tons per year (TPY) (2,424,037 MMBtu/yr × 0.2072 lb/MMBtu).

2. 2028 control scenario: The control scenario is a NOx reduction of 51.8%, or 130 TPY, to a controlled rate of 121 TPY (2,424,037 MMBtu/yr × 0.1000 lb/MMBtu) for Unit #3. No change to heat input, exhaust characteristics, or any other pollutants were assumed.

Below we discuss the Sundt/Irvington emissions that are in the existing (2016) modeling platform and the approach for modeling the SundtGS emissions in the 2028 CAMx simulations.

4.1 2016 Sundt/Irvington Emissions Removed from 2016 Beta Emissions Platform

The EPA 2016 beta platform had emissions for the SundtGS (labeled Irvington) for four units as shown in Table 4-1. Unit 1 is a coal-fired dry bottom boiler with annual NOx emissions of 512.5 tons per year (TPY). Units 2, 3 and 4 are tangentially-fired natural gas (NG) boilers with annual NOx emissions of 45.7, 29.3 and 184.8 TPY. (These correspond to Units I4, I2, I1, and I3, respectively, using TEP's numbering for the generating units at SundtGS. Unit I4 was converted to natural gas; there is no coal firing at the facility). For this visibility modeling analysis, emissions from these 4 units were removed from the EPA 2016beta platform and replaced by the 2028 emission scenarios for the SundtGS as discussed in Section 4.2 below. All other emissions in the EPA 2016 beta platform remained the same for the 2028 CAMx modeling.

Table 4-1. SundtGS Emissions in the EPA 2016 beta modeling platform.

2016beta													
Sum of ann_v							poll						
facility_nai	facility_ic	agy_unit_id	unit_id	scc	oris_boiler_ic	oris_facility_code	CO	NH3	NOX	PM10-PRI	PM25-I	SO2	VOC
Irvington	977911	1	48108713	10100202	4	126	82.672	0.000	512.498	110.774	98.136	16.357	9.903
		2	48108813	10100604	2	126	7.581	1.012	45.740	0.169	0.140	1.139	1.741
		3	48108913	10100604	1	126	4.048	0.540	29.268	0.090	0.075	0.608	0.930
		4	48109013	10100604	3	126	23.568	3.146	184.821	0.526	0.435	3.540	5.412
Grand Total							117.870	4.698	772.327	111.560	98.785	21.644	17.985

4.2 2028 SundtGS/Irvington Emissions

Table 4-2 lists the 2028 emissions projections for the (Irvington) SundtGS that TEP provided to ADEQ. Boiler Units 1 – 4 correspond to the four units from the EPA 2016 beta platform. Units 1 and 2 have been permanently shut down and will have zero emissions in 2028. The Unit 3 boiler (i.e. the subject of this visibility modeling analysis), has projected 2028 NOx emissions of 251.1 TPY, these emissions are used as the SundtGS 2028 base case emissions scenario. The Unit 4 boiler has projected 2028 NOx emissions of 510.8 TPY. The cooling towers have no NOx emissions and the two turbines have NOx emissions of 8.8 and 9.5 TPY. The Sundt NG Reciprocating Internal Combustion Engines (RICE) have combined NOx emissions for Units 1-10 of 170.0 TPY.

Table 4-2. SundtGS 2028 Emissions (tons per year).

EMIS_UNIT_DESCRIPTION	CO	NOX	SO2	VOC	PM10-PRI	PM10-FIL	PM25-PRI	PM25-FIL
UNIT I1 BOILER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIT I2 BOILER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIT I3 BOILER	0.15	251.13	4.41	6.54	9.03	2.26	9.03	2.26
UNIT I3 COOLING TOWER	0.00	0.00	0.00	0.00	130.63	130.63	130.63	130.63
UNIT I4 BOILER	18.38	510.82	13.37	14.07	20.95	6.36	20.95	6.36
UNIT I4 COOLING TOWER	0.00	0.00	0.00	0.00	260.48	260.48	260.48	260.48
UNIT IGT-1 TURBINE	2.26	8.81	0.09	0.06	0.18	0.05	0.18	0.05
UNIT IGT-2 TURBINE	2.43	9.50	0.10	0.06	0.20	0.06	0.20	0.06
RICE UNITS 1-10	256.86	170.00	14.20	215.41	109.42	0.52	109.42	0.52
Total	**280.09**	**950.26**	**32.18**	**236.14**	**530.88**	**400.36**	**530.88**	**400.36**

4.3 2028 Sundt/Irvington Control Scenario

The control scenario is a NOx reduction of 51.8%, or 130 TPY, to a controlled rate of 121 TPY (2,424,037 MMBtu/yr × 0.1000 lb/MMBtu) for Unit #3. No change to heat input, exhaust characteristics, or any other pollutants and no change to the other Sundt/Irvington units.

4.4 Additional 2028 Emissions Specifications

4.4.1 SundtGS Stack Parameters

Both 2028 SundtGS emissions scenarios use the same stack parameters as in the 2016 base case simulation. Note that some emissions control technologies may alter stack parameters (e.g., wet FGD controls would cool the effluent and change its exit velocity). In this case, for simplicity, the control technology is assumed to have no or minimal effect on stack parameters and on emissions of other pollutants than NOx.

4.4.2 Temporal Profiles for SundtGS emissions

We followed the same temporal profile strategy as for the Springerville visibility modeling (Ramboll, 2020) and used a flat temporal profile (i.e. the annual average emissions for each Unit were distributed equally over each hour of the year) for the 2028 SundtGS CAMx modeling.

4.4.3 Other Emissions

All other emissions sources sectors (e.g., mobile sources) were kept at 2016 emissions levels since 2028 emissions estimates were not available as part of the EPA 2016 beta modeling platform which was used in the Springerville visibility modeling (Ramboll, 2020) that is the basis for the SundtGS visibility assessment. Note that 2028 emissions for all emissions source sectors are now available with the EPA 2016 version 1 platform.

5.0 VISIBILITY MODELING APPROACH

In this section we describe how the SundtGS CAMx visibility modeling was conducted and the post-processing procedures used to evaluate the SundtGS visibility contributions at IMPROVE sites representing Class I Areas (CIAs) for the two emission scenarios.

5.1 Locations of Class I Areas to be Analyzed

EPA's guidance does not specify a distance from a source that CIAs should be included in a modeled visibility evaluation. The uncertainty in the modeling results increases as a function of distance from the source and at longer distances there is the potential that the visibility impacts from a single-source may become close to model "noise" so are not reliable. In the past, a 300-km distance from the source has been used in CIA visibility analysis, however that distance was based on limitations in the CALPUFF model that is not appropriate to apply to CAMx. When WRAP conducted a Q/D analysis[10] to rank sources to assist in the selection of sources for the four-factor analysis, a 400-km distance between a source and CIA was initially used for inclusion in the Q/D analysis. WRAP then realized that the 400-km distance limitation may undesirably screen out larger sources that may have visibility impacts at CIAs further than 400-km away, so they performed additional analyses of the contributions of larger emitting sources to CIAs at distances greater than 400-km downwind.

To balance the goals of: (1) providing a comprehensive visibility analysis, with (2) reducing the potential for unreliable estimates at long distances, we evaluated the contribution of SundtGS emissions to visibility impairment at all Class I areas within 600-km of the facility.

Figure 5-1 displays the location of the SundtGS with a 600-km surrounding radius circle along with the locations of the CIAs and IMPROVE monitoring sites representing CIAs and selected IMPROVE monitoring sites within the 12SW2 modeling domain. There are 52 IMPROVE sites within the 12-km 12SW2 modeling domain but some of those sites are not associate with a CIA (e.g., IMPROVE protocol sites; e.g. PHOE1) and many are further than 600-km from SundtGS. The visibility contributions of the SundtGS emissions scenarios will only be examined at IMPROVE sites that are associated with CIAs and within 600-km of the facilities, that are indicated on the map with pink squares.

Table 5-1 lists the CIAs and associated IMPROVE sites that are within 600 km of SundtGS in the 12SW2 domain. Note that in some cases a CIA is just within 600-km but the IMPROVE monitor is slightly more distant. Also given in Table 5-1 are the IDs and names of the IMPROVE monitors representative of each CIA. We assessed the SundtGS contributions to visibility impairment at 25 CIAs although some of the results will be duplicates since they are based on the same IMPROVE data that represents multiple CIAs.

[10] http://views.cira.colostate.edu/tssv2/Emissions/QDAnalysis.aspx

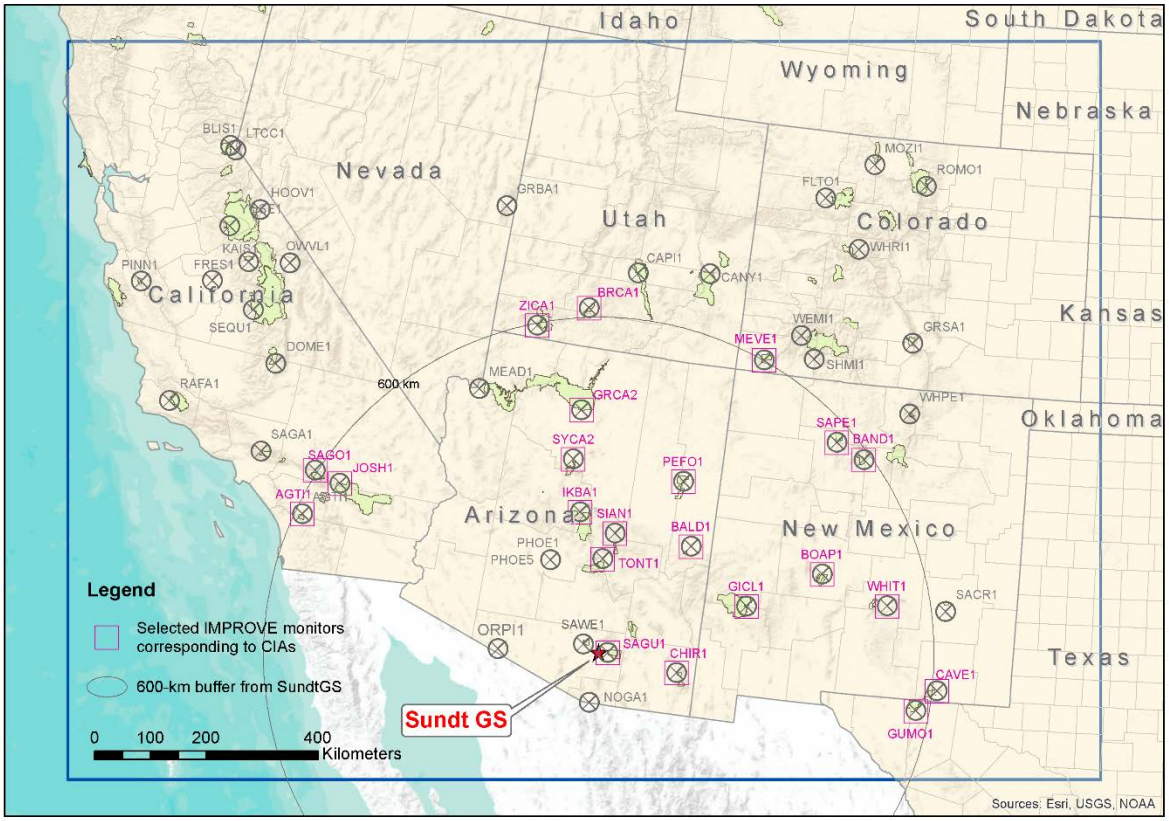

Figure 5-1. Location of the Sundt Generation Station (red star), Class I Areas (green), IMPROVE monitoring sites (grey circles with crosses) and selected IMPROVE monitoring sites (pink squares) that represent CIAs that are within 600-km of the SundtGS.

Table 5-1. CIAs within 600-km of the Sundt Generating Stations and representative IMPROVE monitors, sorted by distance of the IMPROVE site to the Sundt Generating Station.

Class I Areas (CIAs)	State	Representative IMPROVE Monitor ID	IMPROVE Site Name	# of CIAs associated with IMPROVE site	Distance of IMPROVE monitor to Sundt Facility (km)
Saguaro Wilderness	AZ	SAGU1	Saguaro	1	16
Chiricahua NM	AZ	CHIR1	Chiricahua NM	3	144
Chiricahua Wilderness	AZ	CHIR1	Chiricahua NM	3	144
Galiuro Wilderness	AZ	CHIR1	Chiricahua NM	3	144
Tonto National Forest Wilderness (Superstition Wilderness)	AZ	TONT1	Tonto National Forest	1	167
Sierra Ancha Wilderness	AZ	SIAN1	Sierra Ancha	1	215
Mount Baldy Wilderness	AZ	BALD1	Mount Baldy	1	251
Mazatzal Wilderness	AZ	IKBA1	Ike's Backbone	2	253
Pine Mountain Wilderness	AZ	IKBA1	Ike's Backbone	2	253
Gila Wilderness	NM	GICL1	Gila	1	276
Petrified Forest National Park	AZ	PEFO1	Petrified Forest National Park	1	341
Sycamore Canyon Wilderness	AZ	SYCA2	Sycamore Canyon	1	348
Bosque del Apache Wilderness	NM	BOAP1	Bosque del Apache	1	423
Hance (Grand Canyon) NP	AZ	GRCA2	Hance (Grand Canyon)	1	435
White Mountain Wilderness	NM	WHIT1	White Mountain	1	523
Joshua Tree NP	CA	JOSH1	Joshua Tree	1	553
San Pedro Parks Wilderness	NM	SAPE1	San Pedro Parks	1	568
Guadalupe Mountains NP	TX	GUMO1	Guadalupe Mountains	1	577
Agua Tibia Wilderness	CA	AGTI1	Agua Tibia	1	585
Bandelier NM	NM	BAND1	Bandelier	1	586
Zion Canyon NP	UT	ZICA1	Zion Canyon	1	595
Mesa Verde NP	CO	MEVE1	Mesa Verde	1	601
San Gorgonio Wilderness	CA	SAGO1	San Gorgonio	2	603
San Jacinto Wilderness	CA	SAGO1	San Gorgonio	2	603
Carlsbad Caverns NP	NM	CAVE1	Carlsbad Caverns	1	609

5.2 CAMx Visibility Modeling Approach

The 2028 future year CAMx modeling used the same modeling platform as the 2016 CAMx base case modeling except for emissions inputs for the SundtGS. Two CAMx simulations were performed corresponding to the two SundtGS 2028 emission scenarios described in Chapter 4. All other inputs besides SundtGS emissions (e.g. meteorological inputs) were identical to the CAMx 2016 base case simulation. All emissions besides SundtGS emissions (e.g., mobile sources) were kept at 2016 emissions levels for the reasons stated previously. The 2028 CAMx simulations were initiated using 5-days of spin-up before January 1.

5.2.1 Source Apportionment Strategy for the SundtGS

We conducted the CAMx SundtGS source apportionment modeling by tagging emissions from three Source Groups as follows:

1. SundtGS Unit #3 (Varied for the two 2028 CAMx simulations)
2. SundtGS all other Units (i.e. Unit 4 tangentially-fired NG + NG Turbines, NG RICE + Cooling towers; Same for both 2028 CAMx simulations)
3. All non-SundtGS emissions sources (Same for both 2028 CAMx simulations)

This tagging strategy enables us to obtain the contributions to visibility impairment from the SundtGS Unit #3 scenarios and from the entire SundtGS facility. Since only Unit #3 had varying emissions we restricted the final visibility analysis to Unit #3 contributions in this preliminary analysis and did not analyze the SundtGS impacts from the other Units.

5.2.2 Tracking SundtGS Contributions with CAMx PSAT

The CAMx Particulate Source Apportionment Technology (PSAT) was used to track Particulate Matter (PM) contributions due to emissions from the SundtGS. PSAT uses reactive tracers (tagged species) that operate in parallel to the host model to track PM contributions due to emissions from user selected source groups. Emissions from each defined source group were separately tagged for tracking by PSAT including the all non-SundtGS emissions since PSAT needs to keep track of all sources. The PSAT sulfate (SO_4), nitrate/ammonium (NO_3/NH_4) and primary Particulate Matter (PM) families of tracers were used in the simulation. The PSAT SO_4 family consists of two tracers (SO_2 and SO_4) for each Source Group to track the contributions of the source group emissions to particle SO_4. The PSAT NO_3/NH_4 family of tracers consists of 8 separate tracers for each Source Group that includes 6 reactive nitrogen species that tracks the formation of particle NO_3 from NO and NO_2 emissions with many intermediate products including accounting for the re-nitrification of NOx from nitric acid and PAN. The other two NO_3/NH_4 tracers are NH_3 and NH_4 reduced nitrogen species. The PSAT primary PM family of tracers includes elemental carbon (EC), primary organic carbon (POA), fine and coarse crustal species and fine and coarse other PM species. More details on the formulation of PSAT can be found in the CAMx User's Guide (Ramboll, 2018[11]).

[11] http://www.camx.com/files/camxusersguide_v6-50.pdf

5.2.3 Mapping of CAMx PSAT Species to the IMPROVE Equation Species

The CAMx PSAT source apportionment runs provide incremental concentration contributions due to SundtGS emissions for the following species that will be used in the revised IMPROVE visibility equation discussed below:

- Sulfate (SO_4) [multiplied by 1.375 to make AmmSO4]
- Nitrate (NO_3) [multiplied by 1.29 to make AmmNO3]
- Elemental Carbon (EC)
- Primary Organic Aerosol (POA, used for Organic Mass)
- Fine Crustal (FCRS) and Other (FPRM) primary $PM_{2.5}$ emissions (used for Soil).
- Coarse Crustal (CCRS) and Other (CPRM) coarse ($PM_{2.5-10}$) PM species (used for CM or PMC)
- Nitrogen Dioxide (NO_2)

5.3 SundtGS Visibility Post-Processing Approach

EPA's modeling guidance for making regional haze projections (EPA, 2018b)[12] recommends using modeling results in a relative fashion to scale the observed visibility on the 20% most impaired days (MID) to project 2028 future year 20% MID visibility levels. Similarly, projections are also made for the 20% cleanest days. EPA provides the Software for the Modeled Attainment Test (SMAT[13]) tool to make future year 20% MID visibility projections using base year and future year modeling results and observed visibility conditions.

5.3.1 SMAT Tool

SMAT extracts model concentrations from the grid cells at IMPROVE sites or CIAs for the base and future year and calculates the ratio of future over base year concentrations for each pollutant for a set of days (i.e. MID and 20% cleanest days) that are defined based on observational data at that IMPROVE site. These model-derived ratio values are referred to as relative response factors (RRFs) and are site-specific and species-specific. Model-derived RRFs are used to scale observed base year concentrations, and future year visibility is then calculated (based on the scaled base year concentrations) using the "revised" or "second" IMPROVE light extinction equation. The results are reported in terms of light extinction (in Mm^{-1}) as well as Haze Index (deciviews).

[12] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf
[13] https://www.epa.gov/scram/photochemical-modeling-tools

5.3.2 Revised IMPROVE Light Extinction Equation

The "revised" (or Second) IMPROVE equation (Pitchford et al, 2007) replaced the original IMPROVE equation since it reduced the bias for high and low light extinction extremes. It has been in use for at least the last 10 years. The revised IMPROVE light extinction equation converts PM species in μgm^{-3} to light extinction (b_{ext}) in inverse megameters (Mm^{-1}) as follows:

$$b_{ext} = b_{SO4} + b_{NO3} + b_{EC} + b_{OCM} + b_{Soil} + b_{PMC} + b_{SeaSalt} + b_{Rayleigh} + b_{NO2}$$

where

b_{SO4} = $2.2 \times f_S(RH) \times$ [Small Sulfate] + $4.8 \times f_L(RH) \times$ [Large Sulfate]

b_{NO3} = $2.4 \times f_S(RH) \times$ [Small Nitrate] + $5.1 \times f_L(RH) \times$ [Large Nitrate]

b_{OCM} = $2.8 \times$ [Small Organic Mass] + $6.1 \times$ [Large Organic Mass]

b_{EC} = $10 \times$ [Elemental Carbon]

b_{Soil} = $1 \times$ [Fine Soil]

b_{PMC} = $0.6 \times$ [Coarse Mass]

$b_{SeaSalt}$ = $1.7 \times f_{SS}(RH) \times$ [Sea Salt]

$b_{Rayleigh}$ = Rayleigh Scattering (Site-specific)

b_{NO2} = $0.33 \times$ [NO_2 (ppb)] {or as: $0.1755 \times$ [NO_2 ($\mu g/m^3$)]}.

f(RH) are relative humidity adjustment factors that account for the fact that sulfate, nitrate, organic aerosols and sea salt aerosols are hygroscopic and are more effective at scattering radiation at a higher relative humidity. Class I area-specific "climatological" monthly average f(RH) values are used.

Sulfate and nitrate in the IMPROVE extinction equation above are assumed to be completely neutralized by ammonium, so the CAMx SO_4 and NO_3 concentrations are multiplied by 1.375 and 1.29, respectively, to account for the presence of ammonium. Thus, the CAMx PSAT NH_4 concentrations are not directly used in the IMPROVE extinction equation, but ammonia/ammonium in the model simulation does affect how much nitrate is in the form of particle NO_3 versus gaseous nitric acid.

The revised IMPROVE equation treats "large sulfate" and "small sulfate" separately because large and small aerosols affect an incoming beam of light differently. However, the IMPROVE measurements do not separately measure large and small sulfate; they measure only the total $PM_{2.5}$ sulfate. Similarly, CAMx writes out a single concentration of particulate sulfate for each grid cell. Part of the definition of the revised IMPROVE equation is a procedure for calculating the large and small sulfate contributions based on the magnitude of the model output sulfate concentrations; the procedure is documented in FLAG (2010) and Pitchford et al, (2007) and is an empirically derived formula. The sulfate concentration magnitude is used as a surrogate for distinguishing between large and small sulfate concentrations. For a given grid cell, the large and small sulfate contributions are calculated from the model output sulfate (which is the "Total Sulfate" referred to in the FLAG (2010) guidance) as:

For Total Sulfate < 20 $\mu g/m^3$:

[Large Sulfate] = ([Total Sulfate] / 20 $\mu g/m^3$) × [Total Sulfate]

For Total Sulfate ≥ 20 μg/m^3:

[Large Sulfate] = [Total Sulfate]

For all values of Total Sulfate:

[Small Sulfate] = [Total Sulfate] – [Large Sulfate]

The procedure is identical for nitrate and organic mass. The split between Large and Small Sulfate is based on the Total Sulfate concentrations from the model. We assume that the incremental Sulfate concentrations due to just emissions from SundtGS have the same split between Large and Small Sulfate concentrations as the modeled Total Sulfate concentration.

5.3.3 Deciview Haze Index

Another key visibility evaluation metric used in regional haze analysis is the Haze Index which is measured in deciview (dv) units and is defined as follows:

$$HI = 10 \times \ln[b_{ext}/10]$$

b_{ext} is the atmospheric light extinction reported in inverse megameters (Mm^{-1}) that was described in the previous section. The SMAT tool reports future year visibility projections using both light extinction (Mm^{-1}) and Haze Index (dv).

5.3.4 Calculating the SundtGS "Single-Source" Contributions using SMAT

To estimate incremental visibility contribution from SundtGS emissions using the SMAT tool, we performed multiple SMAT runs and used the following procedure:

1. Used SMAT to project the 2014-2018[14] IMPROVE observed visibility for the 20% Best and 20% MID to 2028 visibility conditions for each SundtGS emissions case (i.e. 2028 base and the 2028 control case)

2. Used SMAT to project the 2014-2018 IMPROVE observed visibility for the 20% Best and 20% MID to 2028 visibility conditions in the absence of SundtGS emissions for each case (i.e. 2028 base and the 2028 control case) by subtracting the PSAT-estimated SundtGS concentrations for each particulate matter (PM) component from total modeled concentrations

3. Calculated the difference between the SMAT-estimated visibility conditions with and without the PSAT-estimated concentrations to obtain SundtGS visibility contributions on the 20% Best and 20% MID

In each case, the SMAT base year input file was the same 2016 base year CAMx simulation. A sample SMAT control file is presented in Appendix B.

As previously noted, EPA's new regional haze guidance recommends evaluating single-source visibility impacts using extinction (Mm^{-1}) and not deciview (dv). However, we report visibility impacts in both metrics so that the SundtGS visibility cost-effectiveness may be evaluated using deciview (i.e., $/Δdv) facilitating comparisons with results from the first round of regional haze SIPs.

[14] We used 2014-2018 results for all sites, except for SIAN which has missing data for 2016-2018. For SIAN we used 2013-2017 and a relaxed requirement of only 1 year of valid data required.

6.0 SUNDTGS VISIBILITY RESULTS

This section presents results of the CAMx visibility impact modeling for the SundtGS. Results of SundtGS CAMx visibility modeling are reported in terms of Haze Index (i.e. deciview units) in Table 6-1 through Table 6-4. An analogous set of tables are reported in terms of light extinction (Mm^{-1}) in Table 6-5 through Table 6-8. The first two tables in each section report the output of SMAT for best 20% days and 20 % MID, respectively, and include 2016 base year visibility and 2028 future year visibility for four SMAT runs (i.e. with and without Sundt emission contributions for 2028 base emissions and for 2028 control emissions). Table 6-3 and Table 6-7 present the Sundt emissions contributions to visibility impairment for the 2028 base emissions scenario and the 2028 control emissions scenario for the best 20% days and the 20% MID in terms of Haze Index and light extinction, respectively. Table 6-4 and Table 6-8 present the relative difference in visibility contributions for the two emissions scenarios, as well as the relative contribution of the 2028 base case emissions scenario to total visibility impairment, in terms of Haze Index and light extinction, respectively.

6.1 SundtGS Visibility Impacts in Deciview Units

Table 6-1 and Table 6-2 show that SMAT-projected 2028 future year visibility is generally very similar to 2016 base year visibility. This is primarily because the 2028 CAMx modeling used 2028 emissions for the Sundt facility and 2016 emissions for other emissions sources. Therefore, away from the Sundt source we expect the visibility to be very similar for base and future years.

Table 6-3 shows that the Sundt Unit #3 emissions contributions to visibility impairment generally decreases with distance from the source, the maximum 2028 base contribution is 0.00317 dv at Saguaro Wilderness averaged over the 20% MID, and the maximum 2028 control case contribution is 0.00220 dv at Saguaro Wilderness averaged over the 20% MID. A graphical representation of the results in Table 6-3 is presented in Section 6.3.

Table 6-4 reports the differences between the control scenario and the base scenario, which is calculated as (Control – Base)/Base. The largest improvement in visibility on the Best 20% days occurred in Petrified NF where the control scenario emissions contribution to visibility impairment is 42.4% lower than the base scenario's contribution. Averaged over all the sites analyzed, the reductions in NOx emissions for the control scenario (i.e. 51.8 % reduction in NOx for Unit #3) results in a 31.8% smaller contribution to visibility impairment due to Sundt Unit #3.

For additional context, we calculate the relative contribution of the 2028 base emissions to total visibility impairment in the right two columns of Table 6-4, which shows the largest contribution closest to the Sundt facility at Saguaro Wilderness and on the 20% Best days Sundt Unit #3 contributes 0.0372% to the total visibility impairment in terms of Haze Index.

Table 6-1. SMAT visibility results in deciview units for Best 20% Days.

Haze Index - Deciviews Analysis							
			Best 20% Days				
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	SMAT Base Year: 2016 (dv)	SMAT Future Year: 2028 With Sundt Unit #3 Base Emissions (dv)	SMAT Future Year: 2028 Without Sundt Unit #3 Base Emissions (dv)	SMAT Future Year: 2028 With Sundt Unit #3 Alternative Emissions (dv)	SMAT Future Year: 2028 Without Sundt Unit #3 Alternative Emissions (dv)
Saguaro Wild.	SAGU1	16	6.0864	6.1709	6.1686	6.1703	6.1688
Chiricahua NM	CHIR1	144	3.9537	3.9585	3.9581	3.9583	3.9581
Chiricahua Wild.	CHIR1	144	3.9537	3.9585	3.9581	3.9583	3.9581
Galiuro Wild.	CHIR1	144	3.9537	3.9585	3.9581	3.9583	3.9581
Superstition Wild.	TONT1	167	5.0319	5.0302	5.0301	5.0301	5.0301
Sierra Ancha Wild.	SIAN1	215	4.2925	4.2942	4.2941	4.2941	4.2940
Mount Baldy Wild.	BALD1	251	1.7773	1.7686	1.7685	1.7685	1.7685
Mazatzal Wild.	IKBA1	253	4.1636	4.1625	4.1624	4.1624	4.1624
Pine Mountain Wild.	IKBA1	253	4.1636	4.1625	4.1624	4.1624	4.1624
Gila Wild.	GICL1	276	2.0700	2.0706	2.0705	2.0705	2.0705
Petrified Forest NP	PEFO1	341	3.2467	3.2445	3.2445	3.2445	3.2445
Sycamore Canyon Wild.	SYCA2	348	4.1832	4.1828	4.1828	4.1828	4.1828
Bosque del Apache Wild.	BOAP1	423	4.5900	4.5875	4.5875	4.5875	4.5875
Grand Canyon NP	GRCA2	435	1.5185	1.5184	1.5184	1.5184	1.5184
White Mountain Wild.	WHIT1	523	2.5396	2.5386	2.5385	2.5386	2.5385
Joshua Tree NP	JOSH1	553	4.6902	4.6888	4.6887	4.6888	4.6888
San Pedro Parks Wild.	SAPE1	568	0.3707	0.3701	0.3701	0.3702	0.3702
Guadalupe Mountains NP	GUMO1	577	4.7293	4.7298	4.7298	4.7298	4.7298
Agua Tibia Wild.	AGTI1	585	7.0986	7.0987	7.0987	7.0988	7.0988
Bandelier NM	BAND1	586	3.0174	3.0192	3.0192	3.0192	3.0192
Zion Canyon NP	ZICA1	595	3.8631	3.8631	3.8631	3.8631	3.8631
Mesa Verde NP	MEVE1	601	2.2792	2.2799	2.2799	2.2799	2.2799
San Gorgonio Wild.	SAGO1	603	3.3256	3.3251	3.3251	3.3251	3.3251
San Jacinto Wild.	SAGO1	603	3.3256	3.3251	3.3251	3.3251	3.3251
Carlsbad Caverns NP	CAVE1	609	4.7293	4.7298	4.7298	4.7298	4.7298

Table 6-2. SMAT visibility results in deciview units for 20% MID.

Haze Index - Deciviews Analysis							
			20% MID				
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	SMAT Base Year: 2016 (dv)	SMAT Future Year: 2028 With Sundt Unit #3 Base Emissions (dv)	SMAT Future Year: 2028 Without Sundt Unit #3 Base Emissions (dv)	SMAT Future Year: 2028 With Sundt Unit #3 Alternative Emissions (dv)	SMAT Future Year: 2028 Without Sundt Unit #3 Alternative Emissions (dv)
Saguaro Wild.	SAGU1	16	10.7539	10.9050	10.9018	10.9043	10.9021
Chiricahua NM	CHIR1	144	9.4090	9.4186	9.4183	9.4185	9.4182
Chiricahua Wild.	CHIR1	144	9.4090	9.4186	9.4183	9.4185	9.4182
Galiuro Wild.	CHIR1	144	9.4090	9.4186	9.4183	9.4185	9.4182
Superstition Wild.	TONT1	167	10.4505	10.4541	10.4538	10.4539	10.4538
Sierra Ancha Wild.	SIAN1	215	9.3670	9.3677	9.3676	9.3677	9.3676
Mount Baldy Wild.	BALD1	251	7.2929	7.2934	7.2932	7.2933	7.2932
Mazatzal Wild.	IKBA1	253	9.4718	9.4728	9.4725	9.4726	9.4725
Pine Mountain Wild.	IKBA1	253	9.4718	9.4728	9.4725	9.4726	9.4725
Gila Wild.	GICL1	276	7.5756	7.5775	7.5774	7.5775	7.5774
Petrified Forest NP	PEFO1	341	8.1609	8.1498	8.1497	8.1498	8.1497
Sycamore Canyon Wild.	SYCA2	348	11.6267	11.6273	11.6273	11.6273	11.6273
Bosque del Apache Wild.	BOAP1	423	10.4692	10.4604	10.4604	10.4604	10.4604
Grand Canyon NP	GRCA2	435	6.8718	6.8710	6.8710	6.8710	6.8710
White Mountain Wild.	WHIT1	523	9.9515	9.9467	9.9466	9.9466	9.9466
Joshua Tree NP	JOSH1	553	12.8745	12.8747	12.8746	12.8746	12.8746
San Pedro Parks Wild.	SAPE1	568	6.4320	6.4357	6.4357	6.4357	6.4357
Guadalupe Mountains NP	GUMO1	577	12.6432	12.6435	12.6435	12.6435	12.6435
Agua Tibia Wild.	AGTI1	585	16.3443	16.3443	16.3443	16.3443	16.3443
Bandelier NM	BAND1	586	8.4439	8.4454	8.4453	8.4454	8.4453
Zion Canyon NP	ZICA1	595	8.7588	8.7581	8.7581	8.7581	8.7581
Mesa Verde NP	MEVE1	601	6.5087	6.5115	6.5115	6.5115	6.5115
San Gorgonio Wild.	SAGO1	603	14.4499	14.4499	14.4499	14.4499	14.4499
San Jacinto Wild.	SAGO1	603	14.4499	14.4499	14.4499	14.4499	14.4499
Carlsbad Caverns NP	CAVE1	609	12.6432	12.6435	12.6435	12.6435	12.6435

Table 6-3. SundtGS visibility contributions for 2028 base and 2028 alternative scenarios in deciviews.

Haze Index - Deciviews Analysis						
			Best 20% Days		20% MID	
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	Sundt #3 Contribution: 2028 Base Emissions (dv)	Sundt #3 Contribution: 2028 Alt Emissions (dv))	Sundt #3 Contribution: 2028 Base Emissions (dv)	Sundt #3 Contribution: 2028 Alt Emissions (dv)
Saguaro Wild.	SAGU1	16	0.00229	0.00155	0.00317	0.00220
Chiricahua NM	CHIR1	144	0.00039	0.00025	0.00024	0.00020
Chiricahua Wild.	CHIR1	144	0.00039	0.00025	0.00024	0.00020
Galiuro Wild.	CHIR1	144	0.00039	0.00025	0.00024	0.00020
Superstition Wild.	TONT1	167	0.00009	0.00006	0.00032	0.00019
Sierra Ancha Wild.	SIAN1	215	0.00011	0.00007	0.00008	0.00006
Mount Baldy Wild.	BALD1	251	0.00004	0.00002	0.00015	0.00011
Mazatzal Wild.	IKBA1	253	0.00005	0.00003	0.00025	0.00014
Pine Mountain Wild.	IKBA1	253	0.00005	0.00003	0.00025	0.00014
Gila Wild.	GICL1	276	0.00006	0.00004	0.00007	0.00006
Petrified Forest NP	PEFO1	341	0.00006	0.00003	0.00007	0.00005
Sycamore Canyon Wild.	SYCA2	348	0.00003	0.00002	0.00005	0.00003
Bosque del Apache Wild.	BOAP1	423	0.00005	0.00004	0.00003	0.00002
Grand Canyon NP	GRCA2	435	0.00000	0.00000	0.00006	0.00004
White Mountain Wild.	WHIT1	523	0.00003	0.00002	0.00004	0.00003
Joshua Tree NP	JOSH1	553	0.00000	0.00000	0.00006	0.00003
San Pedro Parks Wild.	SAPE1	568	0.00001	0.00000	0.00006	0.00004
Guadalupe Mountains NP	GUMO1	577	0.00003	0.00002	0.00001	0.00001
Agua Tibia Wild.	AGTI1	585	0.00000	0.00000	0.00000	0.00000
Bandelier NM	BAND1	586	0.00001	0.00001	0.00003	0.00002
Zion Canyon NP	ZICA1	595	0.00000	0.00000	0.00002	0.00001
Mesa Verde NP	MEVE1	601	0.00000	0.00000	0.00003	0.00002
San Gorgonio Wild.	SAGO1	603	0.00000	0.00000	0.00000	0.00000
San Jacinto Wild.	SAGO1	603	0.00000	0.00000	0.00000	0.00000

Table 6-4. SundtGS visibility companions. 2028 alternative compared to 2028 base. 2028 based compare to total Haze Index.

Haze Index - Deciviews Analysis						
			Relative Difference between Base and Alternative Contribution to Haze Index		2028 Sundt Base Emissions Contribution to total Haze Index	
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	20% Best Days	20% MID	2028 Sundt Base Emissions Contribution to total Haze Index on Best 20% Days	2020 Sundt Base Emissions Contribution to total Haze Index on the 20% MID
Saguaro Wild.	SAGU1	16	-32.3%	-30.6%	0.0372%	0.0291%
Chiricahua NM	CHIR1	144	-36.5%	-14.9%	0.0098%	0.0025%
Chiricahua Wild.	CHIR1	144	-36.5%	-14.9%	0.0098%	0.0025%
Galiuro Wild.	CHIR1	144	-36.5%	-14.9%	0.0098%	0.0025%
Superstition Wild.	TONT1	167	-32.8%	-38.8%	0.0019%	0.0030%
Sierra Ancha Wild.	SIAN1	215	-41.0%	-23.0%	0.0026%	0.0009%
Mount Baldy Wild.	BALD1	251	-38.4%	-26.8%	0.0021%	0.0020%
Mazatzal Wild.	IKBA1	253	-38.1%	-42.2%	0.0011%	0.0026%
Pine Mountain Wild.	IKBA1	253	-38.1%	-42.2%	0.0011%	0.0026%
Gila Wild.	GICL1	276	-41.6%	-14.1%	0.0030%	0.0009%
Petrified Forest NP	PEFO1	341	-42.4%	-29.0%	0.0018%	0.0008%
Sycamore Canyon Wild.	SYCA2	348	-35.1%	-30.9%	0.0008%	0.0004%
Bosque del Apache Wild.	BOAP1	423	-34.2%	-27.1%	0.0012%	0.0003%
Grand Canyon NP	GRCA2	435	-31.0%	-36.7%	0.0003%	0.0009%
White Mountain Wild.	WHIT1	523	-39.6%	-27.1%	0.0011%	0.0004%
Joshua Tree NP	JOSH1	553	-21.9%	-48.7%	0.0001%	0.0005%
San Pedro Parks Wild.	SAPE1	568	-34.7%	-28.8%	0.0019%	0.0010%
Guadalupe Mountains NP	GUMO1	577	-31.2%	-17.5%	0.0006%	0.0001%
Agua Tibia Wild.	AGTI1	585	-8.7%	-28.6%	0.0000%	0.0000%
Bandelier NM	BAND1	586	-34.4%	-26.3%	0.0003%	0.0004%
Zion Canyon NP	ZICA1	595	-7.1%	-30.5%	0.0001%	0.0002%
Mesa Verde NP	MEVE1	601	-23.8%	-27.9%	0.0001%	0.0004%
San Gorgonio Wild.	SAGO1	603	-23.5%	-41.7%	0.0001%	0.0000%
San Jacinto Wild.	SAGO1	603	-23.5%	-41.7%	0.0001%	0.0000%

6.2 SundtGS Visibility Impacts in Light Extinction

This section provides the SMAT results in terms of light extinction and is an analogous set of tables as in the previous section and the findings are similar. Discussions of the results is provided in Section 6.3.

Table 6-5. SMAT visibility extinction results for Best 20% Days.

Extinction Analysis (Mm^{-1})							
			Best 20% Days				
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	SMAT Base Year: 2016 (Mm^{-1})	SMAT Future Year: 2028 With Sundt Unit #3 Base Emissions (Mm^{-1})	SMAT Future Year: 2028 Without Sundt Unit #3 Base Emissions (Mm^{-1})	SMAT Future Year: 2028 With Sundt Unit #3 Alternative Emissions (Mm^{-1})	SMAT Future Year: 2028 Without Sundt Unit #3 Alternative Emissions (Mm^{-1})
Saguaro Wild.	SAGU1	16	18.4536	18.6120	18.6077	18.6109	18.6080
Chiricahua NM	CHIR1	144	14.9001	14.9074	14.9068	14.9072	14.9068
Chiricahua Wild.	CHIR1	144	14.9001	14.9074	14.9068	14.9072	14.9068
Galiuro Wild.	CHIR1	144	14.9001	14.9074	14.9068	14.9072	14.9068
Superstition Wild.	TONT1	167	16.6331	16.6303	16.6302	16.6302	16.6301
Sierra Ancha Wild.	SIAN1	215	15.4207	15.4233	15.4231	15.4232	15.4231
Mount Baldy Wild.	BALD1	251	11.9833	11.9726	11.9726	11.9726	11.9726
Mazatzal Wild.	IKBA1	253	15.2231	15.2213	15.2213	15.2213	15.2213
Pine Mountain Wild.	IKBA1	253	15.2231	15.2213	15.2213	15.2213	15.2213
Gila Wild.	GICL1	276	12.3375	12.3382	12.3382	12.3382	12.3382
Petrified Forest NP	PEFO1	341	13.8874	13.8844	13.8843	13.8843	13.8843
Sycamore Canyon Wild.	SYCA2	348	15.3021	15.3016	15.3016	15.3016	15.3016
Bosque del Apache Wild.	BOAP1	423	15.8924	15.8885	15.8884	15.8884	15.8884
Grand Canyon NP	GRCA2	435	11.6759	11.6758	11.6758	11.6758	11.6758
White Mountain Wild.	WHIT1	523	12.9362	12.9348	12.9348	12.9348	12.9348
Joshua Tree NP	JOSH1	553	16.0925	16.0901	16.0901	16.0901	16.0901
San Pedro Parks Wild.	SAPE1	568	10.4014	10.4009	10.4009	10.4010	10.4009
Guadalupe Mountains NP	GUMO1	577	16.2303	16.2312	16.2311	16.2312	16.2311
Agua Tibia Wild.	AGTI1	585	20.5366	20.5368	20.5368	20.5369	20.5368
Bandelier NM	BAND1	586	13.5642	13.5666	13.5666	13.5666	13.5666
Zion Canyon NP	ZICA1	595	14.7691	14.7692	14.7692	14.7692	14.7692
Mesa Verde NP	MEVE1	601	12.5853	12.5863	12.5863	12.5863	12.5863
San Gorgonio Wild.	SAGO1	603	14.0147	14.0139	14.0139	14.0139	14.0139
San Jacinto Wild.	SAGO1	603	14.0147	14.0139	14.0139	14.0139	14.0139
Carlsbad Caverns NP	CAVE1	609	16.2303	16.2312	16.2311	16.2312	16.2311

Table 6-6. SMAT visibility extinction results for 20% MID.

Extinction Analysis (Mm^{-1})							
			20% MID				
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	SMAT Base Year: 2016 (Mm^{-1})	SMAT Future Year: 2028 With Sundt Unit #3 Base Emissions (Mm^{-1})	SMAT Future Year: 2028 Without Sundt Unit #3 Base Emissions (Mm^{-1})	SMAT Future Year: 2028 With Sundt Unit #3 Alternative Emissions (Mm^{-1})	SMAT Future Year: 2028 Without Sundt Unit #3 Alternative Emissions (Mm^{-1})
Saguaro Wild.	SAGU1	16	29.7232	30.1832	30.1733	30.1809	30.1741
Chiricahua NM	CHIR1	144	25.8521	25.8773	25.8767	25.8770	25.8765
Chiricahua Wild.	CHIR1	144	25.8521	25.8773	25.8767	25.8770	25.8765
Galiuro Wild.	CHIR1	144	25.8521	25.8773	25.8767	25.8770	25.8765
Superstition Wild.	TONT1	167	28.7379	28.7486	28.7477	28.7480	28.7474
Sierra Ancha Wild.	SIAN1	215	25.6801	25.6820	25.6817	25.6819	25.6817
Mount Baldy Wild.	BALD1	251	21.0761	21.0772	21.0769	21.0771	21.0768
Mazatzal Wild.	IKBA1	253	26.1624	26.1655	26.1647	26.1651	26.1647
Pine Mountain Wild.	IKBA1	253	26.1624	26.1655	26.1647	26.1651	26.1647
Gila Wild.	GICL1	276	21.5517	21.5559	21.5558	21.5558	21.5557
Petrified Forest NP	PEFO1	341	22.8517	22.8260	22.8258	22.8259	22.8258
Sycamore Canyon Wild.	SYCA2	348	32.3825	32.3846	32.3844	32.3844	32.3843
Bosque del Apache Wild.	BOAP1	423	28.9783	28.9534	28.9533	28.9533	28.9533
Grand Canyon NP	GRCA2	435	20.0738	20.0720	20.0719	20.0720	20.0719
White Mountain Wild.	WHIT1	523	27.8126	27.7989	27.7988	27.7988	27.7987
Joshua Tree NP	JOSH1	553	36.8059	36.8066	36.8064	36.8064	36.8063
San Pedro Parks Wild.	SAPE1	568	19.5691	19.5767	19.5765	19.5766	19.5765
Guadalupe Mountains NP	GUMO1	577	36.1521	36.1531	36.1531	36.1531	36.1530
Agua Tibia Wild.	AGTI1	585	51.9952	51.9951	51.9951	51.9951	51.9951
Bandelier NM	BAND1	586	23.7864	23.7901	23.7900	23.7900	23.7900
Zion Canyon NP	ZICA1	595	24.1896	24.1880	24.1880	24.1881	24.1880
Mesa Verde NP	MEVE1	601	19.4085	19.4142	19.4141	19.4141	19.4141
San Gorgonio Wild.	SAGO1	603	43.3554	43.3553	43.3553	43.3553	43.3552
San Jacinto Wild.	SAGO1	603	43.3554	43.3553	43.3553	43.3553	43.3552
Carlsbad Caverns NP	CAVE1	609	36.1521	36.1531	36.1531	36.1531	36.1530

Table 6-7. SundtGS SMAT visibility extinction results for 20% MID.

Extinction Analysis (Mm^{-1})						
			Best 20% Days		20% MID	
Class I Areas (CIAs)	**IMPROVE Monitor ID**	**Distance of IMPROVE monitor to Sundt Facility (km)**	**Sundt #3 Contribution: 2028 Base Emissions (Mm^{-1})**	**Sundt #3 Contribution: 2028 Alt Emissions (Mm^{-1})**	**Sundt #3 Contribution: 2028 Base Emissions(Mm^{-1})**	**Sundt #3 Contribution: 2028 Alt Emissions (Mm^{-1})**
Saguaro Wild.	SAGU1	16	0.00428	0.00290	0.00995	0.00685
Chiricahua NM	CHIR1	144	0.00059	0.00037	0.00062	0.00053
Chiricahua Wild.	CHIR1	144	0.00059	0.00037	0.00062	0.00053
Galiuro Wild.	CHIR1	144	0.00059	0.00037	0.00062	0.00053
Superstition Wild.	TONT1	167	0.00016	0.00011	0.00094	0.00057
Sierra Ancha Wild.	SIAN1	215	0.00017	0.00010	0.00022	0.00017
Mount Baldy Wild.	BALD1	251	0.00005	0.00003	0.00031	0.00023
Mazatzal Wild.	IKBA1	253	0.00007	0.00004	0.00072	0.00041
Pine Mountain Wild.	IKBA1	253	0.00007	0.00004	0.00072	0.00041
Gila Wild.	GICL1	276	0.00008	0.00005	0.00015	0.00013
Petrified Forest NP	PEFO1	341	0.00008	0.00005	0.00016	0.00011
Sycamore Canyon Wild.	SYCA2	348	0.00005	0.00003	0.00015	0.00011
Bosque del Apache Wild.	BOAP1	423	0.00009	0.00006	0.00009	0.00006
Grand Canyon NP	GRCA2	435	0.00001	0.00000	0.00012	0.00008
White Mountain Wild.	WHIT1	523	0.00004	0.00002	0.00011	0.00008
Joshua Tree NP	JOSH1	553	0.00001	0.00000	0.00022	0.00011
San Pedro Parks Wild.	SAPE1	568	0.00001	0.00000	0.00013	0.00009
Guadalupe Mountains NP	GUMO1	577	0.00005	0.00003	0.00005	0.00004
Agua Tibia Wild.	AGTI1	585	0.00000	0.00000	0.00001	0.00001
Bandelier NM	BAND1	586	0.00001	0.00001	0.00008	0.00006
Zion Canyon NP	ZICA1	595	0.00000	0.00000	0.00005	0.00003
Mesa Verde NP	MEVE1	601	0.00000	0.00000	0.00006	0.00004
San Gorgonio Wild.	SAGO1	603	0.00000	0.00000	0.00002	0.00001
San Jacinto Wild.	SAGO1	603	0.00000	0.00000	0.00002	0.00001

Table 6-8. SundtGS visibility companions. 2028 alternative compared to 2028 base. 2028 base compared to total extinction.

Extinction Analysis (Mm^{-1})						
			Relative Difference between Base and Alternative Contribution to Light Extinction		2028 Sundt Base Emissions Contribution to total Light Extinction	
Class I Areas (CIAs)	IMPROVE Monitor ID	Distance of IMPROVE monitor to Sundt Facility (km)	20% Best Days	20% MID	2028 Sundt Base Emissions Contribution to total Haze Index	2020 Sundt Base Emissions Contribution to total Haze Index
Saguaro Wild.	SAGU1	16	-32.2%	-31.1%	0.0230%	0.0330%
Chiricahua NM	CHIR1	144	-36.4%	-15.1%	0.0039%	0.0024%
Chiricahua Wild.	CHIR1	144	-36.4%	-15.1%	0.0039%	0.0024%
Galiuro Wild.	CHIR1	144	-36.4%	-15.1%	0.0039%	0.0024%
Superstition Wild.	TONT1	167	-32.8%	-39.3%	0.0010%	0.0033%
Sierra Ancha Wild.	SIAN1	215	-41.1%	-23.1%	0.0011%	0.0008%
Mount Baldy Wild.	BALD1	251	-38.5%	-26.7%	0.0004%	0.0015%
Mazatzal Wild.	IKBA1	253	-38.0%	-43.2%	0.0005%	0.0027%
Pine Mountain Wild.	IKBA1	253	-38.0%	-43.2%	0.0005%	0.0027%
Gila Wild.	GICL1	276	-41.5%	-14.2%	0.0006%	0.0007%
Petrified Forest NP	PEFO1	341	-42.3%	-29.4%	0.0006%	0.0007%
Sycamore Canyon Wild.	SYCA2	348	-34.9%	-31.0%	0.0003%	0.0005%
Bosque del Apache Wild.	BOAP1	423	-34.1%	-28.4%	0.0005%	0.0003%
Grand Canyon NP	GRCA2	435	-31.1%	-36.3%	0.0000%	0.0006%
White Mountain Wild.	WHIT1	523	-39.2%	-28.3%	0.0003%	0.0004%
Joshua Tree NP	JOSH1	553	-22.1%	-48.7%	0.0000%	0.0006%
San Pedro Parks Wild.	SAPE1	568	-34.5%	-28.9%	0.0001%	0.0006%
Guadalupe Mountains NP	GUMO1	577	-30.6%	-18.6%	0.0003%	0.0001%
Agua Tibia Wild.	AGTI1	585	-11.9%	-29.4%	0.0000%	0.0000%
Bandelier NM	BAND1	586	-35.1%	-28.1%	0.0001%	0.0004%
Zion Canyon NP	ZICA1	595	-9.9%	-31.1%	0.0000%	0.0002%
Mesa Verde NP	MEVE1	601	-24.5%	-27.4%	0.0000%	0.0003%
San Gorgonio Wild.	SAGO1	603	-25.2%	-41.0%	0.0000%	0.0000%
San Jacinto Wild.	SAGO1	603	-25.2%	-41.0%	0.0000%	0.0000%

6.3 Discussion of SundtGS Visibility Results

Figure 6-1 is a graphical representation of the data in Table 6-3. Sundt Unit #3 contributions to Haze Index are highest at Saguaro Wilderness which is the closest CIA to the SundtGS. The Saguaro IMPROVE monitor is located approximately 16 km from the SundtGS facility. Contributions are approximately an order of magnitude smaller at the next closest Class I areas (~144 km) from SundtGS, those Class I areas are represented by the CHIR1 IMPROVE monitor. In general, the Sundt Unit #3 impacts are higher on the 20% MID compared to the Best 20% days, but there are a few exceptions. At all locations the 2028 control scenario emissions contribute a smaller amount to visibility impairment than the 2028 base case emissions. The average reduction across all CIAs within 600-km of the SundtGS is 31.8% for the Best 20% days and 28.9% for the 20% MIDs.

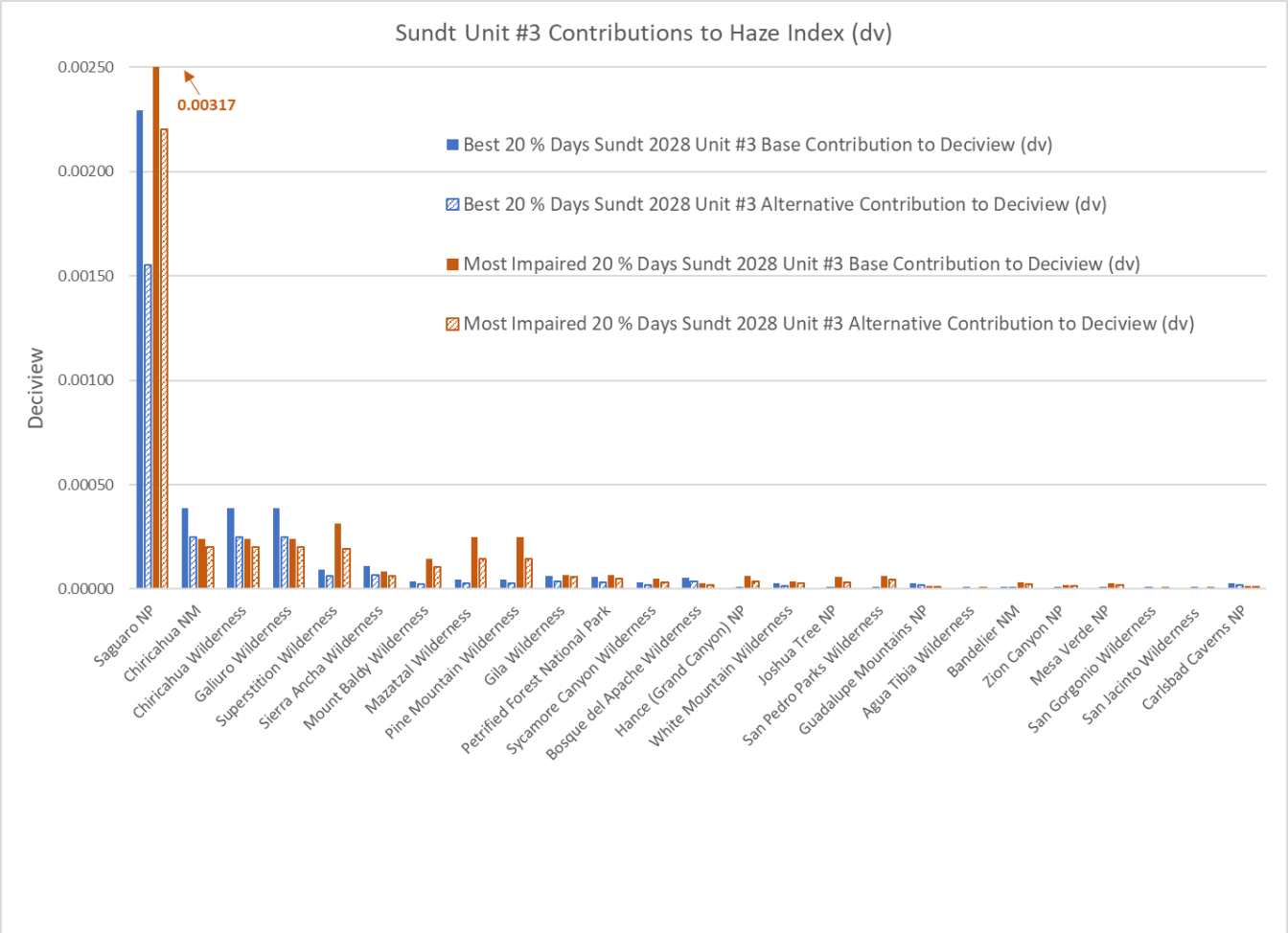

Figure 6-1. Graphical representation of Sundt Unit #3 contributions to visibility impairment for the Best 20% days and 20% MID, for the 2028 base emissions and 2028 controlled emissions.

We found substantial spatial variation in the magnitude of the relative visibility contribution reductions across the 600-km visibility analysis region ranging from a minimum of 7% reduction at Zion NP on the Best 20% days to a maximum reduction of 49% at Joshua Tree NP on the 20% MID (Table 6-4, 4th and 5th columns). In addition, there appears to be spatial coherence to the pattern of variation and we have plotted the reductions in Figure 6-2 and Figure 6-3 for the Best 20% days and 20% MID, respectively.

For the Best 20% days (which typically occur during winter months), Figure 6-2 reveals that the largest visibility benefits of the Unit #3 NOx reductions (i.e. visibility reductions of > 30%) are east and north of the Sundt facility and the smallest reductions are at the most distant IMPROVE monitors (e.g., in California and Nevada). For the 20% MIDs (Figure 6-3), which tend to occur throughout the year and/or are more likely to occur in summer months, there is a very different pattern of visibility reduction than seen for the Best 20% days. East of the Sundt facility, visibility contribution reductions are the smallest, to the northeast of the facility reductions are also small, and reductions are largest to the north of the facility and to the west of the facility at the distant California Class I areas including Joshua Tree NP. A potential reason for differing magnitudes of NOx reductions is the availability of ambient ammonia to form ammonium nitrate. In situations where ammonium nitrate formation is ammonia-limited, reductions in NOx emissions are likely to lead to smaller reductions in ammonium nitrate and visibility impairment, however, when ammonium nitrate formation is nitric acid-limited then NOx emission reductions are likely to lead to larger reductions in ammonium nitrate formation. To better understand ammonia availability, Figure 6-2 and Figure 6-3 also show ammonia emissions that were used in the CAMx modeling. The emissions are 24-hr average of July 1, 2020, a randomly selected summer day. It appears that ammonia emissions are relatively low to the east and north east of the Sundt facility which could explain the spatial variation for the 20% MID but does not explain the (generally inverse) spatial variation on the Best 20% days. Ammonia emissions vary seasonally[15] and tend to be higher during spring (when fertilizer application occurs) and also summer compared to winter months. Nitrate formation occurs more readily during colder months, so seasonal differences are not surprising, and different mechanisms likely play different roles throughout the year. Because sulfate is higher in the summer and ammonia preferentially binds to sulfate over nitrate, particle nitrate formation may be more ammonia-limited in the summer for the MIDs in locations with higher sulfate concentrations, such as east of the SundtGS as opposed to California where there are low SO_2 emissions. To better understand the spatial variations would require a detailed analysis of the 20% MIDs and Best 20% days distribution throughout the year as well as additional chemistry considerations, including atmospheric lifetimes and also an analysis of SO_4 concentrations/chemistry due to the SO_4 and NO_3 competition for ammonia, and is beyond the scope of this analysis.

[15] https://earthobservatory.nasa.gov/images/144351/the-seasonal-rhythms-of-ammonia

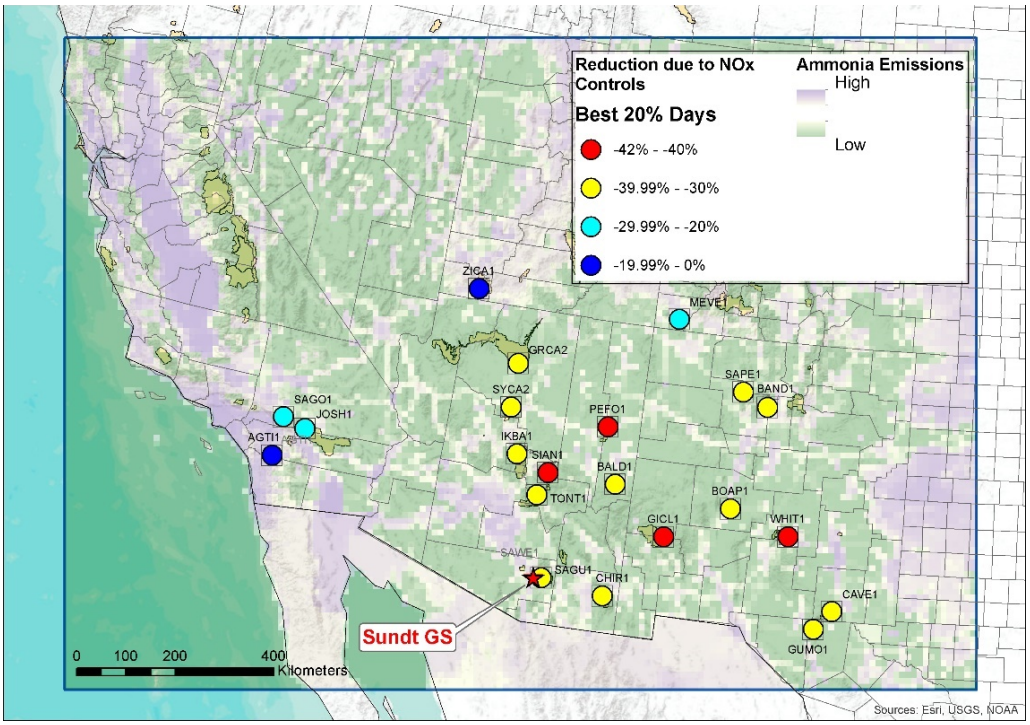

Figure 6-2. Haze Index (dv) contribution reductions due to NOx emissions controls on Best 20% days.

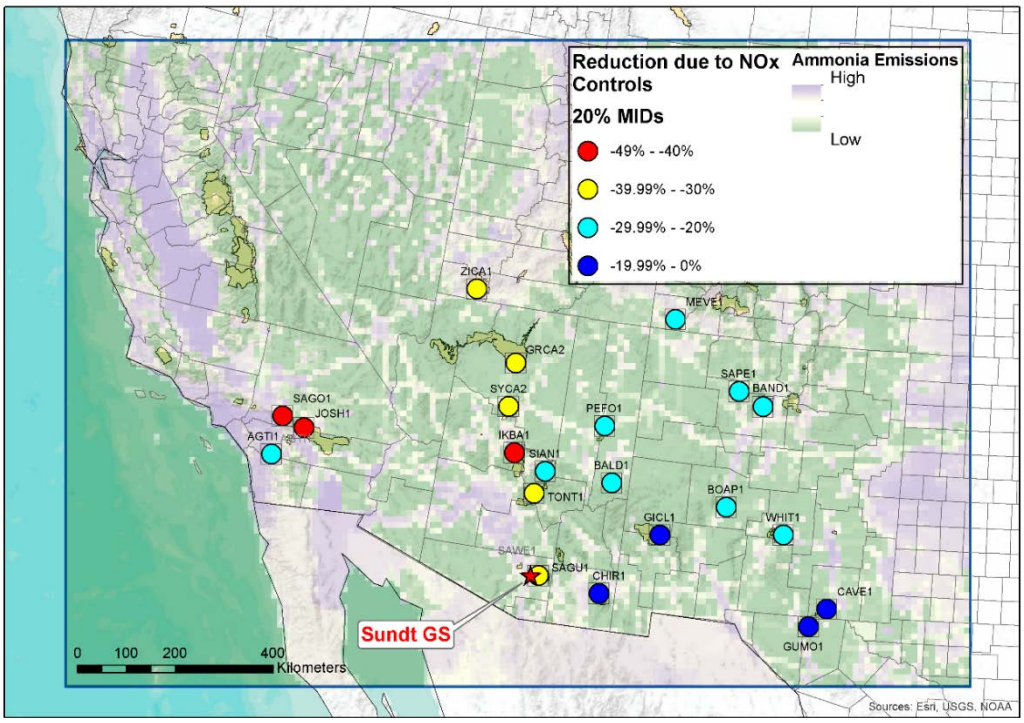

Figure 6-3. Haze Index (dv) contribution reductions due to NOx emissions controls on 20% MIDs.

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APPENDIX A:

CAMX Runscript

APPENDIX A: CAMX Sample Runscript

```
&CAMx_Control

 Run_Message      = 'camx650_soa_cb6r4, 20160331, basecase',

!--- Model clock control ---

 Time_Zone        = 0,              ! (0=UTC,5=EST,6=CST,7=MST,8=PST)
 Restart          = .true.,
 Start_Date_Hour  = 2016,03,31,0000,   ! (YYYY,MM,DD,HHmm)
 End_Date_Hour    = 2016,03,31,2400,   ! (YYYY,MM,DD,HHmm)

 Maximum_Timestep    = 15.,          ! minutes
 Met_Input_Frequency = 60.,          ! minutes
 Ems_Input_Frequency = 60.,          ! minutes
 Output_Frequency    = 60.,          ! minutes

!--- Map projection parameters ---

 Map_Projection = 'LAMBERT',  ! (LAMBERT,POLAR,UTM,LATLON)
 UTM_Zone       =   0,
 Longitude_Pole = -97.,      ! deg (west<0,south<0)
 Latitude_Pole  =  40.,      ! deg (west<0,south<0)
 True_Latitude1 =  33.,      ! deg (west<0,south<0)
 True_Latitude2 =  45.,      ! deg (west<0,south<0)

!--- Parameters for the master (first) grid ---

 Number_of_Grids      = 1,
 Master_SW_XCoord     = -2256.,       ! km or deg, SW corner of cell (1,1)
 Master_SW_YCoord     = -996.,        ! km or deg, SW corner of cell (1,1)
 Master_Cell_XSize    = 12.,          ! km or deg
 Master_Cell_YSize    = 12.,          ! km or deg
 Master_Grid_Columns  = 154,
 Master_Grid_Rows     = 110,
 Number_of_Layers     = 35,

!--- Model options ---

 Diagnostic_Error_Check = .false.,    ! True = will stop after  st timestep
 Advection_Solver       = 'PPM',     ! (PPM,BOTT)
 Chemistry_Solver       = 'EBI',     ! (EBI,IEH,LSODE)
 PiG_Submodel           = 'GREASD',  ! (None,GREASD,IRON)
 Probing_Tool           = 'SA',      ! (None,SA,DDM,PA,RTRAC)
 Chemistry              = .true.,
 Drydep_Model           = 'ZHANG03', ! (NONE,WESELY89,ZHANG03)
 Wet_Deposition         = .true.,
 ACM2_Diffusion         = .false.,
 Super_Stepping         = .true.,
 Gridded_Emissions      = .true.,
 Point_Emissions        = .true.,
 Ignore_Emission_Dates  = .true.,
```

```
 Flexi_Nest            = .false., ! allow flexi-nest of input files including restart
 Inline_Ix_Emissions    = .true.,

!--- Output specifications ---

 Root_Output_Name        =
        '/dhex16d/RTPEnv_Sundt/camx/outputs/basecase/Q1/camx650_soa_cb6r4.basecase
        .20160331',
 Average_Output_3D       = .false.,
 NetCDF_Format_Output     = .false.,
 NetCDF_Use_Compression   = .false.,
 Output_Species_Names(1) = 'NO',
 Output_Species_Names(2) = 'NO2',
 Output_Species_Names(3) = 'O3',
 Output_Species_Names(4) = 'SO2',
 Output_Species_Names(5) = 'CO',
 Output_Species_Names(6) = 'HNO3',
 Output_Species_Names(7) = 'NH3',
 Output_Species_Names(8) = 'PNO3',
 Output_Species_Names(9) = 'PSO4',
 Output_Species_Names(10) = 'PNH4',
 Output_Species_Names(11) = 'POA',
 Output_Species_Names(12) = 'PEC',
 Output_Species_Names(13) = 'FPRM',
 Output_Species_Names(14) = 'SOPA',
 Output_Species_Names(15) = 'SOPB',
 Output_Species_Names(16) = 'FCRS',
 Output_Species_Names(17) = 'SOA1',
 Output_Species_Names(18) = 'SOA2',
 Output_Species_Names(19) = 'SOA3',
 Output_Species_Names(20) = 'SOA4',
 Output_Species_Names(21) = 'NA',
Output_Species_Names(22) = 'PCL',

!--- Input files ---

 Chemistry_Parameters =
        '/disk45/RTPEnv_Sundt/camx/src.v6.50_soa/inputs/CAMx6.5.chemparam.CB6r4_CF
        _SOAP_ISORROPIA',
 Photolyis_Rates      =
        '/disk45/RTPEnv_Sundt/camx/inputs/tuv/tuv.ADEQ_PHX.12km.do_CB6.20160331',
 Ozone_Column         =
        '/disk45/RTPEnv_Sundt/camx/inputs/o3map/o3map.ADEQ_PHX.12km.20160331.txt'
        ,
 Initial_Conditions   = ' ',
 Boundary_Conditions  =
        '/disk45/RTPEnv_Sundt/camx/inputs/bcon/camx.nest.20160331.bc',
 Point_Sources        =
        '/dhex16d/RTPEnv_Sundt/emis/camx_ready/basecase/mrgpt_w_sundt/mrgpt.sundt.
        pig_SAtagged.basecase.adeq12km.20160331.bin',
 Master_Grid_Restart  =
        '/dhex16d/RTPEnv_Sundt/camx/outputs/basecase/Q1/camx650_soa_cb6r4.basecase
        .20160330.inst',
```

```
 Surface_Grid(1) =
        '/disk45/RTPEnv_Sundt/camx/inputs/met/landuse.151221.12US2.zhang.camx.salt',
 Met3D_Grid(1)   =
        '/disk45/RTPEnv_Sundt/camx/inputs/met/met3d.160331.12US2.35.wrf.camx',
 Met2D_Grid(1)   =
        '/disk45/RTPEnv_Sundt/camx/inputs/met/met2d.160331.12US2.35.wrf.camx',
 Vdiff_Grid(1)   =
        '/disk45/RTPEnv_Sundt/camx/inputs/met/vdif.160331.12US2.35.wrf.camx.0.1.YSU.k
        vpatch',
 Cloud_Grid(1)   =
        '/disk45/RTPEnv_Sundt/camx/inputs/met/clra.160331.12US2.35.wrf.camx',
 Emiss_Grid(1)   =
        '/disk45/RTPEnv_Sundt/camx/inputs/emis/base/area/emis2d.20160331.adeq12k.20
        16ff_16j+ss.camx',

 /
!-----------------------------------------------------------------------------
```

APPENDIX B:

SMAT Control File

APPENDIX B: SMAT Control File

```
RunType=RunVisibility
OutputFileDir=C:\Users\fjiang\OneDrive - Ramboll\Documents\My SMAT-CE Files\Result\Output
OutputFileName=RTPEnv_Sundt_BY2016_FY2028_basecase.cfg
scenarioName=RTPEnv_Sundt_BY2016_FY2028_basecase
doTemporallyAdjVisibilityLevelsForecast=1
choiceUseOldVersionforIMPROVEAlgorithm=0
choiceUseNewVersionforIMPROVEAlgorithm=1
choiceUseModelGridCellAtMonitor=1
choiceUseModelGridCellatClassIAreaCentroid=0
doAutomaticallyExtract=1
monitorDataFileOldAlgorithm=
monitorDataFileNewAlgorithm=C:\Program Files (x86)\SMAT-
CE\Data\SampleData\Monitor_data\ClassIareas_NEWIMPROVEALG_2000to2018_2020_may5_IMPAIRMENT.csv
forecastIMPROVEDataFile=C:\Program Files (x86)\SMAT-
CE\Data\SampleData\Monitor_data\ClassIareas_NEWIMPROVEALG_2000to2017_2019_feb11_IMPAIRMENT.csv
needCreateForecastIMPROVEDataFile=1
checkForecastIMPROVEAdvance=0
baselineModelDataFile=C:\Users\fjiang\OneDrive -
Ramboll\Desktop\SMAT\RTPEnv_Sundt\input\RTP_Springerville_base_SMAT_PM25_base_avrg_grd01.csv
forecastModelDataFile=C:\Users\fjiang\OneDrive -
Ramboll\Desktop\SMAT\RTPEnv_Sundt\input\RTPEnv_Sundt_SMAT_PM25_basecase_avrg_grd01.csv
temporalAdjustmentAtMonitorGrid=3x3
startMonitorYear=2014
endMonitorYear=2018
baseModelYear=2016
minYearsForValidVisibilityMonitors=3*
```

**Note that we also ran with 1 year to obtain results for the SIAN monitor*