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SO_2 Four Factor Analysis Regional Haze Rule Second Decadal Review

General James M. Gavin Power Plant
Units 1 and 2

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1. Introduction

The Ohio Environmental Protection Agency (Ohio EPA) is developing a State Implementation Plan (SIP) for the Second Decadal Review period of the federal Regional Haze Rule (42 USC §7491 – Visibility Protection for Federal Class I Areas). The Regional Haze Rule (RHR) requires state and federal agencies to work to improve visibility in U.S. National Parks and Wilderness Areas throughout the country (see 40 CFR §81.401 through 81.437) with the ultimate goal of achieving “natural background” visibility in these Class I areas by the year 2064. Every ten years, agencies are required to evaluate their plans and consider whether additional emission reductions at certain major sources are warranted to continue realizing “reasonable progress” in visibility improvement. Ohio EPA, via an October 5, 2020 correspondence, requested a four-factor analysis for potential reductions of sulfur dioxide (SO_2) emissions from the General James M. Gavin Power Plant (Gavin Power Plant) Units 1 and 2.

As outlined in the RHR, this analysis, referred to as a “Four-Factor Analysis”, needs to first identify all technically feasible control technologies for additional SO_2 emissions control. Each feasible control option then needs to be evaluated relative to the following four statutory factors:

1. Cost of implementing emission controls;
2. Time necessary to install such controls;
3. Energy and non-air quality impacts associated with installing controls; and
4. The remaining useful life of the facility.

Ohio EPA requested the Gavin Power Plant to perform the subject analysis for SO_2 emissions for Units 1 and 2 and submit their findings to the Ohio EPA. Gavin Power Plant contracted AECOM to assist with the analysis. Although not required to be included in the analysis, states have the option to consider a fifth factor – evaluation of visibility benefits - in addition to the four statutory factors when making their reasonable progress determinations. This analysis includes the fifth factor (see Section 6) to provide additional information to Ohio EPA to assist in their consideration of controls for visibility improvement.

This report provides a description of the affected source including existing emission controls (Section 2), a summary of the actions taken during First Decadal Review period of the RHR (Section 3), a summary of actual baseline emissions (Section 4), identification of potentially feasible SO_2 control options and an assessment of each of the four statutory factors for these options (Section 5). Additionally, Section 6 provides a “fifth factor” analysis of the prospective visibility impacts to Class I areas of Units 1 and 2’s current SO_2 emissions and any visibility improvements offered by the potential SO_2 controls. Finally, Section 7 presents a summary of this report’s findings.

2. Source Description and Emission Controls

The Gavin Power Plant is located at 7397 N. State Route 7 Cheshire, OH 45620. The Plant is licensed to operate under Ohio EPA’s Title V Operating Permit No. P0089258 (Expiration date – May 6, 2025). Units 1 and 2 are designated as B003 and B004 in the Title V permit.

Gavin Power Plant Units 1 and 2 are pulverized coal-fired, dry bottom boilers designed to burn bituminous coal. The boilers are high-efficiency, supercritical units with steam turbine-driven electric generators that provide electricity to the regional electric grid. The units were manufactured by Babcock and Wilcox and commissioned in 1974 and 1975. Bituminous coal is supplied by regional mines (including Ohio) and delivered to the plant site by barges. Based on the Title V permit, the nominal rated heat input capacity for each boiler is 11,936 MMBtu/hr. The nominal power output is 1,430 MW gross and 1,330 MW net for Unit 1 and 1,460 MW gross and 1,350 MW net for Unit 2. An aerial view of the Gavin Power Plant is presented in **Figure 2-1**.

Figure 2-1 Gavin Power Plant Units 1 and 2: Aerial View

Emissions of SO_2 on Units 1 and 2 are each controlled by wet flue gas desulfurization (wet FGD) systems that were installed in 1995. Each unit has its own wet FGD system and exhausts via its dedicated stack. Originally, each of the two scrubber systems consisted of six (6) absorbers, used magnesium-enhanced lime[1] and had a design SO_2 removal efficiency of 95%. At these collection / control levels, the Plant's solids handling capabilities are at their design limits.

In May 2019, the units began employing limestone as the reagent. When limestone is the reagent, all six absorbers and all twelve recycle pumps are required to be operational when Units 1 and 2 are running at or near full load. The recycle pumps have a recirculation rate of 19,000 gallons per minute (gpm). Each pump feeds its own spray header to allow for the full pump flow to the spray nozzles. Both headers spray above the two new reaction trays in the absorber. Full load liquid-to-gas ratio (L/G) is 56 with all six absorbers in service. An additive is used in the system to help add buffer capacity to the recycle slurry to improve performance. Currently, the upper recycle pump motors are being upgraded from 450 hp to 600 hp motors.

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[1] The historical supplier of magnesium-enhanced lime, the Carmeuse Lime and Stone Maysville mine, is no longer producing magnesium-enhanced lime. A potential supply for magnesium-enhanced lime has not been identified, however, the system is already optimized as the FGD system has achieved 95% removal efficiency with limestone. At these collection / control levels, the Plant's solids handling capabilities are at their design limits.

This will boost the upper pump flow to approximately 21,000 gpm to further improve the L/G. The upgraded system is also designed for a 95% SO_2 removal efficiency.

The boilers are each equipped with a selective catalytic reduction (SCR) system for control of NOx and an electrostatic precipitator (ESP) for particulate matter (PM) control. The Gavin Power Plant is subject to, and compliant with, the Coal- and Oil-Fired Electric Utility Steam Generating Units (EGU) National Emission Standards for Hazardous Air Pollutants (NESHAP) Rule, also known as the Mercury and Air Toxics Standards (MATS) Rule (40 CFR Part 63, Subpart UUUUU). The existing SCR system oxidizes the mercury emissions which are then controlled in the wet FGD system. The units are also equipped with dry sorbent injection (DSI) systems for control of sulfur trioxide (SO_3) emissions.

Units 1 and 2 are also subject to, and compliant with, the Cross-State Air Pollution Rule (CSAPR or Transport Rule) and the related requirements promulgated under Ohio Administrative Code (OAC) 3745-14 and OAC 3745-109 and 40 CFR 75 - Continuous Emissions Monitoring. The Gavin Power Plant operates and maintains (i) certified continuous emission monitoring systems (CEMs) for NOx, SO_2 and carbon dioxide (CO_2) and (ii) a certified exhaust gas stream flow monitor at the exhaust duct. Certified emissions, heat input and gross electrical load data are submitted quarterly to the U.S. Environmental Protection Agency (EPA).

In summary, contemporary emission control devices are already installed, operated and maintained on Units 1 and 2, and these devices provide for effective control of criteria and hazardous air pollutants.

3. First Regional Haze Planning Period Reasonable Progress Determination

During the First Decadal Review period of the RHR (i.e., 40 CFR 51 Subparts 308 and 309), Units 1 and 2 were subject to Best Available Retrofit Technology (BART) review as they were placed into service within the rule-specified BART applicability window (between August 7, 1962 and August 7, 1977) and satisfied the other eligibility criteria. BART requirements for SO_2 and NOx emissions were satisfied by compliance with EPA’s Clean Air Interstate Rule (CAIR), now superseded by the more stringent CSAPR.[2]

4. Source Emissions

Actual emissions and annual capacity factors for Units 1 and 2 for the 2017 through 2019 period are summarized in **Table 4-1**.

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[2] Per EPA, who ruled that CAIR achieved greater reasonable progress than BART for SO_2 and NOx emissions at BART-eligible electric generating units located in CAIR-affected states.

Table 4-1 Gavin Power Plant – Units 1 and 2 Actual Annual Operation and Emissions

Time Period	Unit	Annual Operating Hours[(a)]	Power Output [(a)]	Capacity Factor based on MWh [(b)]	Annual Fuel Use [(a)]	SO_2 Emissions [(a)]	
		(hr/yr)	(MWh)	%	(MMBtu/yr)	(ton/yr)	(lb/MMBtu) [(c)]
2017 through 2019	1	7,102	8,026,519	64.1%	73,806,437	13,039	0.353
	2	7,309	8,453,514	66.1%	74,131,407	13,458	0.363
	Avg	7,206	8,240,017	65.1%	---	---	0.358
	Total	14,412	16,480,033	---	147,937,844	26,497	---

(a) EPA Air Markets Program Data (https://ampd.epa.gov/ampd/)

(b) Rated capacity for Unit 1 is 1,430 MW, gross and that for Unit 2 is 1,460 MW, gross.

(c) Title V permit limit for SO_2 is 7.41 lb/MMBtu.

5. Emissions Control Options

This section presents an evaluation of potential emissions reduction options applicable for SO_2 emissions for Units 1 and 2 at the Gavin Power Plant. The evaluation starts with listing potential control options and determining if the option is technically feasible. For those options considered technically feasible, an analysis was conducted considering the four statutory factors: (1) costs of compliance; (2) the time necessary for compliance; (3) the energy and non-air quality environmental impacts of compliance; and (4) the remaining useful life of the emission unit. Following the evaluation are conclusions related to the feasibility and reasonability of implementing the options.

5.1 Identification of Potentially Available SO_2 Emissions Reduction Options

Based on a review of available SO_2 control technologies, as well as operational practices and equipment upgrades implemented on existing control systems, potentially available options to control SO_2 emissions from Units 1 and 2 at the Gavin Power Plant are listed in **Table 5-1**. **Figure 5-1** presents the current layout of the Gavin Power Plant's Units 1 and 2.

Table 5-1 Available SO_2 Control Approaches

SO_2 Control Technologies
Fuel Switching
Retrofit New Dry FGD
Retrofit New Wet FGD
Existing Wet FGD Operational Improvements

5.1.1 Fuel Switching: Lower Sulfur Fuels

Emissions of SO_2 from boilers are directly proportional to the sulfur content of the fuel and its higher heating value (HHV). The Gavin Power Plant currently burns eastern Bituminous coal with typical HHV of 12,600 Btu/lb, a sulfur content in the 3.9% to 4.2% range and uncontrolled SO_2 emissions in the 6.2 lb/MMBtu to 6.7 lb/MMBtu range.

5.1.1.1 Natural Gas

The ability to fire natural gas for normal / baseload power production is contingent upon construction of a gas pipeline to supply the necessary quantity of gas from interstate transmission lines. Natural gas is not currently available at the site. The closest interstate gas line is approximately 10 miles from the Gavin Power Plant. Also, the pipeline does not currently have the capacity to supply the required full-load natural gas to the Plant.

Locating the necessary capacity, acquiring the right of ways and approvals would require time and would likely be challenging. As such, the control option of evaluating natural gas as an alternative fuel is not being studied further as part of this four-factor analysis.

5.1.1.2 Lower Sulfur Coal

The Gavin Power Plant burns eastern bituminous coal with a typical sulfur content ranging from 3.9% to 4.2%. The pre-control emission rate for SO_2 typically ranges from 6.2 lb/MMBtu to 6.7 lb/MMBtu. The SO_2 permit limit for Units 1 and 2 is 7.41 lb/MMBtu.

Combustion of lower sulfur coal can result in several operational issues that preclude the use of this option as a reasonable SO_2 control measure. The fly ash generated at the Gavin Power Plant is used to stabilize the waste generated in the boilers' FGD systems. Combustion of lower sulfur coal will result in a decrease in the amount of FGD solids produced thereby resulting in a decrease in the ash demand for stabilization. The ash that would not be mixed with FGD sludge would need to be disposed of using other means. Also, a lower sulfur coal would typically have a higher ash content. The increased ash loading to the ESP plates would overburden the ESP and reduce its control efficiency. Also, the reduced sulfur in the flue gas (less acidic) would increase the resistivity of the ash, and therefore, lowering the control efficiency. The plant had tried a 20% Powder River Basin coal blend but the trial was discontinued due to slagging issues.

For the reasons outlined above, switching to a lower sulfur fuel (or blend) is considered to be a technically infeasible SO_2 control option for Units 1 and 2. The Gavin Power Plant has coal purchase contracts in place that it needs to honor. Additionally, the existing SO_2 control system (wet FGD system) was designed for the coal sulfur content in this range. Lastly, EPA's RHR guidance[3] allows states to deem fuel switching unreasonable as fuel is fundamental to the design and operation of the emission source. Therefore, fuel switching to a lower sulfur coal is not evaluated further as part of this four-factor analysis.

5.1.2 Add-on SO_2 Controls

There are multiple add-on control options for controlling the emissions of SO_2 from coal-fired power plants. These options fall in three general categories:

1. Dry Sorbent Injection (DSI).
2. "Dry" FGD (e.g.; spray dryer absorber (SDA), circulating dry scrubbers (CDS), or novel integrated desulfurization (NID)); and,
3. Wet Flue Gas Desulfurization (wet FGD);

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[3] US EPA; "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period" in August 2019, Page 30. Available at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

A DSI system involves the injection of a lime or limestone powder into the exhaust gas stream. The stream is then passed through a baghouse to remove the sorbent and entrained SO_2. It is expected that a DSI system on Units 1 and 2 will not provide significant SO_2 emission control due to a variety of factors including residence time, gas stream temperature, the amount of sorbent injected, and the use of an ESP (as opposed to a fabric filter) for PM emissions control. The existing DSI systems on units 1 and 2 are designed for SO_3 emissions control. High sorbent injection rates required for any appreciable SO_2 control would likely exceed the capability of the existing ESP to handle particulate emissions. Therefore, implementing a DSI system is not a practical control option and is not evaluated further.

An SDA system is a dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the SO_2 is absorbed by the droplets. The absorption of the SO_2 leads to the formation of calcium sulfite ($CaSO_3 \bullet 2H_2O$) and calcium sulfate ($CaSO_4$). The heat of the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder that is carried out with the gas and collected with a fabric filter. Process equipment associated with an SDA control system includes an alkaline storage tank, mixing and feed tanks, atomizer assembly, spray chamber module, integrated fabric filter, and solids recycle system. The recycle system collects solid reaction byproducts and recycles them back to the spray dryer feed system to maximize reactant utilization.

For Units 1 and 2, SDA does not offer advantages compared to the existing wet FGD due to site specific issues such as the cost for replacement of the existing ESP with a costly new fabric filter for PM emission control. Therefore, implementing an SDA system is not a practical control option and is not evaluated further.

Lastly, retrofitting a new wet FGD system is not a reasonable option as the existing wet FGD system was upgraded as recently as May 2019. EPA’s RHR guidance states that if a source has recently made significant expenditure to upgrade an emissions control to ensure reduction in visibility impairing pollutants, it may be reasonable for the state to assume that additional controls are unlikely to be reasonable. Therefore, replacing the existing wet FGD system with a new system is not a practical option.

As discussed in the sections below, process improvements to the existing wet FGD system were evaluated for technical feasibility.

5.1.3 Wet FGD System Process Improvements/Optimization

The SO_2 removal efficiency of a limestone-based wet FGD system is driven by two phenomena:

- Absorption of SO_2 via gas/liquid contact, and,
- Rate of neutralization of the alkaline scrubbing medium by the acidic SO_2.

As noted previously, the wet FGD systems on Units 1 and 2 were upgraded in May 2019 to use limestone (instead of magnesium-lime) as a reagent. By design, with the six absorbers (per wet FGD system) and all 12 recycle pumps in service, the systems can each achieve an SO_2 control efficiency of 95%.

As part of the reagent switch, several other enhancements were made to the wet FGD system including:

- Two new trays were installed in each of the six absorber modules.
- Recycle pumps, each capable of 19,000 gpm, were installed. In the current set-up, each pump feeds its own header which allows the entire flow of 19,000 gpm to be sprayed through the nozzles. Both headers spray above the two new trays. Previously, the absorber recycle flow was 20,500 gpm for a single pump and 31,000 gpm when both absorber pumps were operating in parallel.

- To enhance efficiency, an additive is used in the system to add buffering capacity to the recycle slurry.
- At full load, the L/G is now 56, which is a significant improvement from the previous (range 21 – 32).
- The Plant is in the process of upgrading the recycle pump motors on the upper level from 450 hp to 600 hp. This improvement will help increase the upper level recycle flow to 21,000 gpm which will further improve the L/G.

With the improvements noted above, the wet FGD systems have been operating at just above 95% control efficiency level since the upgraded systems' optimization was completed in mid-2020. For the period of August through October 2020, Unit 1's system operated at an SO_2 control efficiency of 95.18% and Unit 2's system operated at an SO_2 control efficiency of 95.53%. As a result of the recent upgrades, the systems are expected to continue to operate at similar efficiency levels going forward.

The wet FGD systems have been optimized and are performing at the best levels that they physically can. Further enhancements are not technically feasible for the following reasons:

- At these collection / control levels, the Plant's solids handling capabilities are at their design limits.
- Significant upgrades would be required as the Plant would need to install additional dewatering capability for the additional FGD sludge generated.
- It is difficult to maintain all six absorbers in operation at full load for long periods of time. There is no margin in the physical design and occasionally, the units need to be derated to meet the 95% control efficiency.

The EPA RHR Guidance[4] notes that an EGU that has a wet FGD system that operates year-round and has an SO_2 control efficiency of 95% is already "effectively controlled". As such, the recently upgraded wet FGD systems are adequate to achieve reasonable progress and no additional SO_2 controls are required.

5.1.3.1 Cost of Compliance (Factor 1)

No additional technically feasible SO_2 emissions controls beyond those already implemented (or in the plans) were identified. The existing wet FGD systems are adequate to achieve reasonable progress. Therefore, there is no additional cost of compliance beyond that already recently incurred to upgrade the systems.

5.1.3.2 Time Necessary for Compliance (Factor 2)

As noted previously, the existing wet FGD systems are adequate to achieve reasonable progress. The wet FGD systems will continue to operate at the optimized 95% SO_2 control efficiency. Therefore, there is no additional time necessary for compliance.

5.1.3.3 Energy and Non-Air Quality Environmental Impacts (Factor 3)

There are significant energy and solid waste impacts associated with wet limestone FGD systems. However, these impacts have been incorporated into the Gavin Power Plant's operations and management systems.

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[4] US EPA; "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period" in August 2019, Page 24. Available at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

5.1.3.4 Remaining Useful Life (Factor 4)

Units 1 and 2 were commissioned in 1974 and 1975, respectively. Although the units are about 45 years old, no retirement date has been set for either unit. Per the Plant's current estimates, the boilers' remaining useful life may be assumed to be 20 years.

6. Additional 5th Factor Consideration - Visibility Impacts

The goal of the RHR is to improve the visibility in Class I areas. Accordingly, when evaluating possible emissions reduction projects or programs, it is appropriate to consider the degree to which individual control projects might contribute towards that goal. Although states have a statutory requirement to consider the "4 factors" addressed in **Section 5** of this report, EPA's guidance[5] also allows inclusion by states of a "5th factor" which involves consideration of visibility impacts of candidate control options. This section addresses the visibility impacts of current operations. As explained below, because the visibility impacts attributable to the Gavin Power Plant are low, further SO_2 controls and/or lower emission limits, even if technically and economically feasible, would not yield material visibility benefits at any of the regional Class I areas.

6.1 EPA Guidance Regarding Considerations of Visibility Impacts

The EPA issued "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period" in August 2019. This guidance allows a state, as part of its consideration of emission controls, to include a "5th factor" consideration of visibility impacts of candidate control options.

On pages 36 and 37 of this guidance, the EPA notes that concerning the underlying regulation for ascertaining reasonable further progress, the regulation:

> *"assumes that the state will consider visibility benefits as part of the analysis. Section 51.308(f)(2)(i) of the Regional Haze Rule requires consideration of the four factors listed in CAA section 169A(g)(1) and does not mention visibility benefits. However, neither the CAA nor the Rule suggest that only the listed factors may be considered. Because the goal of the regional haze program is to improve visibility, it is reasonable for a state to consider whether and by how much an emission control measure would help achieve that goal." . . .*
> *". . . EPA interprets the CAA and the Regional Haze Rule to allow a state reasonable discretion to consider the anticipated visibility benefits of an emission control measure along with the other factors when determining whether a measure is necessary to make reasonable progress."*

Although the consideration of visibility impacts is not necessarily an "off-ramp" for not requiring a four-factor analysis, it is a useful tool for the overall decision as to whether candidate control options should be adopted. Decisions made by states for the First Decadal Review have many examples for which a marginally cost-effective control option was evaluated in conjunction with the expected visibility improvement. In a number of cases for the First Decadal Review[6], an

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[5] US EPA; "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period" in August 2019. Available at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

[6] Several cases are discussed as part of a comment listed in the Wyoming final rule for a partial Federal Implementation Plan for Wyoming in the January 30, 2014 Federal Register (79 FR 5032). On page 5122, the following discussion is presented:
'EPA has determined in other states that visibility improvements… are too small or inconsequential to justify additional pollution controls. See 77 FR 24794 (0.27 deciview improvement termed ''small'' and did not justify additional pollution controls in New York); 77 FR 11879, 11891 (0.043 to 0.16 delta deciview improvements considered ''very small additional visibility improvements'' that did not justify NOx controls in Mississippi); 77 FR 18052, 18066 (agreeing with Colorado's determination that ''low visibility improvement (under 0.2 delta deciview)'' did not

expected low visibility improvement was considered in conjunction with the cost effectiveness of a control option as part of a final decision not to adopt the control.

6.2 Class I Areas Near Gavin Power Plant

Class I areas in the eastern United States near Ohio are shown in **Figure 6-1**. The closest Class I areas to the Gavin Power Plant are Dolly Sods, James River Face, and Otter Creek Wilderness Areas in West Virginia which are within 300 km of the plant. Other Class I areas within 400 km of the Gavin Power Plant are also shown in the figure.

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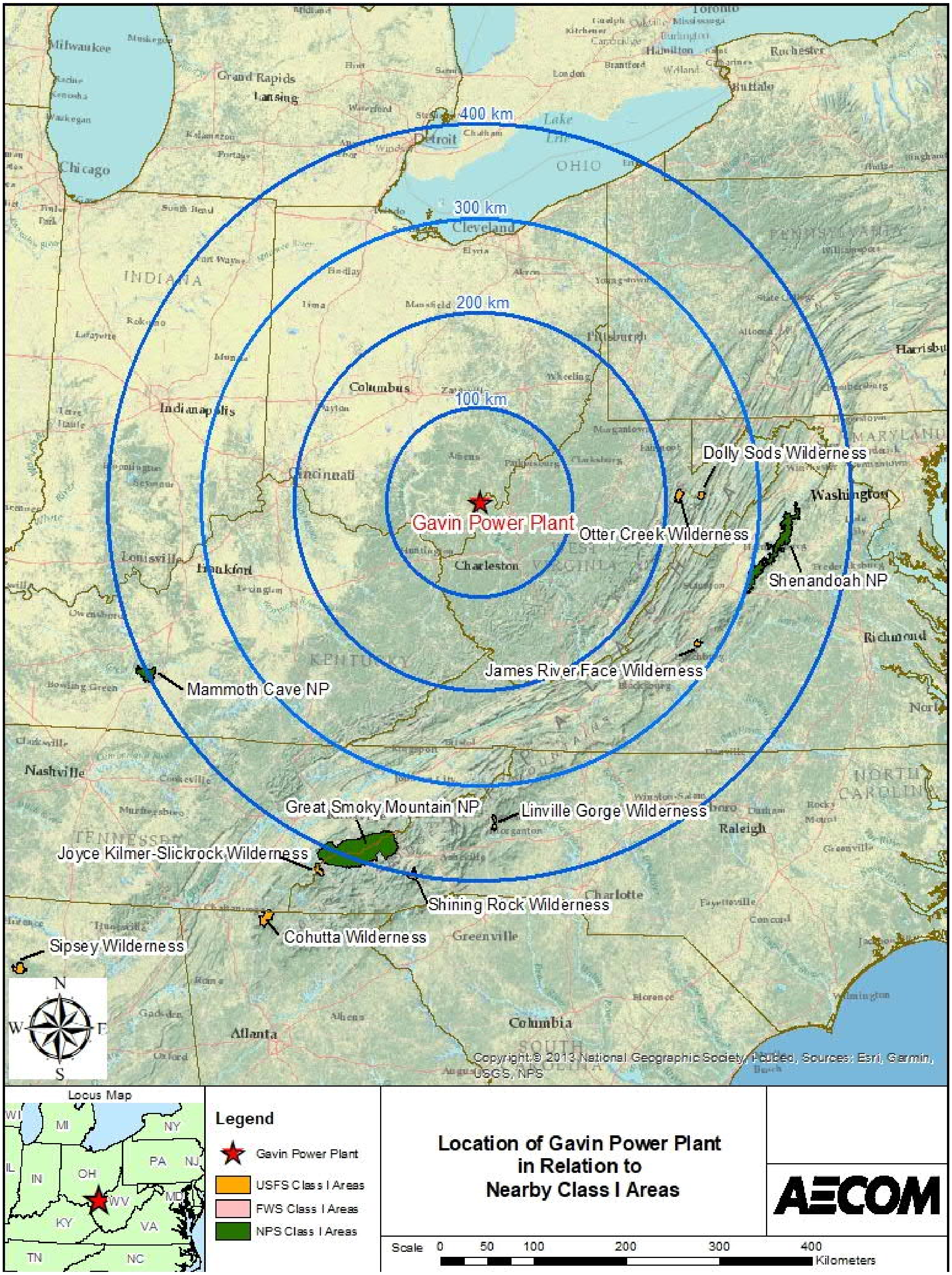
justify SCR for Comanche units)). Tellingly, the ‘‘low visibility improvements’’ that Colorado found at the Comanche units not to justify post-combustion NOx controls, as agreed to by EPA, were 0.17 and 0.14 delta deciview. 77 FR 18066. In Montana, where EPA issued a regional haze FIP directly, it found that a 0.18 delta deciview improvement to be a ‘‘low visibility improvement’’ that ‘‘did not justify proposing additional controls’’ for SO_2 on the source. 77 FR 23988, 24012.’

Figure 6-1 Class I Areas in the Vicinity of Gavin Power Plant



6.3 Lake Michigan Air Directors Consortium (LADCO)

The state of Ohio is a member of the Lake Michigan Air Directors Consortium (LADCO) Regional Planning Organization. LADCO assists its member states by conducting modeling analyses, including photochemical grid modeling, to assess visibility impacts from emission sources. This is especially helpful in determining the haze impact of the current emissions from sources being considered for SO_2 and NOx controls. It is reasonable to consider modeled haze impacts in addition to control costs to determine whether a marginally cost-effective control option is likely to result in a non-trivial improvement in visibility.

A modeling result for this assessment is best obtained for a photochemical grid modeling analysis for which the source's emissions are "tagged" for purposes of determining the sulfate and nitrate haze contributions at each Class I area under consideration. Then, the results of partial controls of either SO_2 or NOx can be linearly scaled due to the relatively large distances to the Class I areas.

LADCO is currently conducting photochemical grid modeling that will assist member states to assess impacts from sources in states and industry sectors (e.g., electric generating stations). As of early December 2020, the LADCO modeling has not been completed. However, it is expected that when the modeling results are available, they will be consistent with independent modeling assessments that have already been completed, as discussed below.

Due to widespread use of photochemical grid models such as CAMx by every other Regional Planning Organization in the country, the next sub-section discusses available CAMx modeling for some Ohio EGUs conducted by the southeastern states Regional Planning Organization, VISTAS / SESARM.

6.4 VISTAS CAMx Modeling Analysis

The impact to Class I area visibility of hypothetical reductions to SO_2 emissions can be determined by analyzing the results of visibility modeling conducted by the VISTAS / SESARM[7] Regional Planning Organization that included emissions for some Ohio power plants. The VISTAS modeling was conducted by Alpine Geophysics and utilized advanced CAMx modeling including modeling particulate matter simulations and source apportionment studies. Determinations of the haze contributions of specified large sources was accomplished by "tagging" the selected sources for determining their contribution to impairment at each Class I area of interest. Gavin Power Plant is a tagged source in the VISTAS analysis.

Visibility impairment is commonly expressed using two parameters to characterize the visibility impairment:

- **Light Extinction (b_{ext})** is the reduction in light due to scattering and absorption as it passes through the atmosphere. Light extinction is directly proportional to pollutant particulate and aerosol concentrations in the air and is expressed in units of inverse megameters or Mm-1.

- **Deciview (DV)** is a unitless metric of haze which is proportional to the logarithm of the light extinction. Deciview correlates to a person's perception of a visibility change, with a

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[7] "VISTAS" is an acronym for Visibility Improvement-State and Tribal Association of the Southeast and "SESARM" stands for Southeastern States Air Resource Managers, Inc. Their web site for Regional Haze Rule modeling results is https://www.metro4-sesarm.org/content/vistas-regional-haze-program.

change of 1 deciview being barely perceptible. The “no degradation” value of 0.1 DV stated in the 1999 Regional Haze Rule is only 10% of this perceptibility threshold.

Both metrics are helpful in understanding changes to visibility impairment. While the deciview is the best parameter to relate the significance of a perceived visibility change, modeling produces results in the form of light extinction using the new IMPROVE equation that converts particulate concentrations to visibility impairment.

In response to comments received from the Federal Land Managers for Ohio’s draft State Implementation Plan submittal earlier in 2021, the Ohio EPA has requested that the conversion between deciviews and extinction should reference the natural conditions endpoint visibility conditions. Ohio has indicated that it is permissible to reference the natural conditions endpoint adjusted for international haze contributions. These adjusted endpoints are available from EPA’s 2019 visibility modeling document[8], Appendix E.

A review of the natural conditions endpoint deciviews published by EPA, adjusted for the influence of international contributions to haze, indicates that the cleanest background is at Dolly Sods and Otter Creek Wilderness Areas, with a deciview value of 11.07. The visibility metrics converter available at https://vista.cira.colostate.edu/Improve/haze-metrics-converter/ can be used to determine the extinction in inverse megameters for a deciview value of 11.07, as well as 10.97 and 11.17 (0.1 dv increments). It turns out that at that deciview level, a change of 0.1 dv is equivalent to an extinction change of 0.3 Mm^{-1}. This conversion is used in the discussion provided below.

Charts shown in **Figure 6-2** and **6-3** are taken from the VISTAS Regional Haze modeling project update (webinar) updated on September 10, 2020 (after being originally presented on May 20, 2020). They show, in units of deciview, the actual visibility measurements and projected modeling results of visibility for most impaired days at the Dolly Sods Wilderness Area and the James River Face Wilderness Area where the Gavin Power Plant’s SO_2 emissions have the greatest visibility impacts.

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[8] Available at https://www.epa.gov/sites/production/files/2019-10/documents/updated_2028_regional_haze_modeling-tsd-2019_0.pdf.

Figure 6-2 Visibility Trends at Dolly Sods Wilderness Area

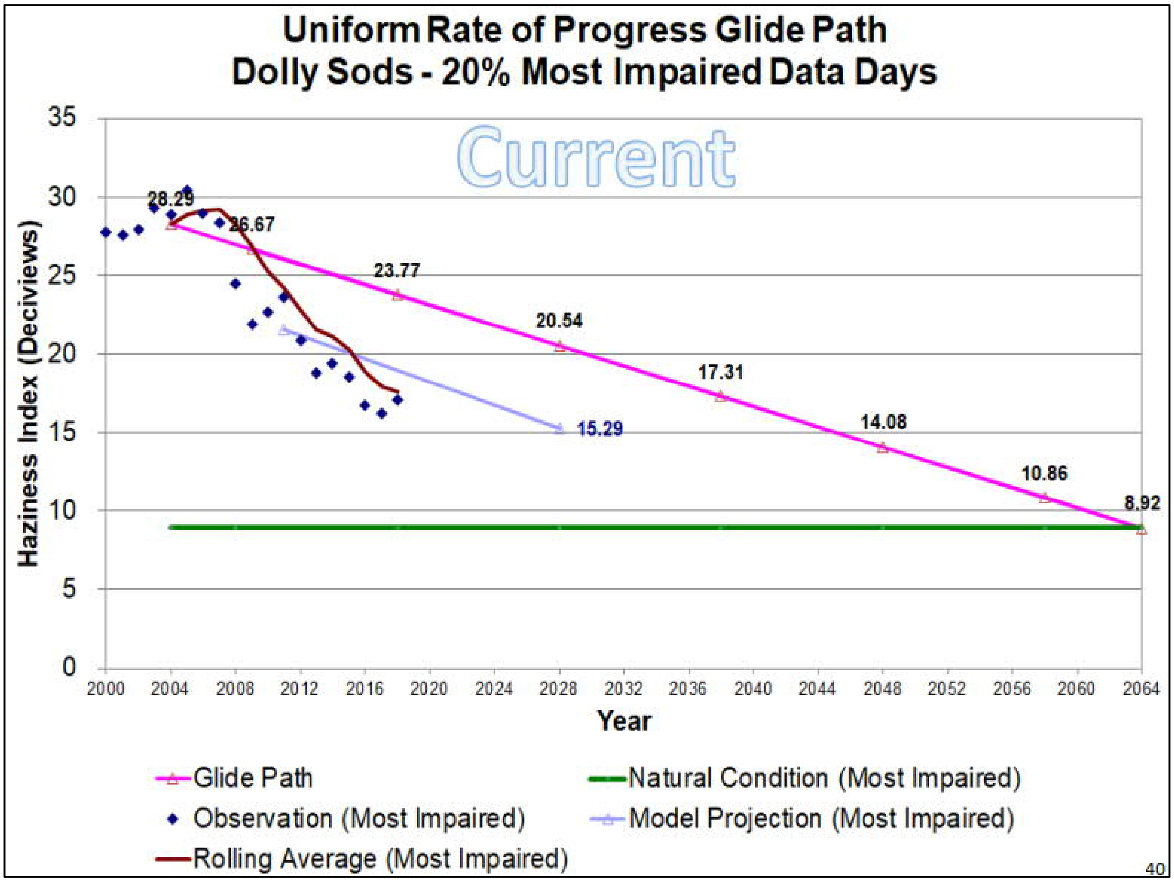
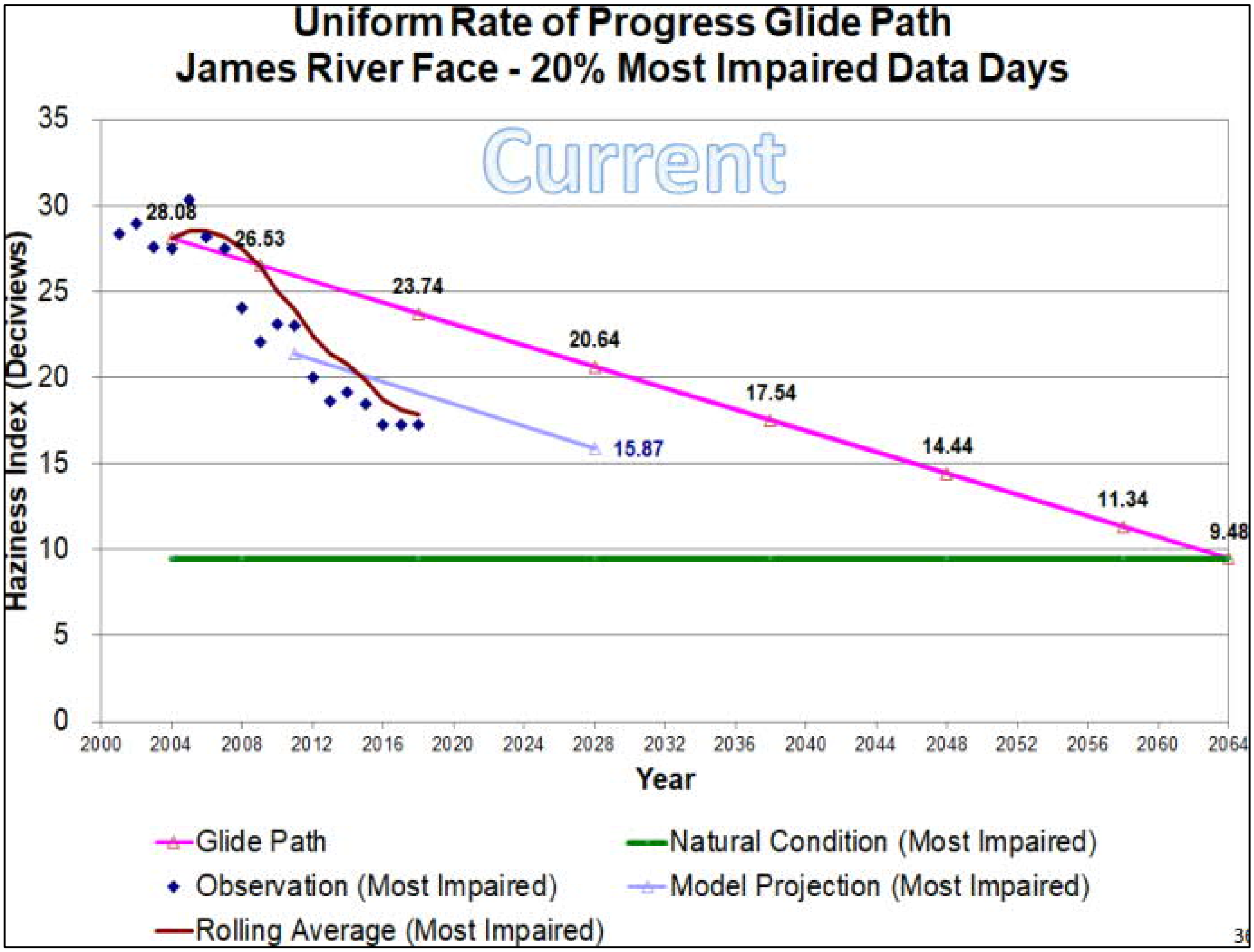


Figure 6-3 Visibility Trends at James River Face Wilderness Area



Figures 6-2 and **6-3** show that actual visibility measurements (the diamonds) confirm a strong trend of improved visibility in the past 10 years from about 28 DV to 16 DV in Dolly Sods WA and from 30 DV to about 17 DV in James River Face WA. These rates of actual improvement are much faster than the RHR target to maintain a “uniform rate of progress” or “glide path” (the pink line), which could be revised to a less-steep revised glide path to account for internationally-caused haze. However, VISTAS believes that since the Class I areas in this region are so far ahead of projections, that refinement is not necessary at this time.[9] Additionally, VISTAS modeling of the expected emissions reductions in the coming years (on-the-books / on-the-way controls) projects (the blue line) that visibility should continue to significantly improve, reaching 15.3 DV and 15.9 DV by the next RHR milestone year of 2028 for Dolly Sods and James River Face, respectively. These charts show that visibility in these Class I areas is currently running at least 10 to 20 years ahead of the RHR targets and is expected to continue to do so. VISTAS modeling of other regional Class I areas shows very similar trends and all areas are far ahead of their glide path targets. Therefore, no additional emissions reductions at any regional facilities, beyond those already planned, are needed to continue to meet the RHR interim goals.

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[9] VISTAS/SESARM response during Q&A of VISTAS Regional Haze modeling webinar presented on May 20, 2020.

6.5 Impact of Potential SO_2 Emission Reductions

The VISTAS modeling used 2011 actual annual emissions, and these values can be scaled to current representative emissions for the Gavin Power Plant with reductions to account for impacts (improvements) resulting from potential SO_2 controls options. Ohio EPA has stipulated that 2017 through 2019 average emissions should be considered as a representative baseline for this analysis and effects of potential SO_2 controls options were applied to these baseline emissions. The Gavin Power Plant's current emissions of SO_2 can be compared to modeled emissions for the Gavin Power Plant to develop, with linear scaling, conservative estimates of visibility impacts of the current SO_2 emissions. **Table 6-1** presents the baseline visibility impacts of the Gavin Power Plant's SO_2 emissions.

Table 6-1 Visibility Impact of Current SO_2 Emissions

Class I Areas Nearest to the Gavin Power Plant	**Total Haze Impacts of Current SO_2 Emissions**	
	Mm^{-1}	**DV***
Dolly Sods WA	***1.1460***	***0.3820***
James River Face WA	0.7064	0.2355
Shenandoah NP	0.6995	0.2332
Linville Gorge WA	0.5408	0.1803
Great Smoky Mountain NP	0.6305	0.2102
Mammoth Cave NP	0.2478	0.0826

** Potential Improvement in DV is listed for the 20% most impaired days for each Class I area. Conversion between deciviews and extinction is based upon the discussion in Section 6.4: 0.1 dv is equivalent to 0.3 Mm^{-1} for extinction.*

7. Conclusion

The current SO_2 controls on Units 1 and 2 are over 95% effective at reducing emissions of SO_2. There are no other technically feasible control measures identified in the four-factor analysis that are more efficient at controlling the SO_2 emissions on Units 1 and 2 than the currently installed wet FGD systems. The systems were recently upgraded and optimized to achieve a 95% SO_2 control efficiency and further optimization is not feasible at this time given the physical limitation of the systems.

Unit 1 and 2's current actual annual emissions of SO_2 result in estimated visibility impacts that are 2.5% of the projected 2028 visibility at the nearest Class I areas (Dolly Sods and James River Face). In addition, both these Class I areas are currently running at least 10 to 20 years ahead of the RHR glide path targets and are expected to continue to do so. Therefore, no further SO_2 reductions are required for Ohio EPA to meet its regional haze reasonable progress goals.