Navajo Nation Environmental Protection Agency
Air & Toxics Department
Air Quality Control Program

Summary of the Navajo Generating Station SO_2 DRR Dispersion Modeling Protocol and Analysis Results

January 2017

Table of Contents

List of Tables

List of Figures

1.1 Modeling Approach

The NNEPA modeling protocol references existing near-field dispersion modeling of NGS using earlier versions of AERMOD, conducted as part of the 2015 Navajo Generating Station – Kayenta Mine Complex EIS study (herein referred to as "2015 NGS EIS") as required for federal lease extension. The modeling protocol has been reviewed and discussed with U.S. EPA Region 9 for applicability to the SO_2 DRR. The modeling presented here for purposes of the SO_2 DRR followed the procedures described in the 2015 NGS EIS study (as referenced in *Guidelines for Air Quality Models*, 40 CFR Part 51, Appendix W) is summarized in Table 1.

Table 1. 2015 NGS EIS Dispersion Modeling Requirements

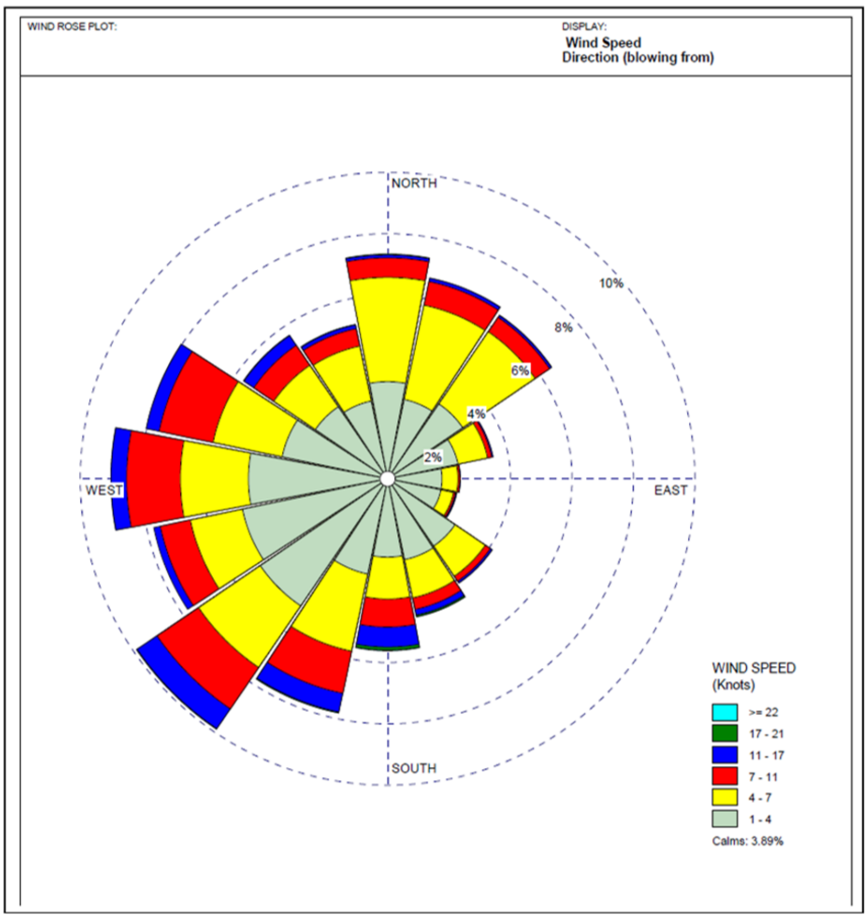
2015 NGS EIS Dispersion Modeling
2008-2012 actual SO_2 emissions, actual temperature and velocity
2008-2012 Meteorological Tower 1 surface observations
AERMOD/AERMET version 14134 with Beta ADJ_U* option
Use of actual stack height for designations using actual emissions
Receptors in all ambient air locations

There are two input data processors that are regulatory components of the AERMOD modeling system: 1) AERMET, meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and 2) AERMAP, a terrain preprocessor that incorporates complex terrain using United States Geological Survey (USGS) Digital Elevation Data. An earlier version of AERMOD and the associated preprocessors available at the time of the 2015 NGS EIS modeling analysis are as follows: AERMOD version 14134, AERMET version 14134, AERSURFACE version 13016 and AERMAP version 11103. The 2015 NGS EIS model applied the beta option to adjust the friction velocity in low wind speed stable conditions (ADJ_U* option). The modeled design concentration for 1-hour SO_2 is the 99^{th} percentile of maximum monitored daily values, averaged over five years. Whereas, the averaging period for the 2010 SO_2 NAAQS is the 99^{th} percentile of maximum monitored daily values, averaged over three years (herein referred to as "design value").

2.1 Meteorological Data

In order to generate meteorological input data for use with AERMOD, AERMET and AERSURFACE, preprocessing for the modeling domain was performed to generate input files for the surface (.sfc) boundary layer parameters and meteorological profile (.pfl). Five (5) years of hourly surface and upper meteorological data from 2008-2012 were collected from meteorological stations nearby NGS (i.e., surface station at Page, AZ Municipal Airport, KPGA and upper sounding data from Flagstaff, AZ, KFGZ), was processed with AERMET. These meteorological stations did meet U.S. EPA's ambient monitoring guidance relative to quarterly data capture completeness of 90%. Furthermore, the data and instrumentation are routinely maintained to the quality that would be required for modeling according to U.S. EPA's ambient monitoring guidance.

AERSURFACE was used to determine surface characteristics around the KPGA meteorological site using land cover data from the USGS National Land Cover Data 1992 archives (NLCD92). AERSURFACE incorporates look-up tables of representative surface characteristic values by land cover category and seasonal category. Hourly precipitation data, years 2008-2012 from the National Climatic Data Center (NCDC) were used to characterize monthly surface moisture conditions. Upper air data for the concurrent period was obtained from NCDC Radiosonde Observation Data Archive website and Flagstaff, Arizona (KFGZ) to characterize conditions in the region. A cumulative wind rose depicting annual trends of wind speed classes and wind direction frequency, years 2008-2012, for the surface station are shown in Figure 1. The wind rose demonstrates that average wind speeds are ~ 2.4 m/s with winds calm (less than 0.5 m/s) for approximately 4 percent of the observations. Predominate wind directions are from the southwest and west.



Source: Environ 2015.

Figure 1. Cumulative Wind Rose for Page Municipal Airport Station (2008-2012)

3.1 Ambient Background Concentration

The 2015 NGS EIS reviewed 2010-2012 1-hour SO_2 monitoring data observed at the NGS Glen Canyon air monitoring station located approximately 6 miles west-northwest of the NGS.

Guidelines from the Arizona Department of Environmental Quality[1] (ADEQ) were followed in the selection of background concentrations. The Glen Canyon monitoring station is maintained by NGS, who maintains a quality assurance program to validate data and ensure integrity and traceability to known standards. The monitor was therefore found to be the closest and most representative SO_2 monitor of ambient background concentrations. The background concentration for 1-hour SO_2 is the 99th percentile of the annual distribution of daily maximum 1-hour values averaged across the most recent three years from the Glen Canyon monitoring station, also referred to as the design value. The design value at this monitor is relatively low (22.5 $\mu g/m^3$) and was added to the modeled concentrations.

3.1.1 Nearby Sources

The 2015 NGS EIS review of major nearby emission sources from NGS indicated there were no existing or potential new reasonable foreseeable development sources within 50 km of NGS.

4.1 Emissions Data

The modeled SO_2 emissions occur primarily due to the combustion of coal in the Electric Generating Units (EGUs), Units 1, 2 and 3. Therefore, dispersion modeling of the NGS 3-Unit stack operations were conducted for this analysis using 2008-2012 hourly SO_2 emissions, hourly exit temperatures, and hourly exit velocities. Table 2 summarizes exhaust parameters for the NGS 3-Unit stack operations. Each of Units 1, 2, and 3 has its own stack, and the steel-lined concrete stacks are 775-foot (236.22 m) high. The three EGU stacks were modeled as buoyant point sources using the stack parameters listed in Table 2. Stack coordinates are based on UTM Zone 12, NAD 83 projection datum. Exempt intermittent emissions sources were excluded from the 1-hour SO_2 modeling.

Table 2. Units 4 and 5 Exhaust Parameters

	Stack 1	Stack 2	Stack 3
UTM X, Zone 12, NAD83	465,330	465,362	465,397
UTM Y, Zone 12, NAD83	4,084,392	4,084,324	4,084,219
Stack Base Elevation (m)	1,333.50	1,333.50	1,333.50
Stack Height (m)	236.22	236.22	236.22
Effective Diameter (m)	7.47	7.47	7.47
Stack Temperature (K)	321.50	321.50	321.50
Exit Velocity (m/s)	26.91	26.91	26.91

The 2015 NGS EIS modeling analysis for 1-hour SO2, in addition to stack emissions, also includes emissions from ancillary equipment such as vehicle exhaust, non-road diesel engines, the auxiliary boilers, and other sources.

[1] "Air Dispersion Modeling Guidelines for Arizona Air Quality Permits," *Air Quality Division, Arizona Department of Environmental Quality*, September 2013.

5.1 Receptors

The modeling domain was centered on the NGS and extend out to 80 km. A combined receptor grid system consisting of a nested Cartesian receptor grid, a polar grid, and discrete receptors was used for the near-field dispersion and deposition modeling to meet the needs in both resolution and the modeling domain coverage needed for the 2015 NGS EIS study. The details of the nested Cartesian grid and the polar are as follows:

- 10 meter spacing along the fence line
- 100 meter spacing in a 4 x 4 km Cartesian grid (out to 2 km);
- 200 meter spacing in a 10 x 10 km Cartesian grid (out to 5 km);
- 500 meter spacing in a 20 x 20 km Cartesian grid (out to 10 km); and
- 1 - degree polar grid spacing with distances 30, 40, 50, and 80 km from the facility

Additional discrete receptors were added for specific areas and locations where sensitive receptors are located. These locations include one or more of the following:

- Daycare facilities
- Schools
- Hospitals and health care facilities
- Senior homes and centers
- Residential areas
- Parks
- Ecological habitats
- Field sampling and monitoring locations

The latest version of AERMAP (Version 11103) was used to extract terrain elevations and critical hill heights for all receptors defined in the nested receptor grid using National Elevation Data (NED) with a horizontal spacing of 10 m. The receptor grid used in the dispersion and deposition modeling analysis was based on NAD 83 datum and in UTM Zone 12. Terrain elevations from USGS National Elevation Data (NED) were processed with AERMAP (version 11103) to develop the receptor terrain elevations required by AERMOD.

6.1 Building Downwash Analysis

According to the Modeling TAD, “EPA recommends the use of actual stack heights so that the modeling analysis can most closely represent the actual ambient air quality conditions as influenced by the source.” Also, “for both actual and Good Engineering Practice (GEP) stack heights, if building downwash is being considered, the BPIPRIME program should be used to input building parameters for AERMOD.” The actual stack heights listed in Table 2, were used in the modeling analysis as building downwash effects can influence the predictions from many modeled stacks and point sources. EPA’s Building Profile Input Program (BPIPPRM-Version 04274) was used to characterize buildings and structures to support AERMOD’s downwash algorithms. Wind direction-specific building dimensions for input to AERMOD were developed with BPIPPRM. A total of 26 structures were identified and included in the BPIPPRM modeling based on site-specific information (CAD drawings) provided by the Salt River Project Utilities Company (SRP). The heights for each building and each tier were measured by SRP. The building dimensions (length and width) for each structure were extracted using CAD drawings provided by SRP for the NGS site.

7.1 Modeling Analysis Results

The 2015 NGS EIS modeling analysis results of the 99th percentile maximum daily values, averaged over the five years modeled, are equal to 163.6 µg/m^3 (63 ppbv), which is below the 1-Hour SO_2 NAAQS of 196 µg/m^3 (75 ppbv). Impacts from SO_2 emissions are dominated by the main stack plumes with the peak maximum impacts occurring at approximately 8.3 km to the southeast of NGS And limited to a very small area of high terrain of NGS (see Figure 2 (see Figure 2). All modeling archive files are listed in Appendix A, with a digital copy provided. The NNEPA provides this information to U.S. EPA Region 9 in support of a NAAQS attainment designation.

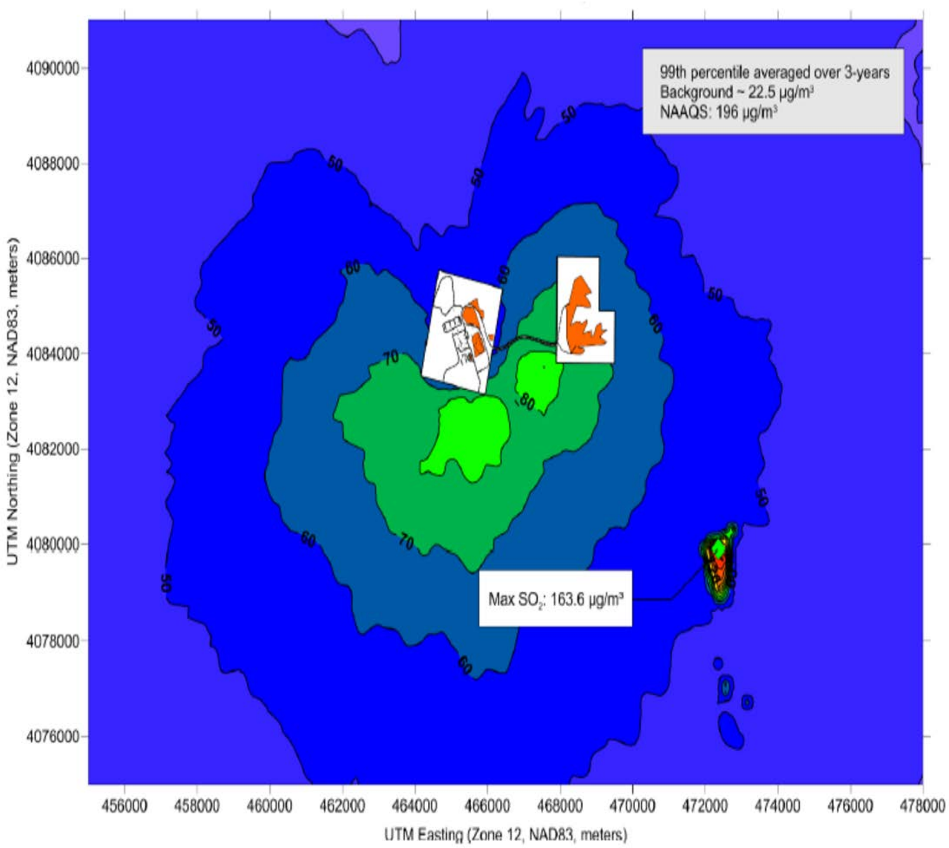


Figure 2. Navajo Generating Station 1-Hour SO_2 Air Dispersion Modeling Results

Appendix A

EIS Modeling Archive Files for Salt River Project Navajo Generating Station
SO_2 AERMOD Modeling
October 28, 2016

AERMET

The surface meteorological data from Page Municipal Airport (KPGA, WMO ID 723785) and upper air data from Flagstaff (KFGZ, WMO ID 72376) were processed with AERMET version 14134, using the adjust u* option.

- *.in1, *.in2, *.in3 : The AERMET Stage 1, Stage 2, and Stage 3 input files
- *.SFC : Surface data file for AERMOD
- *.PFL : Upper Air data file for AERMOD
- UPA/*.TXT : Upper Air soundings from Flagstaff
- SFC/*.ISHD : ISHD format of the surface data from KPGA

AERMINUTE

AERMINUTE version 11325 was used to process the 1 minute data from KPGA. These data can be found in the aermet_30comp\1MIN\ directory.

- *.inp : AERMINUTE input file
- *.DAT : AERMINUTE output file
- KPGA.1MIN.data.tar.gz : Archive of raw 1-minute data

AERSURFACE

The aermet_30comp\SFC\LANDUSE* directories contain files used to process the land use data around the Page Municipal Airport for input into Stage3. AERSURFACE version 13016 was run for all three surface moisture conditions – average, wet, and dry. These files were combined together based on comparison with historic 30-year monthly precipitation data for each year of met data. The input and output files can be found under the aermet_30comp\SFC directory for each of the three surface moisture types. The compiled surface parameter file can be found under the aermet_30comp\SFC\LANDUSE directory. Prepared with state-wide NLCD92 landuse data, "arizona.nlcd.tif," available upon request.

- *.inp : AERSURFACE input file
- *.OUT : AERSURFACE output file

Note that the raw landuse data file was not provided because of its large size. These data can be downloaded from the USGS National Map Viewer and are available upon request.

AERMAP

This folder contains AERMAP (version 11103) files used to process terrain data to produce the receptor elevations and critical hill heights for use in AERMOD. Combined, 10-meter resolution USGS NED data file, "terrain_large_UTM.tif" available upon request.

- *.inp : AERMAP input file for the Cartesian grid receptors
- *.recs : AERMAP output file of the Cartesian grid receptors

Note that the raw terrain data files are not provided because of their large size. These data can be downloaded from the USGS National Map Viewer and are available upon request.

BPIP

This BPIP folder, located under the aermod.naaqs.2020.B2 folder, contains BPIP input and output files processed with BPIP Version 04274. Data from the summary file were organized by source in the aermod.naaqs.2020.B2\incl directory.

- bpip/*.in : BPIP input file
- bpip/*.out : BPIP output file
- bpip/*.sum : BPIP summary file
- incl/*.bpip : Source specific BPIP downwash data used in AERMOD

Emissions

SO_2 emissions from the coal-fired boiler stacks at NGS were based on a 0.1 lb/MMBtu limit and are 3239.6 tons/year from each of the three stacks. Stack parameters are shown in Table 2-2 of the “July 2016 Final Near-field AERMOD modeling” report prepared for the DEIS. No temporal profile was used for the stack emissions. Note that emissions from several other source categories were also modeled for the EIS.

AERMOD

This folder contains the AERMOD input and plot results for the SO_2 and SOx modeling. Due to the large number of sources and receptors, the input files in the aermod.naaqs.2020.B2\ directory were “zoned” into 49 groups for the SO_2 modeling and 16 groups for the SOx modeling. Zoned input, output, plot results, and receptors can be found under the zoned_files\ directory. These files were processed using AERMOD version 14134. The zoned plot files were merged for each year and labeled with the suffix, *.plot.join.dat, in the aermod.naaqs.2020.B2\ directory.

- *.in : Original AERMOD input file
- zoned_files\zone[X].[Y].rec : Receptor file for zone [X] of [Y] zones.
- zoned_files*.in : Zoned AERMOD input file
- zoned_files*.out : Zoned AERMOD output file

- zoned_files*.plot : Zoned AERMOD plot result file
- *.plot.join.dat : Merged AERMOD plot result file

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unix2dos.exe

The AERMOD runs were done on Linux. All files use UNIX style line endings. The unix2dos.exe program has been included to help convert these files to DOS formatted line endings, if necessary for review.