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User Manual for the Beta Version of the Emissions Variability Processor (EMVAP) Modeling System

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ABSTRACT

This User's Guide provides documentation for the EMissions VAriability Processor (EMVAP) System (version 2.0, level 11333). The motivation for the development of the EMVAP system is to provide an option for satisfying the dispersion modeling challenges posed by the newly promulgated 1-hour National Ambient Air Quality Standards (NAAQS) for sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), although the application of the EMVAP system is not necessarily limited to 1-hour average modeling applications. The SO_2 NAAQS statistic is the 99th percentile daily maximum 1-hour concentration (4th highest) over a year at any single location, averaged over three consecutive years. The NO_2 NAAQS statistic is identical, except that it is based on the 98th percentile daily maximum 1-hour concentration (8th highest) over a year.

Standard practice in dispersion modeling to assess NAAQS compliance is to apply the maximum permitted emission rate to modeled sources for every hour of a year to assure that modeled concentrations are conservative. In areas where emissions from major sources are highly variable, modeling in this unrealistic manner is so conservative that the modeling results cannot reasonably be relied upon in determining NAAQS compliance.

One way to avoid such extreme and unrealistic modeling results, but at the same time ensure meaningful modeling results, is to account for a degree of emissions variability in computing the NAAQS statistic. EMVAP is a Monte Carlo-based probabilistic technique that accommodates emissions variability in dispersion modeling assessments in a manner that is both statistically robust and readily verifiable through the use of continuous emissions monitoring (CEM) and record-keeping common to many industrial sources.

Keywords

NAAQS (National Ambient Air Quality Standards)
Emission
Plume model
Dispersion model
AERMOD
EMVAP
SO_2
NO_2

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1
INTRODUCTION

1.1 Overview of the EMVAP Modeling System

This User's Guide provides documentation for the EMissions VAriability Processor (EMVAP) System (version 2.0, level 11333) developed by AECOM under contract with the Electric Power Research Institute (EPRI). The impetus for the development of the EMVAP system is to meet the dispersion modeling challenges posed by the newly promulgated statistically-based 1-hour National Ambient Air Quality Standards (NAAQS) for sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), although the application of this system is not necessarily limited to 1-hour average modeling applications. The SO_2 NAAQS statistic is the 99th percentile daily maximum 1-hour concentration (4th highest) over a year at any single location, averaged over three consecutive years. The NO_2 NAAQS statistic is identical, except that it is based on the 98th percentile daily maximum 1-hour concentration (8th highest) over a year.

Guidance provided by the United States Environmental Protection Agency (EPA) indicates that if on-site meteorological data is available, NAAQS compliance can be based on a minimum of 1 year or the average for up to 5 years. If off-site meteorological data is used, EPA has determined that the average over 5 years of modeling (rather than the 3 years inherent in the NAAQS definitions) should be used, as it represents an unbiased estimate. Standard practice in dispersion modeling to assess NAAQS compliance is to apply the maximum permitted emission rate to modeled sources for every hour of a year to assure that modeled concentrations are conservative. In areas where emissions from major sources are highly variable, modeling in this unrealistic manner is so conservative that the modeling results cannot reasonably be relied upon in determining NAAQS compliance.

One way to avoid such extreme and unrealistic modeling results, but at the same time ensure some level of conservatism, is to account for a degree of emissions variability in computing the NAAQS statistic. EMVAP is a Monte Carlo-based probabilistic technique that accommodates emissions variability in dispersion modeling assessments in a manner which is both statistically robust and readily verifiable through the use of continuous emissions monitoring (CEM) and record-keeping common to many industrial sources.

The EMVAP system is comprised of three computer program modules (written in Fortran):

1. EMDIST is an auxiliary program that can be used for a source to assist in the development of the frequency distribution of the hourly emission rate. This module provides a standardized methodology that will simplify the assessment and help remove subjective aspects. Additionally, EMDIST provides a recommended set of emission bins for use with EMVAP.
2. EMVAP applies a Monte-Carlo approach to create a user-specified number of realizations of hourly modeled concentrations, each representing 1-year of modeling results (e.g., for SO_2, the 99th percentile daily maximum concentration at each receptor) based on random sampling from a user-specified emissions distribution, such as the output of EMDIST.

3. EMPOST is a post-processing program that combines the results of EMVAP for each modeled source and allows the user to select the results in a probabilistic manner.

Section 2 of this user's guide provides a technical description of each module followed by detailed user instructions in Sections 4, 5 and 6 for EMDIST, EMVAP and EMPOST, respectively.

1.2 Disclaimer Notification

The EMVAP modeling system has been developed by AECOM as a package of modeling post-processors to provide the capability of accommodating emissions variability into AERMOD dispersion modeling.

The EMVAP system software and accompanying documentation is provided "as-is", and no warranty of its suitability for any particular application is provided. AECOM assumes no liability for the use of this software by non-AECOM users.

Although this software has been tested to some degree, it is the user's responsibility to determine if EMVAP is appropriate for any particular application. The user ultimately assumes all responsibility and liability for its use. Please note that computer codes and documentation may contain coding, implementation, and technical errors that are often discovered through extensive use.

AECOM would appreciate the receipt of user information about any EMVAP application or code enhancements that are worthy of sharing for purposes of code improvements.

2
TECHNICAL DESCRIPTION OF EMVAP

2.1 Developing Emission Bins and Frequencies using EMDIST

EMDIST can be used to assist the user in specifying the emissions distribution ("bins") for input into the EMVAP program by examining the hourly emissions data file from a source and presenting two sets of recommended bins, one based on even distribution by emission flux and a second based on evenly distributed chance of occurrence. The present beta test version of EMVAP assumes that emissions variability is independent of time of day, time of year and so forth. Because the statistic of interest is the daily maximum modeled concentration, it is conservative to assume that emissions are randomly distributed, as this maximizes the possibility that high emissions will be distributed among different days rather than lumped together on the same day. Nevertheless, there may be cases that these correlations are important in accurately characterizing emissions. Therefore, EMDIST can characterize emissions variations for the whole year in addition to time of day and season of the year.

The emission frequency bins used by EMVAP are defined by the user according to a user-specified set of emission bins that are each assigned a frequency of occurrence. Presently, specification of emission bins in terms of emission rate and frequency are left up to the user on a source-by source basis. EMDIST automatically generates recommended emission bins directly from the emissions data, which then can be adjusted by the user or taken as is and input into EMVAP.

An example of how bins and frequencies can be established from a continuous record of hourly emissions is illustrated in Figure 2-1. This can be done in the following steps:

1. Plot the cumulative distribution of hourly emissions
2. Select frequency cutpoints for the bins that capture the distribution
3. From these cutpoints, determine the frequency assigned to each bin
4. Set an emissions rate for each bin that is equal to or slightly exceeds the maximum emission rate within the bin.

In cases where the variability in emissions is at least in-part related to the operating load of the source, EMVAP requires that an appropriate stack temperature and exit velocity be modeled for each bin. If the continuous emission record includes these parameters, the data should be analyzed to determine the median (50^{th} percentile) stack temperature and exit velocity corresponding to each emissions bin. For the example shown in Figure 2-1, the median stack parameters would be determined for the following emission rate categories: 100 to 140 g/sec, 65 to 100 g/sec, 40 to 65 g/sec, 25 to 40 g/sec, and 1 to 25 g/sec. If stack temperature and exit velocity data are included in the input to EMDIST for each hour, EMDIST calculates the 50^{th} percentile of the data within each bin and presents a recommended stack temperature and exit velocity along with emissions and percent chance of occurrence.

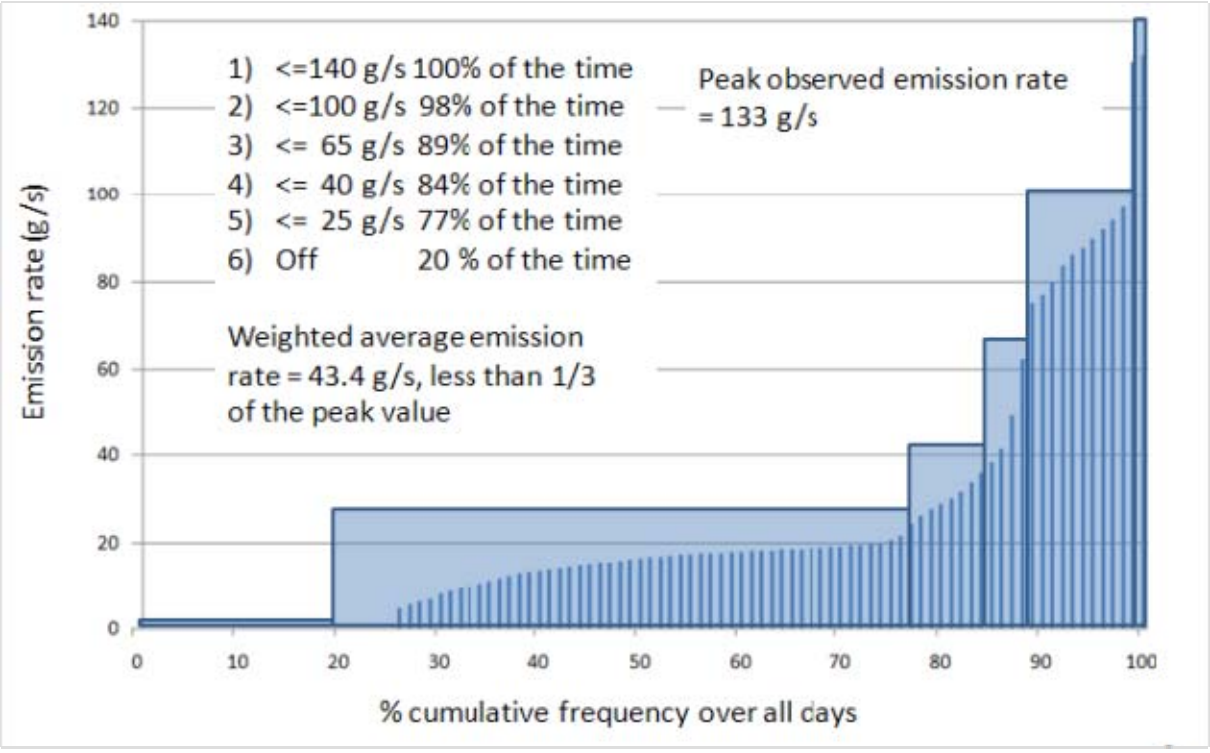

Figure 2-1
Example Emissions "Bins" for EMVAP from Cumulative Frequency Profile

For a new source or for sources that do not have a continuous historical record of hourly emissions, the analyst should assign bins and frequencies based on distributions for similar facilities, engineering judgment or operational experience. In such cases, the methods and assumptions used will need to be thoroughly documented and, if applicable, approved by the regulatory authority.

2.2 Compute Randomized AERMOD Simulations of NAAQS Statistics with EMVAP

The EMVAP program is used to generate data sets of hourly modeled concentrations generated by assigning a randomly selected emission rate to emission-normalized modeled hourly concentrations generated by AERMOD. As discussed above, the emissions can be determined by analyzing actual or proposed emission data and creating "emission bins", each of which are assigned to a specific load case or cases that represent various operating scenarios of the source being considered. Each of these bins is assigned a probability of occurring during any given hour and that probability is used to determine which emission rate is assigned each hour. To include a source with constant emissions throughout the year, a single bin with a 100% frequency is specified. To include background concentrations, a source with zero emissions can be specified and the background option is specified in the AERMOD run.

The appropriate NAAQS statistic (e.g., for SO_2, the 99th percentile daily maximum concentration over a year) from each simulation, representing one time through an AERMOD run of up to 5 years of meteorological data, is then written to a text file to be used as input to EMPOST post-processor.

In EMVAP, the user specifies:

- Number and list of years included in the analysis
- The NAAQS standard for which the EMVAP results are to be compared
- The number of source data sets included in the EMVAP run
- For each source data set:
  - The load cases and names of the AERMOD result files
  - Emission bins and associated frequencies
  - The number of Monte Carlo simulations (up to 5000)
  - Receptor files (up to 1000 receptors per EMVAP run)
  - Selection of random number file used to choose the hourly emission bins. For sources with emissions that vary in unison, the sources are included in the same AERMOD run.
- Whether or not EMVAP should generate logs of the modeled daily maxima and/or hourly concentrations for debugging purposes.

For each simulation, EMVAP creates a file containing the output in the form of the standard being considered is generated to be used as input into EMPOST. The data file for each iteration includes:

- Simulation Number
- Years being evaluated
- Number of receptors in the study
- First random hour selected for this specific iteration
- The calculated concentration corresponding to the NAAQS statistic for each receptor and for each year of data.

2.3 Computing Probabilistic NAAQS Statistics with EMPOST

The EMPOST program is applied to collate the data output by the EMVAP and present a statistical analysis of the results. EMPOST calculates the NAAQS statistic (design value), then presents the statistical results based on the Monte Carlo simulations performed in the study.

The EMPOST program generates an output file named “EMPOST.out”, containing the following information:

- Summary of the program inputs.
- List of the iteration file names analyzed.
- For each iteration, the maximum calculated design value at each receptor.
- A summary of the results of all iterations including:
  - The maximum design value over all receptors at each receptor included in the study.
  - The average design value over all receptors at each receptor included in the study.
  - Results for up to 10 percentile levels input by the user

- A summary table with the overall highest design concentration, which receptor it occurred at, and which iteration it occurred during (see Table 2-1).
- A summary table with the highest average design concentration and the receptor at which it occurred.

- Reports at which percentile the applicable standard is exceeded, if any.

Table 2-1
Example of EMPOST Summary Output

SUMMARY OF RESULTS: ALL ITERATIONS (ug/m3)

Receptor		Overall MAX	Overall AVG	PERCENTILE RESULTS 50	60	70	75	80	85	90	95
3600.00	69700.00	251.41	202.87	196.86	208.71	219.07	219.07	225.74	225.74	231.50	239.73
4520.00	69780.00	458.40	354.04	340.82	350.50	364.54	371.26	372.07	400.39	413.85	415.39
5500.00	70450.00	306.59	260.69	254.45	275.24	302.87	302.87	302.87	306.59	306.59	306.59
4780.00	70700.00	406.56	347.33	348.99	355.01	366.12	374.81	375.74	382.31	382.31	390.87
5110.00	70850.00	385.87	333.46	339.37	341.06	344.04	344.04	345.11	348.24	348.24	348.24
5810.00	70900.00	343.94	298.31	295.45	296.18	299.22	309.22	325.64	326.75	331.71	336.66
5860.00	71340.00	127.98	111.75	109.31	111.92	116.23	119.27	119.27	123.29	126.98	126.98
6250.00	71070.00	352.58	307.48	319.45	319.49	327.76	327.76	328.51	329.25	338.62	352.58
6930.00	71300.00	110.80	99.95	99.64	100.07	102.04	105.32	105.32	105.68	106.28	108.69
MAXIMUM VALUES		458.40	354.04	348.99	355.01	366.12	374.81	375.74	400.39	413.85	415.39

3
USER INSTRUCTIONS FOR EMDIST

3.1 How to Use the EMDIST Program

The EMDIST program is used to determine the emissions data to be input into the EMVAP program, which in turn uses AERMOD output data to apply a probabilistic approach to emissions from a source rather than assuming maximum PTE emissions for the entire modeling period, with the aim of producing more realistic modeled impacts. This is especially valuable when applied to a NAAQS with a probabilistic form such as the 1-hour NO_2 or SO_2, or the 24-hour $PM_{2.5}$ NAAQS.

EMDIST takes hourly emissions data from a source and processes it to aid in the categorization of the data into emissions "bins" for input into the EMVAP program.

The EMDIST program generates 2 output files containing the following information:

- The main output file containing the following information:
  - Summary of maximum and average emissions, total and online-only, by season and annually.
  - Hourly breakdown of average emissions, maximum emissions and time online, also broken down by season and annually.
  - Number of hours online by season with percentages.
  - An outage report detailing the duration of each off-line period for the source, along with the dates.
  - Details including the total number of outages, total hours offline, and average length of an outage.
  - Most importantly, EMDIST Recommends two sets of emission bins for use with EMVAP: the first analyzes the emissions flux and creates a number of bins defined by the user equally distributed by emission flux. The second set creates a number of bins equally distributed by percentile. In both sets of bin recommendations, the emission rate to be used for each bin is suggested; along with the recommended stack exit temperature and velocity associated with each bin (developed by using the 50th percentile of all hours included in the defined bin. For more information on how the recommended bins are developed, see the "Recommended Emission Bins" section below.
- The second file, created if the user has provided hourly temperature data concurrent to the emissions data input, includes:
  - Average temperature in Fahrenheit for each day.
  - Average emissions when the unit was online by day.
  - Summary of the number of hours online for which temperature data was available for each day.

3.2 How to Set Up the Input File and Run EMDIST

The EMDIST program takes input data from a text file which must be named "EMDIST.inp". See the example file included in the program folder. The data must be formatted EXACTLY as seen in that file in order to be processed correctly (do not remove any of the lines of comments). The following inputs are required:

- Number of years to be analyzed (1 through 5).
- Name of the emission files, one for each year (up to 40 characters). One filename per line.
- Years to be analyzed (on one line, with spaces between each year).
- Format of the data: Enter "1" if the data is in the form of an AERMOD input file, "2" if the data has been pulled from the Acid Markets Database or another source and put into the format described below. There must be one line for every hour of the year in question within the input file:
  1. AERMOD input file format. The emissions data must be in g/s and is read in the following order:

     "SO HOUREMIS"(ignored), Year, Month, Day, Hour, Stack name(ignored), Emissions (g/s), Stack Temp. (K) if available, Stack Exit Velocity (m/s) if available

     An example of this form of input is:

```
SO HOUREMIS  88  1  1  1 STK4N5    175.605  403.160   14.123
SO HOUREMIS  88  1  1  2 STK4N5    159.854  404.827   14.856
SO HOUREMIS  88  1  1  3 STK4N5    132.284  399.271   12.740
SO HOUREMIS  88  1  1  4 STK4N5     95.782  387.049    8.344
SO HOUREMIS  88  1  1  5 STK4N5     77.730  384.271    7.284
SO HOUREMIS  88  1  1  6 STK4N5     79.478  383.716    7.041
SO HOUREMIS  88  1  1  7 STK4N5     76.521  383.716    7.121
SO HOUREMIS  88  1  1  8 STK4N5     81.619  384.271    7.204
SO HOUREMIS  88  1  1  9 STK4N5     81.619  384.271    7.204
SO HOUREMIS  88  1  1 10 STK4N5     90.234  385.938    7.854
```

     etc….

  2. Free form data from Acid Markets Database or another source. The emissions data must be in lb/hr. The data is read in the following order:

     Month, Day, Year, Hour, Emissions (lb/hr), Stack Temp. (K) if available, Stack Exit Velocity (m/s) if available

     An example of this form of input is (note that in this format the hour of the day is hour beginning and thus runs from 0 to 23 each day):

Month	Day	Year	Hour	SO2	Temp	Exit. Vel.
1	1	2009	0	16585.0	403.160	14.123
1	1	2009	1	16445.7	404.827	14.856
1	1	2009	2	16035.2	399.271	12.740
1	1	2009	3	16016.9	387.049	8.344
1	1	2009	4	16450.4	403.160	14.123
1	1	2009	5	16821.2	404.827	14.856
1	1	2009	6	15975.4	385.938	7.854
1	1	2009	7	13666.0	384.271	7.204
1	1	2009	8	11787.2	403.160	14.123
1	1	2009	9	14818.2	404.827	14.856
1	1	2009	10	15643.9	404.827	14.856
1	1	2009	11	15711.3	383.716	7.121
1	1	2009	12	13832.1	385.938	7.854
1	1	2009	13	11855.7	403.160	14.123
1	1	2009	14	9998.9	404.827	14.856
1	1	2009	15	9319.1	383.716	7.121
1	1	2009	16	11817.1	384.271	7.204
1	1	2009	17	14965.1	403.160	14.123
1	1	2009	18	14269.1	404.827	14.856
1	1	2009	19	15227.8	383.716	7.121
etc....						

Note also that the first line in this format is a header and the data starts on line number 2.

An example of each types of input data file is included in the program package.

Finally, note that EMDIST assumes a full year of data for each year input. There may be hours with zero emissions (representing down time for the emissions unit), but there *MUST* be an entry for every hour in every year included in the study.

- The user identifies whether stack temperature and/or exit velocity are included in the input data. The following entries are allowed:
  1. Emissions only, no stack temperature or exit velocity data included
  2. Emissions, stack temperature, and exit velocity all included
  3. Emissions and stack temperature included (no stack exit velocity)
  4. Emissions and stack exit velocity included (no stack temperature data)
- Do you have an hourly temperature file? Enter "1" if yes, or "2" if no. If yes, a report of daily average temperatures and emissions will be generated as output by EMDIST.
- If yes, what is the name of the hourly temperature data file(s)? Enter the name of one file per line. Each file must have a line for each hour of the year and temperature data must be in degrees Fahrenheit. 40 character limit per filename. The data must be in the following order, separated by 1 or more spaces:

  Year, Month, Day, Hr, Temperature (F)

  An example of the format of the temperature file is included in the program package and is also shown below. Missing temperature data is indicated in the file by entering 999.00 for that hour.

Yr	Mo	Dy	Hr	Temp(F)
2009	1	1	1	19.85
2009	1	1	2	19.31
2009	1	1	3	19.31
2009	1	1	4	18.95
2009	1	1	5	19.31

etc….

- Name of the output temperature data file (40 characters max.). EMDIST will output the daily average temperature and emissions to this file. If no temperature file was included, this line will be ignored by EMDIST. The output will be in the following form:

01/01 Avg. Temp(F):	22.1	Avg. Emissions(g/s):	1831.9	Active Hours	24
01/02 Avg. Temp(F):	28.9	Avg. Emissions(g/s):	911.3	Active Hours	1
01/03 Avg. Temp(F):	0.0	Avg. Emissions(g/s):	0.0	Active Hours	0
01/04 Avg. Temp(F):	0.0	Avg. Emissions(g/s):	0.0	Active Hours	0
01/05 Avg. Temp(F):	31.7	Avg. Emissions(g/s):	237.3	Active Hours	16
01/06 Avg. Temp(F):	29.8	Avg. Emissions(g/s):	941.5	Active Hours	24
01/07 Avg. Temp(F):	34.7	Avg. Emissions(g/s):	1477.5	Active Hours	24
01/08 Avg. Temp(F):	23.8	Avg. Emissions(g/s):	1490.0	Active Hours	24
01/09 Avg. Temp(F):	22.9	Avg. Emissions(g/s):	1541.9	Active Hours	24
01/10 Avg. Temp(F):	28.8	Avg. Emissions(g/s):	1539.1	Active Hours	24

  Note that in the calculations for this data, only hours that have both non-missing temperature data and emissions greater than 0 are considered in the averages. The last column of the output data indicates how many valid hours were considered for each day.
- The number of emission bins EMDIST should create. This must be a number between 5 and 20 (10 being the default).
- Enter whether or not to accept the default emission flux values when developing the recommended bins based on equally distributed emission flux. Enter "1" to accept defaults, "2" to define the flux bins manually.
- If the user selected user defined emission fluxes for bins, enter the emission fluxes in g/s, in ascending order, one for each bin. There must be one for each bin. All entries should be on the same line and must equal the number of bins defined earlier in the input file. For example, if the user input 10 for the number of emission files, the line might read:

  100 200 300 400 500 600 700 800 900 1000

  This input would define the emissions for each bin as 100 g/s through 1000 g/s. EMDIST would then determine the number of hours falling into each bin and develop recommended percentage chance of occurring for each bin.

3.3 EMDIST Output

Only one output file, named "EMDIST.out", is created regardless of the number of years of data input: if more than one year of data was included, the results are added together. The output file has four sections: data by season, annual data, outage report, and recommended bins. The seasonal report looks as follows:

Hour	Max (g/s)	Avg (g/s)	Hours Online	Avg. when Online (g/s)	Pct. Online
Hour: 01	2089.66	829.68	54	1382.80	60.0
Hour: 02	2072.11	830.32	53	1409.98	58.9
Hour: 03	2020.39	821.05	53	1394.24	58.9
Hour: 04	2018.08	813.08	53	1380.69	58.9
Hour: 05	2072.70	813.66	54	1356.11	60.0
Hour: 06	2119.42	832.75	53	1414.11	58.9
Hour: 07	2012.85	865.69	53	1470.04	58.9
Hour: 08	1959.15	938.42	53	1593.55	58.9
Hour: 09	2852.51	970.33	54	1617.22	60.0
Hour: 10	2384.72	955.02	54	1591.70	60.0
Hour: 11	2176.07	963.95	54	1606.58	60.0
Hour: 12	2268.24	954.15	54	1590.25	60.0
Hour: 13	2180.78	922.25	53	1566.09	58.9
Hour: 14	2938.02	931.29	53	1581.44	58.9
Hour: 15	2225.01	897.75	53	1524.49	58.9
Hour: 16	2181.99	886.32	53	1505.07	58.9
Hour: 17	2092.82	881.98	53	1497.71	58.9
Hour: 18	2089.40	915.95	53	1555.39	58.9
Hour: 19	2113.55	943.84	53	1602.75	58.9
Hour: 20	2112.06	942.10	53	1599.79	58.9
Hour: 21	2081.62	939.64	53	1595.62	58.9
Hour: 22	2053.50	916.53	53	1556.36	58.9
Hour: 23	1974.71	865.64	53	1469.96	58.9
Hour: 24	1882.00	819.08	51	1445.44	56.7
Winter:	2938.02	893.77	1276	1512.96	59.1

As shown above, the data is broken down by hour of the day in order to study any diurnal pattern in emissions the unit may have. The final column summarizes the data for the entire season. The Average When Online column ignores hours where the unit had no emissions while the Average column includes all hours.

The annual report looks identical to the seasonal report except that it summarizes the data over the entire year (or years) analyzed.

The third section of the output file is the outage report, which summarizes the times during the period analyzed when the unit being studies was offline. The outage report looks as follows:

SUMMARY OF OUTAGES IN 2009

START	END	DURATION (hrs)
01/02/09, hour: 2	01/05/09, hour: 4	75
01/05/09, hour: 6	01/05/09, hour: 8	3
01/05/09, hour: 24	01/05/09, hour:24	1
02/20/09, hour: 24	03/01/09, hour:18	211
03/02/09, hour 10	03/02/09, hour:10	1
03/06/09, hour: 3	03/08/09, hour:10	56
03/31/09, hour: 1	04/01/09, hour:22	46
04/08/09, hour: 2	04/10/09, hour: 2	49
04/15/09, hour: 19	04/16/09, hour:16	22
04/25/09, hour: 8	04/25/09, hour:12	5
06/10/09, hour: 23	06/15/09, hour: 5	103
08/09/09, hour: 24	08/10/09, hour: 4	5
09/05/09, hour: 20	09/08/09, hour: 6	59
09/08/09, hour: 10	09/10/09, hour: 5	44
09/11/09, hour: 22	09/20/09, hour: 9	204
10/23/09, hour: 3	10/25/09, hour: 7	53
10/25/09, hour: 21	10/25/09, hour:23	3
11/08/09, hour: 23	11/22/09, hour:14	328
12/06/09, hour: 13	12/31/09, hour:24	612

There were a total of 19 outages in 2009.
Total number of hours offline: 1880
Average number of hours offline per outage: 98.9
The longest single outage lasted 612 hours.

Recommended Emission Bins:

The final section of EMDIST.out contains the recommended emission bins generated by EMDIST.

Recommended Bin Cases by Emission Flux:

The first set of emission bins generated is based on an equal distribution by emission flux, or user defined emission fluxes if the user elected to manually input them. If the default option was chosen, the maximum emission rate read in is divided by the number of bins specified. Then every hour read in is sorted into the appropriate bin to determine the frequency at which each bin will occur. An example set of recommended bins might look as below. The output shows the number of hours in the bin, the corresponding percentage of time this bin will be chosen by EMVAP, the emissions rate associated with this bin, and the corresponding recommended stack temperature and exit velocities (if the data was available) for each bin. The stack temperature and exit velocity are determined by taking the 50^{th} percentile value of all hours in that bin. Note that hours with 0 emissions are ignored for that calculation.

Recommended Bin Cases by Emission Flux:

Bin	Hours	Pct.	Emis.(g/s)	Temp(K)	Vel.(m/s)
1	1236	14.1	19.79	390.38	9.98
2	91	1.0	39.58	381.49	8.02
3	282	3.2	59.37	383.72	8.62
4	851	9.7	79.16	385.94	8.75
5	1170	13.3	98.95	390.38	10.13
6	873	9.9	118.74	392.05	11.36
7	1079	12.3	138.53	397.88	14.12
8	897	10.2	158.32	399.27	16.16
9	620	7.1	178.11	396.91	17.01
10	424	4.8	197.90	380.94	18.03
11	346	3.9	217.69	385.24	22.93
12	297	3.4	237.48	386.49	23.89
13	206	2.3	257.27	387.74	24.72
14	139	1.6	277.06	390.66	26.74
15	135	1.5	296.85	391.49	27.24
16	82	0.9	316.64	391.77	27.96
17	40	0.5	336.44	392.05	28.19
18	13	0.1	356.23	393.99	29.66
19	2	0.1	376.02	382.74	22.38
20	1	0.1	395.81	388.72	24.50

Recommended Bin Cases by Equal Bin Distribution

The second set of bin recommendations is always based on evenly distributed percentage chance of occurring, which is determined by dividing 100 by the number of bins. The example below shows 20 bins, each of which will occur 5% of the time in EMVAP. All hours of input data are sorted by emission rate and the highest emission rate for each bin is determined.

Recommended Bin Cases by Equal Bin Distribution

Bin	Pct.	Emis.(g/s)	Temp(K)	Vel.(m/s)
1	5.0	0.00	0.00	0.00
2	5.0	0.00	0.00	0.00
3	5.0	38.70	385.38	9.20
4	5.0	63.89	384.27	8.02
5	5.0	74.27	385.94	8.75
6	5.0	82.24	386.49	9.08
7	5.0	88.42	390.94	10.22
8	5.0	96.95	391.49	10.13
9	5.0	105.74	390.94	10.54
10	5.0	116.09	391.49	11.79
11	5.0	125.28	394.83	13.55
12	5.0	132.78	398.16	14.45
13	5.0	140.93	398.16	14.37
14	5.0	150.33	398.44	15.92
15	5.0	161.20	399.83	16.24
16	5.0	176.07	396.77	17.21
17	5.0	194.21	380.94	17.54
18	5.0	219.96	385.38	23.06
19	5.0	253.83	387.05	24.16
20	5.0	395.81	391.49	27.46

Adjustments to the Bin Definitions

Due to rounding issues, the total percentages assigned to all bins, when rounded to the nearest 10^{th} of a percent, may sum to slightly more or less than 100%. Since the number of bin percentages input into EMVAP must equal 100%, the following adjustments are made in order to ensure a conservative result:

- All bins must have a minimum percent chance of 0.1% chance of occurrence. If any bin is found to have a 0% chance, the percentage is increased to 0.1%.
- If the sum of all bins is greater than 100%, the difference is subtracted from the lowest emission bin to set the total percentage to 100%.
- If the sum of all bins is less than 100%, the difference is added to the highest emission bin to set the total percentage to 100%.
- It is important to note that the bins generated by EMDIST are only recommendations. The user must decide if these bins accurately represent the operating characteristics of the unit being modeled and make any changes as appropriate.

3.4 Current Limitations of the EMDIST Program

- The program only takes one set of source data at this time. While this data could in theory be the total emissions from any number of stacks, the program only recognizes the data as coming from one source. In order to summarize the data from separate sources, multiple iterations of EMDIST must be performed.

- The program assumes that each year of data is complete and begins on January 1st and ends on December 31st. The program has not been tested for yearly data not starting on January 1st and would likely not work as currently coded. Days where there were no emissions should be entered a 0 emissions, not left blank.
- The program will not accept emissions of greater than 99999.00 lb/hr or g/s (depending on the input format) at this time.
- Inputting an unusual set of percentiles for the generation of emission bins may result in bins being generated that to not accurately model the unit in question. It is recommended that the emission fluxes used closely match those found to occur in the data set input into EMDIST.

3.5 EMDIST Test Cases

In order to be sure that the program was producing the expected results, several test cases were prepared and the results calculated by hand for comparison with program output. Those following test data were used:

- Pawnee Station, Colorado, 2005 through 2009 to test the multiple year capability and the temperature reporting functionality. This data was acquired from the Acid Markets Database.
- Homer City Generating Station, Pennsylvania, Units 1, 2, and 3, 2009. Data acquired from the Acid Markets Database. These units were used to test the ability for a user to define their own emission fluxes for the emission bins.
- Martin Lake Steam Electric Station, Texas, Units 1, 2, and 3, 2009. Data acquired from the Acid Markets Database.
- Edge Moor Power Plant, Delaware, Units 3, 4, and 5, 2008 and 2009. Data acquired from the Acid Markets Database. These units were used to test the ability for a user to define their own emission fluxes for the emission bins.
- William H. Zimmer Power Station, Ohio, 2009. Data acquired from the Acid Markets Database.
- Portland Generating Station, New Jersey, Units 1, and 2 2007 and 2008. This data was in spreadsheet format and put into the lb/hr format described in option 2 for input above.
- Lovett Generating Station, New York, 1988. This data was used as one of the AERMOD test databases and was in AERMOD input file format. This case also had hourly stack temperature and exit velocity data and was used to test the importing of that data for use in developing emission bin stack parameters.

The files for all test cases are included in the Test Cases subfolder of the program folder, including all input and output files. These can be run with EMDIST by updating the sample EMDIST.inp file provided with the program.

3.6 Example Use of EMDIST Output Data

There are many of ways the output data can be used to analyze the results generated by EMDIST or by the organization of data necessary for input into EMVAP. The following pages contain figures that were generated by using the output of EMDIST or raw data and show the types of graphics that may be useful in determining emission patterns for input into EMVAP:

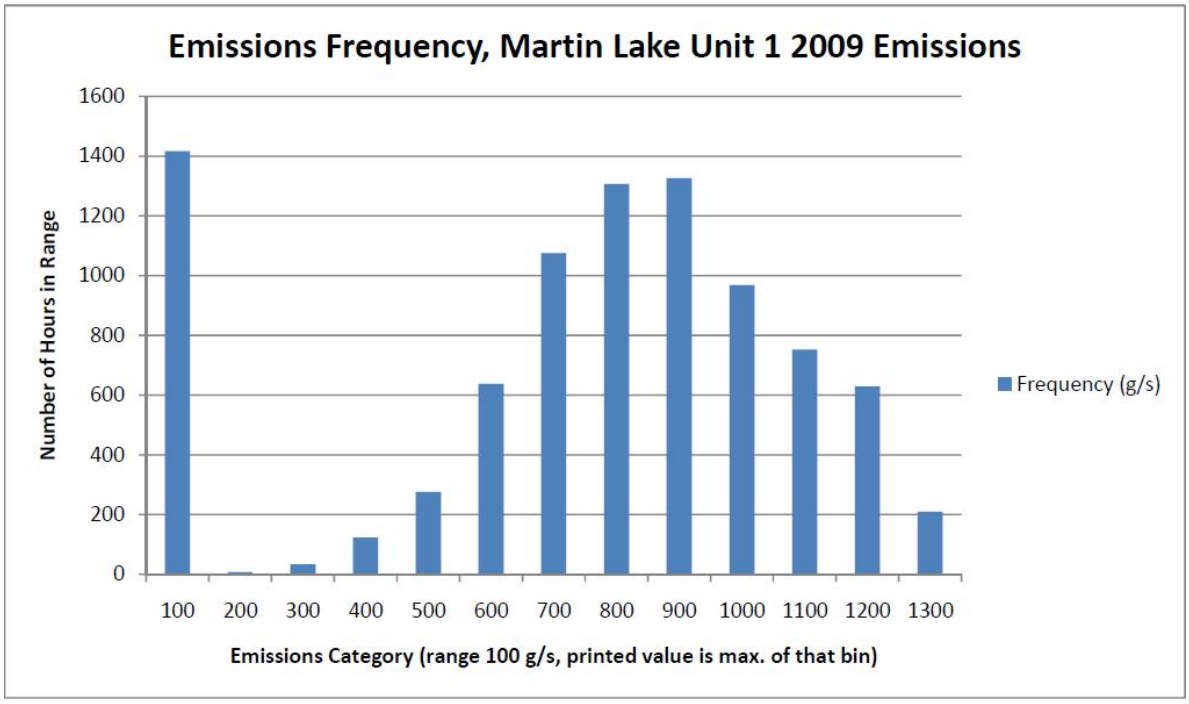

Figure 3-1
Emissions Sorted into 100 g/s "Bins", Potentially for Use with the EMVAP Program

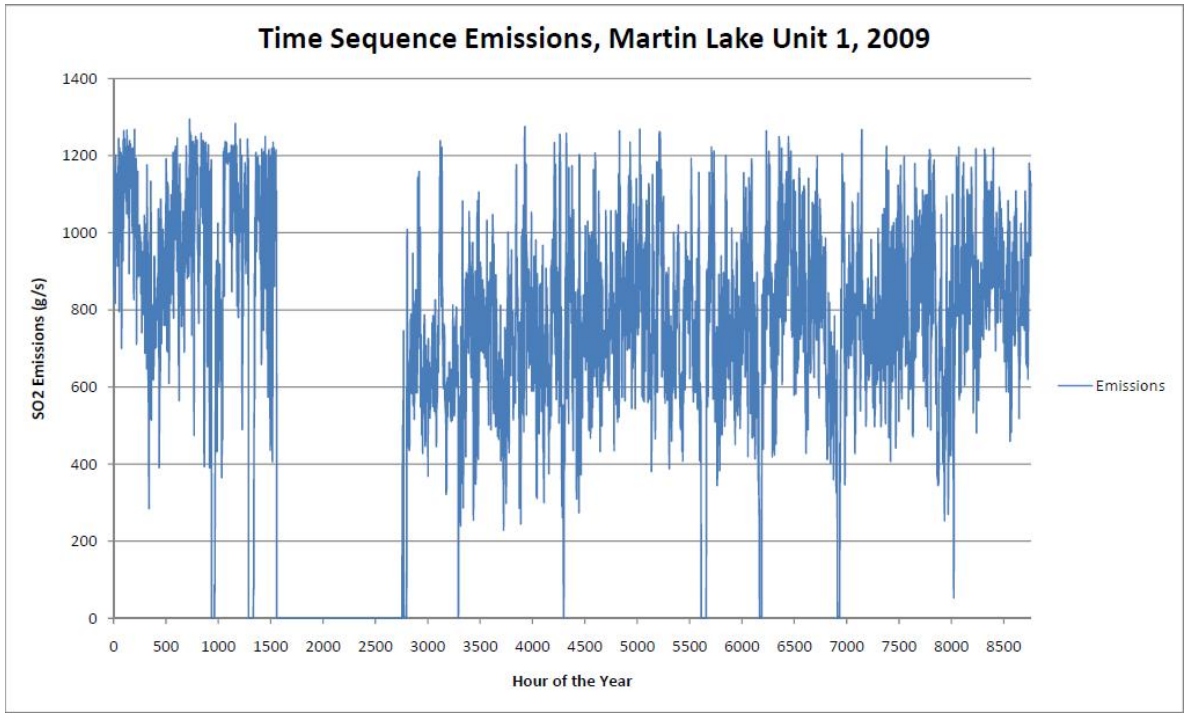

Figure 3-2
Time Sequence of Emissions Over One Year at Martin Lake Electric Steam Station

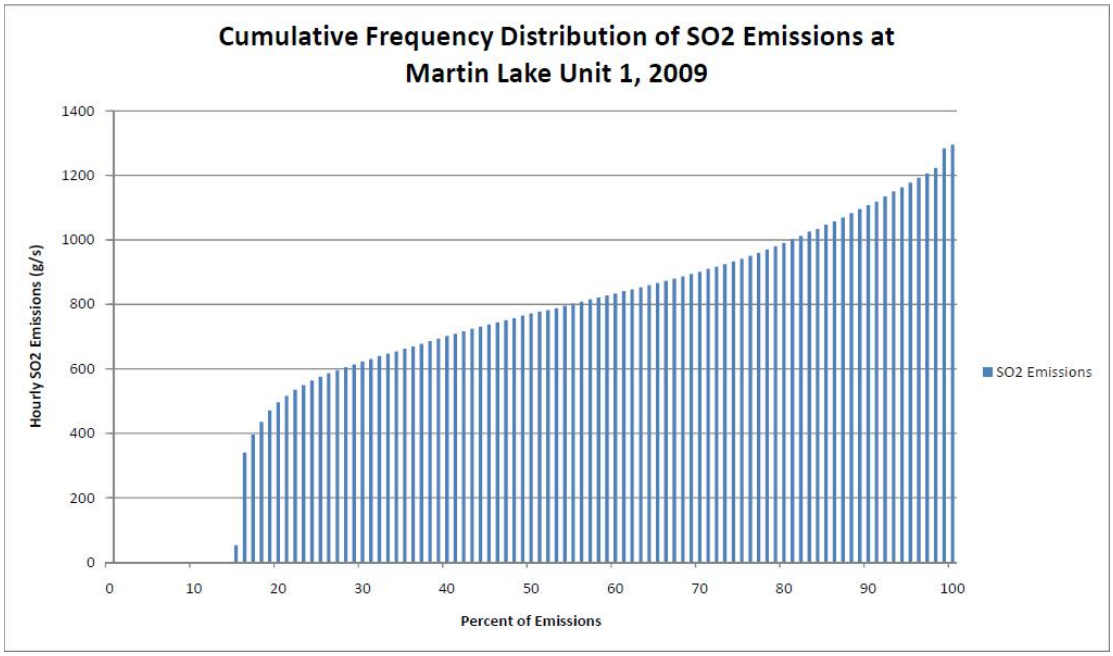

Figure 3-3
Cumulative Frequency Distribution for Use in Determining Emission "Bins" for EMVAP

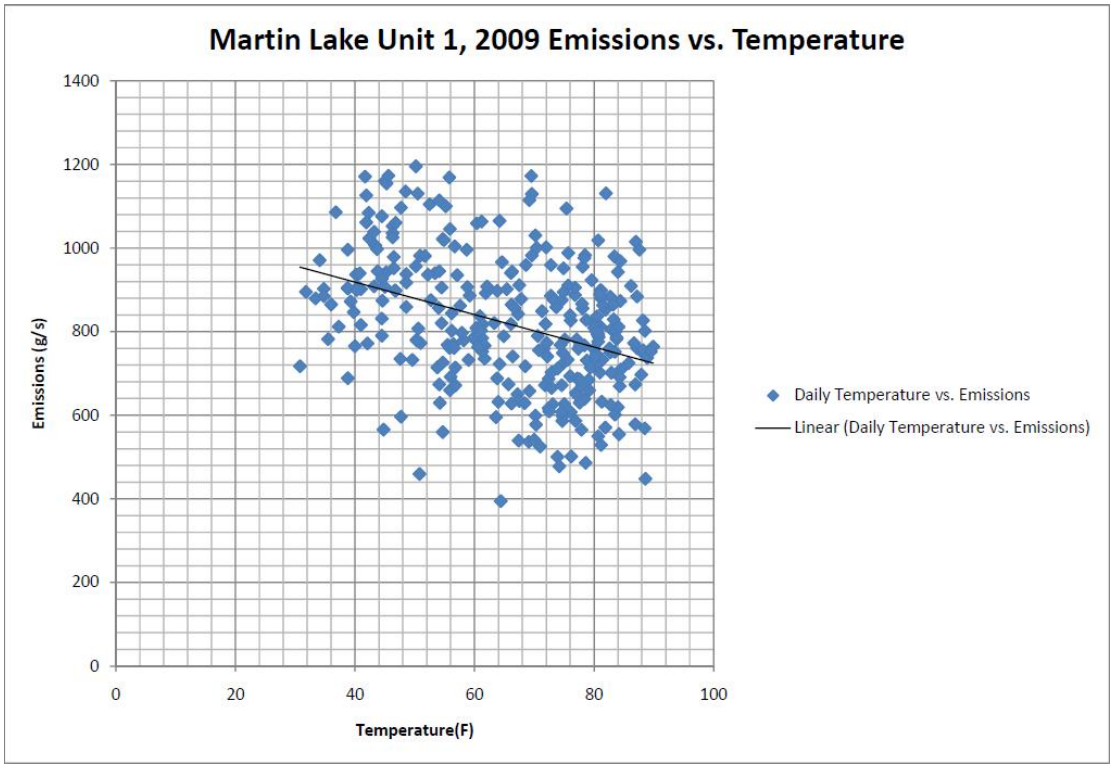

Figure 3-4
Average Daily Temperatures vs. Average Daily Emissions Scatter Chart

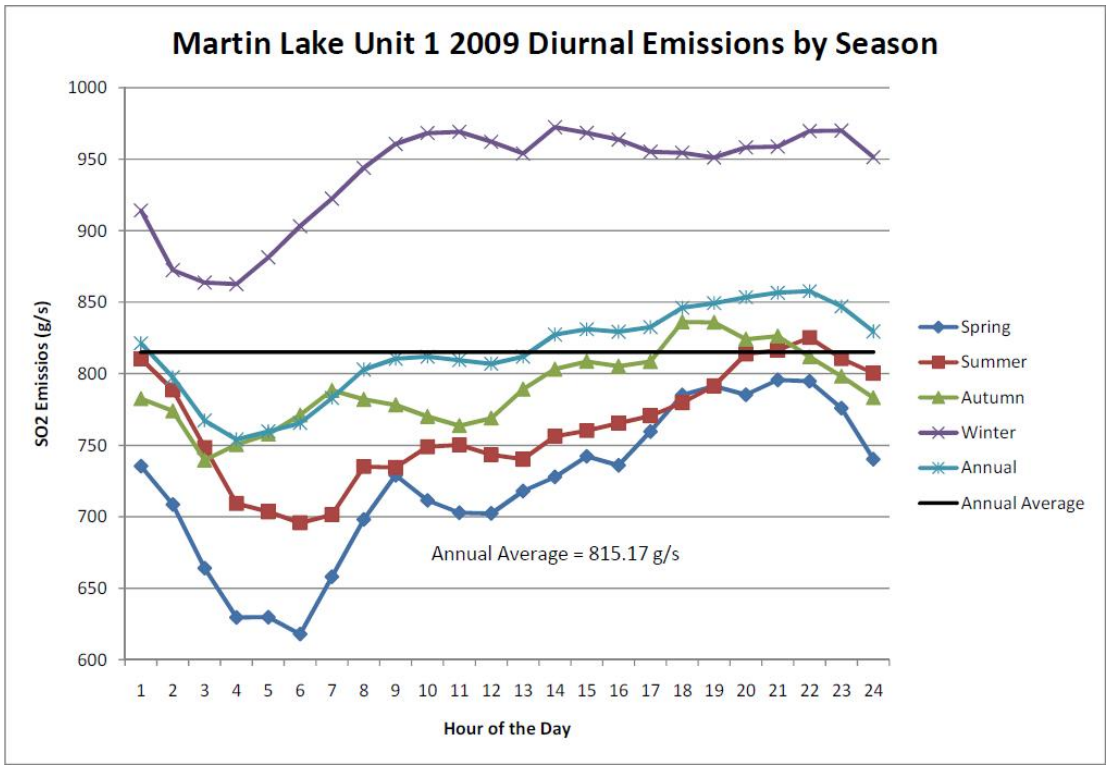

Figure 3-5
Diurnal Emissions by Season and Annual for Martin Lake Electric Steam Station

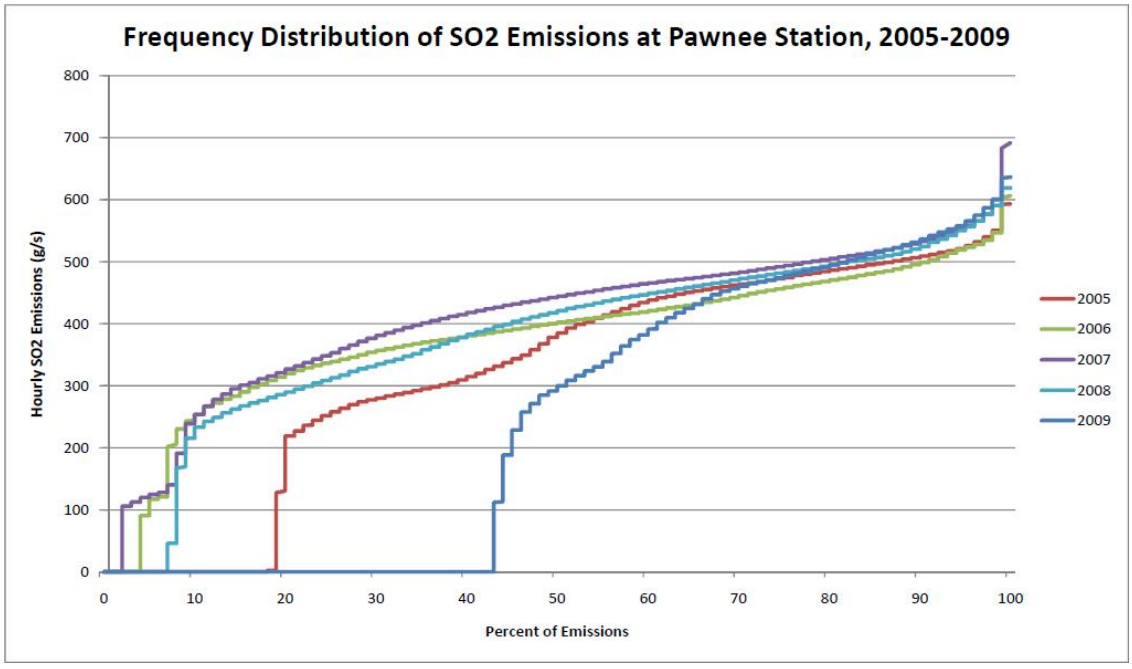

Figure 3-6
Five Year's Emission Data Cumulative Frequency Distributions at Pawnee Station

4
USER INSTRUCTIONS FOR EMVAP

4.1 How to Use the EMVAP Program

The EMVAP program is used to create data sets of modeled impacts generated by assigning a randomly determined emission rate to modeled impacts generated by AERMOD using a unit emission rate on an hourly basis. The emissions are determined by analyzing actual or proposed emission data and creating "emission bins", each of which are assigned to a specific load case or cases that represent various operating scenarios of the source being considered. Each of these bins is assigned a probability of occurring during any given hour and that probability is used to determine which emission rate is assigned each hour. The result from each iteration, representing one time through an AERMOD run of up to 5 years of meteorological data, are then written to a text file in the form of the standard being modeled against. These "iteration files" are then input into the EMPOST post-processor for analysis and reporting or results.

The EMVAP program generates an output file named "EMVAP.out", a results file for each iteration of emissions data analysis performed during the EMVAP execution, and optionally log files containing hourly or maximum daily modeled concentrations for use in debugging. The EMVAP.out file is the summary file for the program and contains one of two types of data:

- Summary of the program inputs including:
  - Number of years included in the analysis
  - Which years
  - The standard for which the EMVAP impacts are to be compared to
  - The number of source data sets included in this EMVAP run
  - For each source data set:
    - The load cases and names of the AERMOD binary result files representing them included in this EMVAP run.
    - The bin cases for this source group including which load case each bin is associated with, the probability of that bin being chosen each hour, and the emission rate assigned to that bin.
    - The number of iterations of the data performed
      - Name of the file containing the receptors included in the study
      - The name of the random number file used to choose the hourly emission bins
      - The first hour from the random number file used in this study.

- Alternately, if an error is detected when reading in the input data, an error message is written to EMVAP. out and then the program exits.

For each iteration, a file containing the output in the form of the standard being considered is generated to be used as input into EMPOST. The following data is written to each iteration file:

- Iteration Number
- Years being evaluated
- Number of receptors in the study
- First random hour selected for this specific iteration.
- For each receptor, the calculated design concentration for each year of data is then reported. This data will be pulled in by EMPOST and the final results calculated. The data is stored in a plainly readable format so that the results for each iteration can be hand calculated for debugging purposes:

99th pct. daily max by year:

Receptor		1981	1982	1983
83700.	392390.	659.90	672.15	635.21
78890.	396510.	670.10	654.50	644.89
82570.	402050.	307.27	312.78	306.53
84480.	391050.	700.21	715.34	712.12
86570.	393030.	478.67	467.93	461.64

Finally, the user may specify in the input file that EMVAP should create a debug file containing the daily maximum value calculated for each receptor on every day of the analysis for each iteration, a file containing every hourly concentration at every receptor over the entire period of the analysis for each iteration, or both. The hourly debug file contains the following data:

HOURLY CONCENTRATIONS (ug/m3) FOR ITERATION: 0001

Year: 1988 , Receptor: 3600.00 69700.00

Julian Day: 001 Hourly Concs:	24.44	0.36	0.44	0.32	9.75….. through the 24th hour of the day
Julian Day: 002 Hourly Concs:	0.41	0.04	0.09	0.94	0.95…..
Julian Day: 003 Hourly Concs:	4.81	2.97	3.01	1.68	1.13…..
Julian Day: 004 Hourly Concs:	0.15	0.10	0.41	0.16	0.20…..

The daily maxima debug file contains the following data:

DAILY MAXIMA (ug/m3) FOR ITERATION: 0001

	Year: 1988	1989 …. Etc.
Julian Day: 001 Daily Max.:	69.75	48.27
Julian Day: 002 Daily Max.:	3.19	6.54
Julian Day: 003 Daily Max.:	14.50	16.74
Julian Day: 004 Daily Max.:	13.97	11.21
Julian Day: 005 Daily Max.:	2.44	7.76

4.2 How to Set Up the Input File and Run EMVAP

Prior to running EMVAP:

EMVAP requires binary output files from AERMOD, run with a unit emission rate (1 g/s) for each source group and load case per source group. In the examples below, it is assumed that there are 3 years of input data and 3 load cases, representing 100%, 75%, and 50% load cases, for a given source group. In AERMOD, the source inputs might look like this for each year modeled:

** Source Parameters **

```
SRCPARAM  UNIT1_100     1.00   207.57     433.71     27.43  11.08
SRCPARAM  UNIT1_75      1.00   207.57     325.28     20.57  11.08
SRCPARAM  UNIT1_50      1.00   207.57     217.86     13.72  11.08
```

The source groups might then be defined as:

```
SRCGROUP    UNIT1_100    UNIT1_100
SRCGROUP    UNIT1_75     UNIT1_75
SRCGROUP    UNIT1_50     UNIT1_50
```

Lastly, binary post files must be generated for each source group for each year. Using the example above, the input in the OU section of the AERMOD input file would look like:

```
POSTFILE 1 UNIT1_100 UNFORM   UNIT1_100_2005.pos
POSTFILE 1 UNIT1_75  UNFORM   UNIT1_75_2005.pos
POSTFILE 1 UNIT1_50  UNFORM   UNIT1_50_2005.pos
```

The EMVAP Input File:

The EMVAP program takes input data from a text file which must be named "EMVAP.inp". See the example file included in the program folder. The data must be formatted EXACTLY as seen in that file in order to be processed correctly (do not remove any of the lines of comments). The following inputs are required:

- Number of years to be analyzed (1 through 5).
- Years to be analyzed (on one line, with one space between each year).
- Number of receptors used in the analysis.
- Which standard is being analyzed, 1) 1-hour SO_2 NAAQS, 2) 1-hour NO_2 NAAQS, 3) 24-hour PM2.5 (future enhancement).
- Name of the file containing receptor coordinates. This is a series of 20 character strings, one receptor per line as shown in the example below:

  ```
  575904.25 3809855.50
  576104.25 3809755.50
  575704.25 3809655.50
  575904.25 3809655.50
  ```

- The number of source groups for which AERMOD binary post files are being input.

- The next section of the input file is source data and is repeated for each source group. The sections are preceded and ended by a comment line for each source group:

  ** START - Data Set 1:
  ** END - Data Set 1

- Within each source block, the following inputs must be included in order:
  - Source group Name
  - Number of load cases for this source group. A load case represents a specific operating condition for the source, i.e. 50 percent load, 100 percent load, etc. EMVAP currently supports up to 10 load cases for each source group.
  - The names of the AERMOD binary files for each load case for each year being modeled. For each year, the order the load cases are listed in determined which number they are represented by. List the load cases in order for each year, then repeat for the next year,etc. until AERMOD binary files associated with this EMVAP run are identified. There must be one binary file per load case for each year. For example, if on the previous line it was identified that there were 3 load cases (in this example representing 100%, 75%, and 50% loads), and there were 3 years in the study, the following lines would look like:

    UNIT1_100_2005.pos
    UNIT1_75_2005.pos
    UNIT1_50_2005.pos
    UNIT1_100_2006.pos
    UNIT1_75_2006.pos
    UNIT1_50_2006.pos
    UNIT1_100_2007.pos
    UNIT1_75_2007.pos
    UNIT1_50_2007.pos

  As read in, load case 1 would represent the 100% load scenario, load case 2 would represent the 75% load scenario and load case 3 would represent the 50% load scenario.

  - The number of emission bins for this source group. EMVAP currently supports up to 10 bins per source group.
  - For each emission bin, the percentage of the time the bin should be used, the load case that it is associated with, and the emission rate (in g/s) for that bin. Each probability must be rounded to the nearest 10th of a percent. For example, if 5 bins were identified for the source group identified above, the input bin data might look like:

    10.0 3 40.00
    15.0 2 50.00
    35.0 1 90.00
    28.0 1 110.00
    12.0 1 150.00

In the above example, the first bin has a 10% chance of being selected for any modeled hour, uses the binary post file representing the stack parameters for the 50% load case for the year being processed, and has an associated emission rate of 40 g/s. If that bin was randomly selected for a given hour the impacts for each receptor determined for the 50% load parameters using the

1 g/s emission rate in AERMOD would be multiplied by the bin emission rate of 40 g/s to determine the model concentration for that hour at each receptor. Note that the percentages assigned to the emission bins MUST add up to 100% or EMVAP will write an error message to the EMVAP.out file and exit without processing the data.

- After the end of all source groups, the next line identifies the number of iterations the user wants EMVAP to execute, up to 5000. For every iteration, each year of modeled data is processed and written to a file for input into EMPOST for comparison against the identified standard. EMVAP can process 5 years of modeled data at a time, allowing for a total of 25,000 years of data to be processed in a single EMVAP run. In the development of EMVAP, it has been discovered that once 500 iterations are run, additional iterations have virtually no effect on the 50th through 95th percentile results, which are the percentiles that are generally of interest.
- Enter the name of the random number file. By default, this is the file "Updated1-1000.dat", which is provided with the program in the executable folder. This file contains 500,000 numbers evenly distributed from 1 to 1000. These are used to select a random number each hour which is compared to the occurrence percentages for each bin to select which will be used for given hour. These numbers are pre-generated in order to allow the user to verify the run data in a spreadsheet if desired for QA purposes. If the user wishes to provide an alternative file of random numbers, it must be in the same format as the default file (5000 rows of 100 numbers from 1 to 1000 separated by commas).
- Identify which number, from 1 to 500,000 hour to start the EMVAP run at. When the program starts, the first hour selected for any source group will be the one identified here. EMVAP then runs through the first modeled year or 8760 (or 8784) hours, then will start the next year or source group at hour 8761, etc. Once hour 500,000 is reached the pattern returns to hour 1. However, since 500,000 is not divisible by 24, hour 1 will then be applied to a different hour of the day, thus generating an almost endless array of hourly emission patters. The number of the random hour that starts the iteration is noted in the iteration output file so that the user may recreate the iteration manually in a spreadsheet if desired.
- The name of the prefix to be appended to the beginning of each iteration file generated. For each iteration, the number of the iteration will then be concatenated with the prefix to produce a unique file name. For example, if the prefix were Unit1, the first iteration file would be Unit1Iter0001.dat, the second Unit1Iter0002.dat, etc. This prefix is also used for any debug files generated.
- Whether or not the user wants any logfiles generated for use in debugging. The files will be placed in the DataFiles subfolder along with the iteration files. The user enters a number identifying which option they want:
  1. Normal run mode, no logging
  2. Output daily maxima for debugging
  3. Output hourly concentrations for debugging
  4. Output both daily maxima and hourly concentrations for debugging

  Using the above example, if the prefix Unit1 were entered in the input file and both types of log files were generated, the two files would be called Unit1DailyMax.log and Unit1HourConc.log.

4.3 Current Limitations of the EMVAP Program

- At present, the program has the following upper limits:
  - Unlimited receptors*
  - 5000 iterations
  - 10 source groups
  - 10 load cases per source group
  - 20 emission bins per source group
  - 5 years of modeled data per iteration

  *While there is no programmatic limitation to the number of receptors that EMVAP will run, there is a physical limitation based on the memory available on the system running EMVAP. Keep in mind that the number of iterations, bins, and receptors used are all interrelated: Using less iterations will allow more receptors, and vice versa. In practice, there appears to be little value in running more than 500 iterations, since the percentile results change little if at all over 500 iterations. During testing, 10000 receptors were successfully processed with 5000 iterations.

4.4 Test Cases

In order to be sure that the EMVAP and EMPOST programs were producing the expected results, several test cases were prepared and the results calculated by hand for comparison with program output. Those following test data were used:

- Lovett Generating Station, New York, 1988. This data was used as one of the AERMOD test databases. This case was used to test the basic functionality of the EMVAP/EMPOST software.
- Clifty Creek Generating Station, Indiana, 1975. This data was used as one of the AERMOD test databases and was in AERMOD input file format. Clifty Creek has 3 units and was used to test the capability to process multiple units with differing sets of emission bins and load data.

  Kincaid Power Station, Illinois, 1980. This data was used as one of the AERMOD test databases. This case was used to test the basic functionality of the EMVAP/EMPOST software.

The files for all test cases are included in the Test Cases subfolder of the program folder, including all input, output, and iteration files. These can be run with EMPOST by updating the sample EMPOST.inp file provided with the program. For all cases a 50 iteration test is presented.

5
USER INSTRUCTIONS FOR EMPOST

5.1 How to Use the EMPOST Program

The EMPOST program is used to collate the data output by the EMVAP AERMOD post-processor and present a statistical analysis of the results. EMPOST calculates the design value to be compared to the standard being considered in the analysis, then presents the statistical results over the entire range of iterations performed in the study. This output can then be compared to AERMOD modeling results and monitored ambient values as desired by the user.

The EMPOST program generates an output file named "EMPOST.out" containing the following information:

- Summary of the program inputs.
- List of the iteration file names analyzed.
- For each iteration, the maximum calculated design value at each receptor.
- A summary of the results of all iterations including:
  - The maximum design value over all receptors at each receptor included in the study.
  - The average design value over all receptors at each receptor included in the study.
  - The percentile results, either predefined or input by the user, for each receptor.
  - A summary table with the overall highest design concentration, which receptor it occurred at, and which iteration it occurred during.
  - A summary table with the highest average design concentration at any receptor and which receptor it occurred at.
  - A report of at which percentile the applicable standard has been exceeded, if any.

5.2 How to Set Up the Input File and Run EMPOST

The EMPOST program takes input data from a text file which must be named "EMPOST.inp". See the example file included in the program folder. The data must be formatted EXACTLY as seen in that file in order to be processed correctly (do not remove any of the lines of comments). The following inputs are required:

- Number of years to be analyzed (1 through 5).
- Years to be analyzed (on one line, one space between each year).
- Number of receptors used in the analysis.
- Which standard is being analyzed, 1) 1-hour SO_2 NAAQS, 2) 1-hour NO_2 NAAQS, 3) 24-hour PM2.5 (future enhancement).

- Name of the file containing receptor coordinates. This is a series of 20 character strings, one receptor per line as shown in the example below:

  575904.25 3809855.50
  576104.25 3809755.50
  575704.25 3809655.50
  575904.25 3809655.50

- The number of modeling iterations performed in EMVAP. The current limit to the number of iterations is 5000.
- Accept default percentile reporting (Y/N): If yes, EMPOST will output the following 8 percentiles of design concentrations from the design concentrations calculated for each iteration:
- 50^{th}, 60^{th}, 70^{th}, 75^{th}, 80^{th}, 85^{th}, 90^{th}, and 95^{th}.

  Note that these percentiles are the nth percentile result over all results generated in all of the iterations run in the analysis. These percentiles are not in any way related to the percentiles associated with the 1-hour NO_2 and SO_2 NAAQS (i.e. 98^{th} and 99^{th} percentile of the maximum daily concentrations). The percentiles instead describe the value at which N percent of the results are below the represented value. For example, the 50^{th} percentile will be the modeled impact, over all iterations run, for which 50% of the results are higher, and 50% are lower. 90^{th} percentile will be the value with 10% of the results higher and 90% lower, etc. etc.

  If these default percentiles will not produce the desired data, "N" is entered as the flag to accept default reporting. The user then inputs 8 percentiles for reporting, all on the same line, with a space between each as shown:

  5 10 15 20 30 45 55 60

  This would cause EMPOST to generate the 5^{th}, 10^{th}, 15^{th}, 20^{th}, 30^{th}, 45^{th}, 55^{th}, and 60^{th} percentiles along with the maximum and average design concentrations.

- The name and path (if not in the same directory as the executable) where the iteration files produced by EMVAP can be found, one per line. The total number of files must match the number of iterations input on the 16^{th} line of the input file.

  Ex):
  ./DataFiles/LovettIter0001.Dat
  ./DataFiles/LovettIter0002.Dat
  ./DataFiles/LovettIter0003.Dat
  ./DataFiles/LovettIter0004.Dat
  ./DataFiles/LovettIter0005.Dat
  etc….

5.3 EMPOST output

EMPOST generates a single output file called EMPOST.out. If any of the data in the input file entered by the user is out of range for that specific input, EMPOST will write an error message to this file then exit. Assuming the data input is accurate, EMPOST generates output in four sections

1. Summary data echoing the input file reminding the user which inputs were used for this particular run.
2. For each iteration, a list of the design values calculated for each receptor included in the study for this iteration:

RESULTS FROM ITERATION: 50

Receptor		MAX
3600.00	69700.00	239.73
4520.00	69780.00	319.33
5500.00	70450.00	240.77
4780.00	70700.00	294.99
5110.00	70850.00	330.70

3. A collated summary of the results of all iterations presenting the maximum, average, and percentile results at each receptor as well as the highest value for each statistic:

SUMMARY OF RESULTS: ALL ITERATIONS (ug/m3)

Receptor		Overall MAX	Overall AVG	PERCENTILE RESULTS 50	60	70	75	80	85	90	95
3600.00	69700.00	251.41	202.87	196.86	208.71	219.07	219.07	225.74	225.74	231.50	239.73
4520.00	69780.00	458.40	354.04	340.82	350.50	364.54	371.26	372.07	400.39	413.85	415.39
5500.00	70450.00	306.59	260.69	254.45	275.24	302.87	302.87	302.87	306.59	306.59	306.59
4780.00	70700.00	406.56	347.33	348.99	355.01	366.12	374.81	375.74	382.31	382.31	390.87
5110.00	70850.00	385.87	333.46	339.37	341.06	344.04	344.04	345.11	348.24	348.24	348.24
5810.00	70900.00	343.94	298.31	295.45	296.18	299.22	309.22	325.64	326.75	331.71	336.66
5860.00	71340.00	127.98	111.75	109.31	111.92	116.23	119.27	119.27	123.29	126.98	126.98
6250.00	71070.00	352.58	307.48	319.45	319.49	327.76	327.76	328.51	329.25	338.62	352.58
6930.00	71300.00	110.80	99.95	99.64	100.07	102.04	105.32	105.32	105.68	106.28	108.69
MAXIMUM VALUES		458.40	354.04	348.99	355.01	366.12	374.81	375.74	400.39	413.85	415.39

4. Finally, EMPOST creates two small tables and one report area: one table containing the maximum design concentration calculated for any receptor over all iterations, the receptor where it occurred, and the iteration from which it was calculated, the other table with the highest average design concentration over all iterations and the receptor at which it occurred, and the report area identifying at which percentile of the modeled results the applicable standard is exceeded.

OVERALL MAXIMUM

Receptor		Iteration	Conc.
4520.00	69780.00	1	458.40

HIGHEST OVERALL AVERAGE

Receptor		Conc.
4520.00	69780.00	354.04

NAAQS COMPLIANCE STATUS

The 1-hour SO2 NAAQS is exceeded at the 87th Percentile.

5.4 Current Limitations of the EMPOST Program

- The program only takes one set of source data at this time, which is generated by EMVAP. The data processed by EMVAP may be generated from a number of different source groups.
- The program has the following upper limits (EMVAP has additional limitations):
  - Unlimited receptors*
  - 5000 iterations

  *While there is no programmed limit to the number of receptors that may be included in an EMVAP/EMPOST run, the resources available on the server where EMVAP/EMPOST is run may put a physical limitation on the number of receptors. In practice, there may be little value to running more than 500 iterations as at that point (according to limited testing done so far) the percentile results do not change significantly. During the testing of EMVAP/EMPOST done to date, 10000 receptors were successfully processed in a 5000 iteration run.

5.5 EMPOST Test Cases

In order to be sure that the program was producing the expected results, several test cases were prepared and the results calculated by hand for comparison with program output. Those following test data were used:

- Lovett Generating Station, New York, 1988. This data was used as one of the AERMOD test databases. This case was used to test the basic functionality of the EMVAP/EMPOST software.
- Clifty Creek Generating Station, Indiana, 1975. This data was used as one of the AERMOD test databases and was in AERMOD input file format. Clifty Creek has 3 units and was used to test the capability to process multiple units with differing sets of emission bins and load data.

  Kincaid Power Station, Illinois, 1980. This data was used as one of the AERMOD test databases. This case was used to test the basic functionality of the EMVAP/EMPOST software.

The files for all test cases are included in the Test Cases subfolder of the program folder, including all input, output, and iteration files. These can be run with EMPOST by updating the sample EMPOST.inp file provided with the program. For all cases a 50 iteration test is presented.

5.6 Example Use of EMPOST Output Data

There are many of ways the output data can be used to analyze the results generated by EMPOST. Figures 5-1 and 5-2 show results that were generated using the output of EMPOST along with modeled and observed data for two of the AERMOD test databases, Lovett and Clifty Creek.

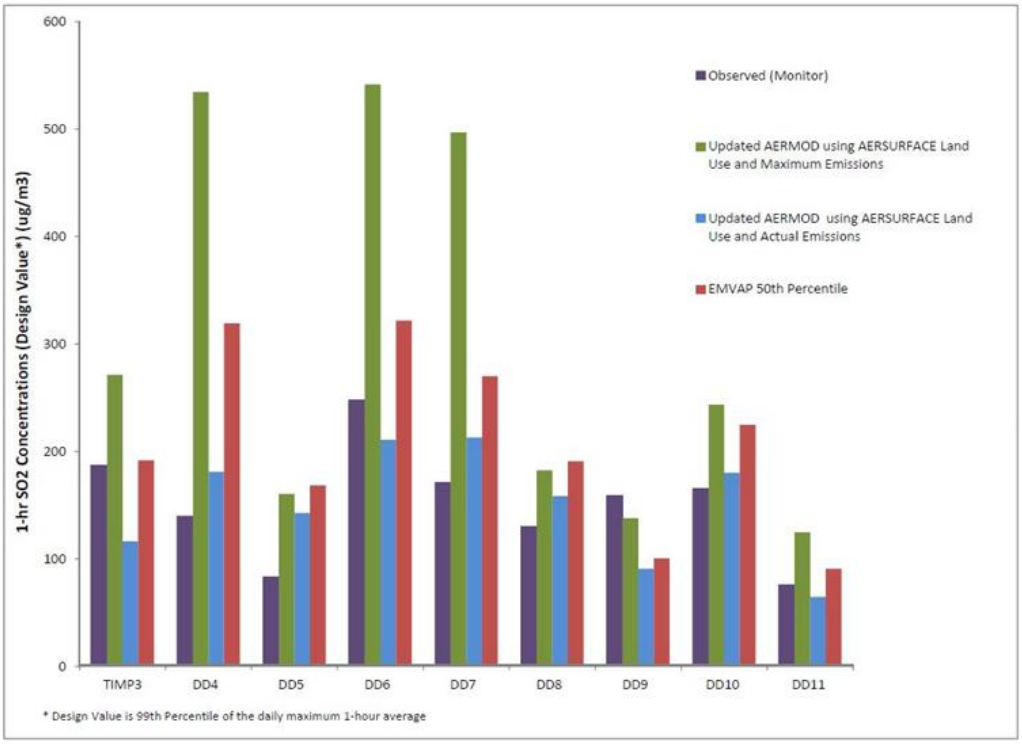

Figure 5-1
Comparison of EMVAP and Deterministic AERMOD Modeling Results for Lovett

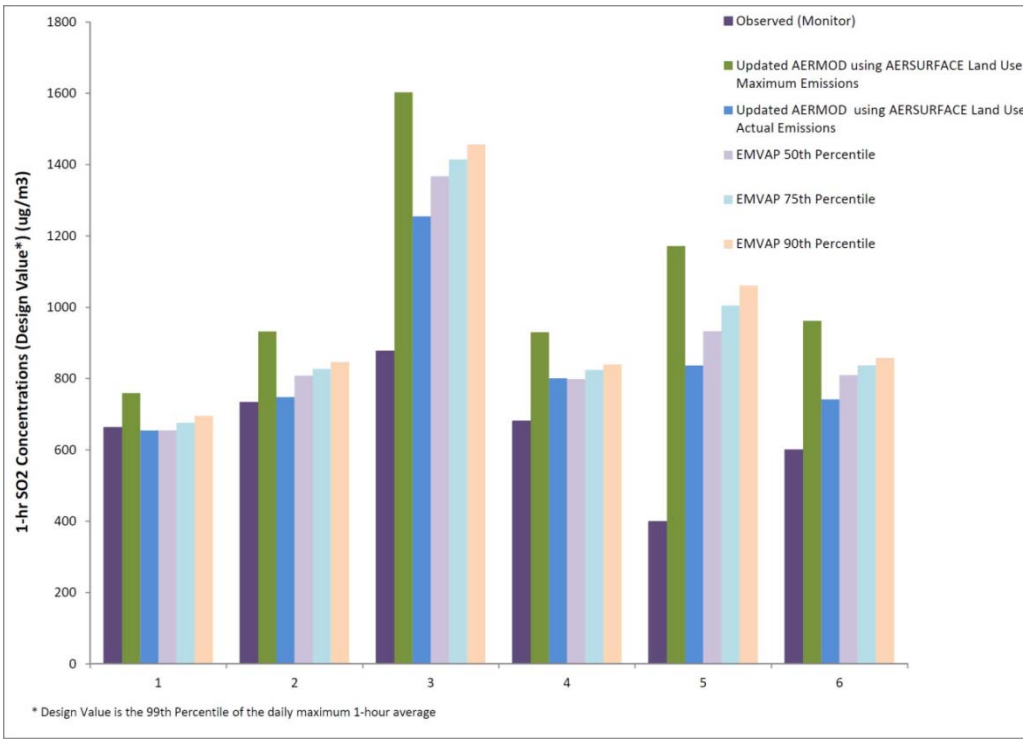

Figure 5-2
Comparison of EMVAP and Deterministic AERMOD Modeling Results for Clifty Creek

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