

**RESPONSE TO MODELING COMMENTS**  
**Bowie Power Station Class I Air Permit Application**  
**June 2014**

**Comment**

Please provide the data capture rate for the ozone monitoring data used in the AERMOD modeling.

**Response**

The ozone monitoring data was collected by the National Park Service (NPS) at Chiricahua National Monument. The monitoring procedures used by NPS call for zero and span checks each day. As a result, ozone data for hours 21 and 22 (9 pm-11 pm) are missing each day due to these daily checks. The data obtained contained other short periods of missing data, as well as two extended periods of missing data including May 12 - May 15, 2001 and January 1 - January 8, 2002.

NPS protocols call for calculating data recovery per calendar quarter based on the number of valid measurements as compared with number of possible measurements, with data lost during calibrations, maintenance, and audits being considered "not possible." (*Gaseous Pollutant Monitoring Program Quality Assurance Project Plan*, NPS, January 2007) The minimum valid data recovery for the program is greater than 75% for all possible gaseous data. Using the period from April 25, 2001 through April 29th, 2002, which matches the period modeled, yields the data statistics shown in Table 1.

**Table 1. Meteorological Data Missing Data Statistics**

Statistic	Time Period					
	April 25, 2001- June 30, 2001 (Quarter)	July 1, 2001- September 30, 2001 (Quarter)	October 1, 2001- December 31, 2001 (Quarter)	January 1, 2001-March 31, 2002 (Quarter)	April 1, 2002-April 29, 2002 (Quarter)	April 25, 2001- April 29, 2002 (Period of Record)
Total hours in period	1,608	2,208	2,208	2,160	696	8,880
Total missing hours	202 (12.5%)	241 (10.91%)	214 (9.69%)	357 (16.53%)	67 (9.63%)	1,081 (12.17%)
Daily calibration missing hours (% of total hours in period)	8.33%	8.33%	8.33%	8.33%	8.33%	8.33%
All other missing hours (% of possible hours)	68 (4.61%)	57 (2.82%)	30 (1.48%)	177 (8.94%)	9 (1.41%)	341 (4.19%)

**Comment**

Suggest running the 1-hour nitrogen dioxide (NO<sub>2</sub>) AERMOD analyses using the Ambient Ratio Method (ARM), rather than the Plume Volume Molar Ratio Method (PVMRM), to confirm that conclusions would remain the same using the simpler analysis.

## Response

Both the 1-hour and annual AERMOD analyses for NO<sub>2</sub> were revised based on the recommended ARM for each averaging period (0.8 for 1-hour, 0.75 for annual). The results are shown in Table 2.

The results of the Class II preliminary analysis that modeled the Bowie Power Station alone indicated that a cumulative analysis was required for the 1-hour NO<sub>2</sub> averaging period but not for the annual averaging period. Impacts above the 1-hour significant impact level (SIL) were predicted out to approximately 50 kilometers (km) from the Bowie Power Station. Therefore, the same additional sources that were included in the PVMRM analysis were included in the revised cumulative analysis using the ARM.

The cumulative Class II 1-hour NO<sub>2</sub> assessment used the model (AERMOD), receptor grid, options, and meteorological data that were used for the Bowie Power Station preliminary analysis. The receptors modeled were limited to those that showed a maximum impact above the 1-hour NO<sub>2</sub> SIL in the preliminary (Bowie Power Station only) analysis.

The AERMOD model has incorporated options to allow modeling compliance with the 1-hour NO<sub>2</sub> standard. Specifying “NO2” as the pollutant to be modeled invokes these options. The 98th percentile (high, 8th high) of the daily maximum 1-hour values from the Bowie project plus other nearby sources was modeled. Background NO<sub>2</sub> concentrations that vary by season and hour of the day were added to the combined impact within the model. The total maximum 98th percentile (high, 8th high) of the daily maximum concentrations, including background, has been compared with the 1-hour NO<sub>2</sub> standard.

The results, shown in Table 1, indicate that total impacts could potentially exceed the 1-hour NO<sub>2</sub> National Ambient Air Quality Standard (NAAQS) limitation of approximately 188.7 micrograms per cubic meter (µg/m<sup>3</sup>). The 1-hour NO<sub>2</sub> NAAQS would potentially be exceeded at one receptor. The largest contributor to the potential exceedance is the Apache Generating Station.

**Table 2. Revised NO<sub>2</sub> Analyses**

Averaging Period/ Pollutant	Maximum Predicted Impact (µg/m³)	Modeling Significant Impact Level (µg/m³)	Significant Monitoring Concentration (µg/m³)
Class II Bowie Power Station Only using Ambient Ratio Method			
1-hour NO₂	118.0	7.5	NA
Annual NO₂	0.22	1	14
Class II Cumulative Analysis Results using Ambient Ratio Method			
1-hour NO₂	252.3	Total, including Background Concentrations	
	36.2	Bowie Power Station Maximum Impact	
Class I Chiricahua National Monument Bowie Power Station Only using Ambient Ratio Method			
Annual NO₂	0.002	0.1	NA

Notes:

µg/m<sup>3</sup> = Micrograms per cubic meter  
 NA = Not applicable  
 NO<sub>2</sub> = Nitrogen dioxide

Bowie’s contribution to impacts above 90% of the NAAQS was determined using the “MAXDCONT” option in AERMOD. There were no impacts with a total concentration (including background) that exceeded 90% of the 1-hour NAAQS where Bowie’s contribution was greater than 3% of the total impact; therefore, no refined grids were developed.

The maximum 1-hour NO<sub>2</sub> concentration predicted by the model, including background, was 252.3 µg/m<sup>3</sup>. A total of 16 hours were predicted to exceed the NAAQS and the largest contribution to any of the potential exceedances by the Bowie Power Station was 0.0678 µg/m<sup>3</sup>, well below the SIL of 7.5 µg/m<sup>3</sup>. The Bowie Power Station will not cause or contribute to any exceedance of the 1-hour NO<sub>2</sub> NAAQS.

The annual NO<sub>2</sub> preliminary analysis for the Class I Chiricahua National Monument (NM) was also revised using the ARM. The results are also shown in Table 1. The Bowie Power Station maximum annual NO<sub>2</sub> impact at the Class I area is well below the SIL and a cumulative increment consumption analysis is not required.

## Comment

For the analysis of Class I particulate matter less than 2.5 micrometers and 10 micrometers (PM<sub>2.5</sub> and PM<sub>10</sub>) increments using CALPUFF, the US Environmental Protection Agency (EPA) has indicated that the modeling should use the expected direct emission rates of these two pollutants, rather than the speciated emissions used for Air Quality Related Values (AQRV) analyses.

## Response

The Class I area PM<sub>2.5</sub> and PM<sub>10</sub> analyses that were conducted using CALPUFF have been revised using direct emission rates of PM<sub>2.5</sub> and PM<sub>10</sub>. The emission rates were modeled in CALPUFF using the non-speciated PM<sub>10</sub> rates as coarse particulate (PMC) and the non-speciated PM<sub>2.5</sub> rates as fine particulate (PMF). In addition, direct nitrogen oxide emissions were included for each scenario modeled so that secondary PM<sub>2.5</sub> impacts could be considered.

For the 24-hour averaging period, stack parameters were varied seasonally and three potential worst-case scenarios were modeled representing: 1) 100% load with duct firing (maximum PM<sub>10</sub>/PM<sub>2.5</sub> emissions), 2) minimum compliance load (worst-case dispersion conditions), and 3) a 24-hour scenario that included three hot starts, two shutdowns, and 100% load with duct firing for the remaining hours (maximum NO<sub>x</sub> emissions). The first two scenarios are consistent with the modeling performed for PM<sub>2.5</sub> and PM<sub>10</sub> using AERMOD for the Class II areas surrounding the Bowie Power Station, with paired NO<sub>x</sub> emissions. The third scenario is a variation using seasonal weighted average stack parameters of the scenario that was modeled to evaluate visibility impacts in Class I areas beyond 50 kilometers (km) from the Bowie Power Station. An annual scenario was also evaluated. The emissions and stack parameters for these three scenarios are shown in Attachment A.

For the 24-hour scenarios, five seasonal periods with differing turbine stack parameters were modeled for each of three years of meteorological data. The periods were January, February through May, June through September, October through November, and December. This produced a total of 15 CALPUFF input files for each year modeled and 30 CALPOST input files or a total of 45 CALPUFF input files and 90 CALPOST input files for the three modeled years of meteorological data (2001-2003). An annual input file was also run for each meteorological year to allow calculation of annual impacts.

The results were processed in CALPOST producing PMF and PMC (PM<sub>2.5</sub>/PM<sub>10</sub>), and nitrate (HNO<sub>3</sub>) concentration values at each receptor in the eight Class I areas modeled. The higher of the PMF or PMC concentrations were used to represent PM<sub>10</sub>. For total PM<sub>2.5</sub>, including secondary PM<sub>2.5</sub>, the results were summarized as follows:

- For the Chiricahua Wilderness Area (WA), which is the closest of the Class I areas evaluated using CALPUFF and which therefore showed the highest impacts, maximum 24-hour PMF impacts were determined for each scenario, season, and year and the corresponding (paired in time and space) nitrate value was added to each PMF to represent total PM<sub>2.5</sub>. Maximum nitrate impacts were also determined and, where those differed from the receptor and time period that

showed maximum PMF impacts, conservative estimates of total PM<sub>2.5</sub> impacts were calculated by adding each maximum nitrate concentration for each scenario and season to the maximum PMF impact for any season in the same scenario (note that in general, maximum nitrate impacts were substantially less than maximum PMF impacts). The highest of these total PM<sub>2.5</sub> impacts is summarized in Table 2.

- ▶ For the more distant Class I areas, maximum 24-hour PMF and nitrate impacts were determined over all seasons and years for each area. The maximum PMF for each Class I area was added to its paired (in time and space) nitrate value to represent total PM<sub>2.5</sub>. These impacts are also shown in Table 2. In addition, the maximum nitrate concentrations for each year (any scenario, any of the more distant Class I areas) were determined and added to the maximum PMF concentration over all years/scenarios/Class I areas as a check to ensure all PM<sub>2.5</sub> concentrations at the more distant Class I areas were below the SIL.
- ▶ For the annual scenario, PMF and nitrate impacts were summed for each receptor and the maximum annual total PM<sub>2.5</sub> concentration at any receptor is shown in Table 2.

With the exception of Chiricahua WA, all impacts shown are below the PM<sub>2.5</sub> and PM<sub>10</sub> 24-hour and annual SILs. Total 24-hour PM<sub>2.5</sub> impacts determined as outlined above were slightly above the 24-hour SIL at Chiricahua WA for a single day and receptor in 2003 under both Scenario 1 and Scenario 3 and for a second day and receptor in 2003 under Scenario 3. All other Chiricahua WA impacts were below the SILs.

**Table 2. Results of Revised Class I Significant Impact Analysis**

<b>Class I Area</b>	<b>24-hour PM<sub>10</sub> (µg/m<sup>3</sup>)<sup>a,b</sup></b>	<b>24-hour PM<sub>2.5</sub> (µg/m<sup>3</sup>)<sup>a,b</sup></b>	<b>Annual PM<sub>10</sub> (µg/m<sup>3</sup>)<sup>c</sup></b>	<b>Annual PM<sub>2.5</sub> (µg/m<sup>3</sup>)<sup>c</sup></b>
Class I Significant Impact Level	0.3	0.07	0.2	0.06
Class I Increment	8	2	4	1
Chiricahua Wilderness Area, Arizona	0.076 <sup>d</sup>	0.076 <sup>d</sup>	0.005	0.006
Galiuro Wilderness Area, Arizona	0.05	0.05	0.004	0.004
Saguaro National Park East Unit/ Saguaro Wilderness Area, Arizona	0.02	0.03	0.0006	0.0007
Gila Wilderness Area, New Mexico	0.02	0.02	0.0006	0.0007
Superstition Wilderness Area, Arizona	0.01	0.01	0.0007	0.0009
Sierra Ancha Wilderness Area, Arizona	0.009	0.009	0.0003	0.0004
Pine Mountain Wilderness Area, Arizona	0.004	0.005	0.00008	0.0001
Bosque del Apache National Wildlife Refuge, New Mexico	0.003	0.004	0.0002	0.0002

<sup>a</sup> Not to be exceeded more than once per year.

<sup>b</sup> Maximum high, 1st high impact at any receptor over three years of meteorological data modeled (2001-2003) and over multiple operating scenarios.

<sup>c</sup> Maximum annual impact at any receptor over three years of meteorological data modeled (2001-2003).

<sup>d</sup> Exceeds 24-hour SIL for single day in 2003 for Scenario 1 and Scenario 3 and for a second day in 2003 for Scenario 3. Maximum impact shown.

Notes:

µg/m<sup>3</sup> = Micrograms per cubic meter  
PM<sub>10</sub> = Particulate matter less than 10 micrometers diameter  
PM<sub>2.5</sub> = Particulate matter less than 2.5 micrometers diameter

**Comment**

The Chiricahua Wilderness Area 2003 visibility impact shown in Table 7 of the April 2014 *Addendum to Modeling Report for the Bowie Power Station* doesn't appear to match the output files.

**Response**

The output file provided in the April 2014 Addendum was the file containing impacts based on receptors associated with the Chiricahua National Monument Class I Area rather than the Chiricahua Wilderness Area Class I area. The appropriate value for the 24-hour 2003 visibility impacts for the Chiricahua Wilderness Area is 4.13 % rather than the 7.17 % as reported in Table 7 of the April 2014 Addendum. The correct CALPOST output file is being provided. The corrected Tables 7 and 8 from the 2014 Addendum are provided below. With the correction, all impacts are below 5%. Federal Land Manager policy has generally considered impacts below 5% to be insignificant.

**Table 7 Revised. Visibility Analysis Maximum Change**

<b>Change in Light Extinction</b>	<b>Maximum % Change 2001</b>	<b>Maximum % Change 2002</b>	<b>Maximum % Change 2003</b>
Chiricahua Wilderness Area, Arizona	3.13	4.03	4.13
Galiuro Wilderness Area, Arizona	2.82	2.46	2.55
Saguaro National Park East Unit/ Saguaro Wilderness Area, Arizona	0.73	1.31	1.33
Gila Wilderness Area. New Mexico	0.59	0.98	0.54
Superstition Wilderness Area, Arizona	0.72	0.64	0.87
Sierra Ancha Wilderness Area, Arizona	0.48	0.59	0.52
Pine Mountain Wilderness Area, Arizona	0.25	0.12	0.21
Bosque del Apache National Wildlife Refuge	0.20	0.20	0.24

Note:

% = Percent

**Table 8 Revised. Visibility Analysis Results**

<b>Change in Light Extinction</b>	<b>Days &gt;5%/10% Change 2001</b>	<b>Days &gt;5%/10% Change 2002</b>	<b>Days &gt;5%/10% Change 2003</b>
Chiricahua Wilderness Area, Arizona	0/0	0/0	0/0
Galiuro Wilderness Area, Arizona	0/0	0/0	0/0
Saguaro National Park East Unit/ Saguaro Wilderness Area, Arizona	0/0	0/0	0/0
Gila Wilderness Area. New Mexico	0/0	0/0	0/0
Superstition Wilderness Area, Arizona	0/0	0/0	0/0
Sierra Ancha Wilderness Area, Arizona	0/0	0/0	0/0
Pine Mountain Wilderness Area, Arizona	0/0	0/0	0/0
Bosque del Apache National Wildlife Refuge	0/0	0/0	0/0

Note:

% = Percent

**ATTACHMENT A**  
**Emissions and Weighted Average Stack Parameter Calculations for Revised**  
**Class I PM<sub>10</sub> and PM<sub>2.5</sub> Modeling**



**BOWIE POWER STATION**

Base Elevation	1139.00 meters
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Pollutant	Averaging Periods	Modeling Scenario(s)	Emission Unit	Emission Rate (lb/hour)	Emission Rate (g/sec)	Stack Height (m)	Stack Exit Temperature (K)	Exit Velocity (m/sec)	Stack Diameter (m)	Operating Scenario for Emissions	Stack Parameter Scenario
NOx	Annual	Class I PM2.5 Increment	Turbines and Duct Burners	15.86	2.00E+00	54.86	355.23	18.10	5.49	Annual average	Weighted average stack parameters 59°F ambient
			Auxiliary Boiler	0.03	3.56E-03	13.70	422.04	15.24	0.76	Annual average	
			Emergency Fire Pump	0.01	1.81E-03	10.67	809.26	65.23	0.13	Annual average	
										Annual average	
PM10	24-hour (Scenario 1)	Class I Increment	Turbines and Duct Burners	8.50	1.07E+00	54.86	352.71	21.33	5.49	Normal Operation - 10°F ambient, 100% load with duct firing used for months with average minimum temperature below freezing (December, January)	Normal Operation - 10°F ambient, 100% load with duct firing used for months with average minimum temperature below freezing (December, January)
				8.50	1.07E+00		352.87	19.81		Normal Operation - 59°F ambient, 100% load with duct firing used for months where 10°F or 102°F not used (February, March, April, May, October, November)	Normal Operation - 59°F ambient, 100% load with duct firing used for months where 10°F or 102°F not used (February, March, April, May, October, November)
				8.50	1.07E+00		353.76	18.90		Normal Operation - 102°F ambient, 100% load with duct firing used for months with average maximum high over 90°F (June, July, August, September)	Normal Operation - 102°F ambient, 100% load with duct firing used for months with average maximum high over 90°F (June, July, August, September)
			Auxiliary Boiler	0.18	2.20E-02	13.70	422.04	15.24	0.76	Operation for 12 hours	
			Emergency Fire Pump	0.01	1.42E-03	10.67	809.26	65.23	0.13	Operation for 4 hours	
			Cooling Tower <sup>a</sup>	0.10	1.22E-02	14.00	294.26	8.59	10.00	Operation for 24 hours	
	24-hour (Scenario 2)	Class I Increment	Turbines and Duct Burners	6.50	8.19E-01	54.86	356.09	15.24	5.49	Normal Operation - Minimum Compliance Load 10°F ambient used for months with average minimum temperature below freezing (December, January)	Normal Operation - Minimum Compliance Load 10°F ambient used for months with average minimum temperature below freezing (December, January)
				6.50	8.19E-01		355.32	13.11		Normal Operation - Minimum Compliance Load 59°F ambient used for months where 10°F or 102°F not used (February, March, April, May, October, November)	Normal Operation - Minimum Compliance Load 59°F ambient used for months where 10°F or 102°F not used (February, March, April, May, October, November)
				6.50	8.19E-01		358.21	13.72		Normal Operation - Minimum Compliance Load 102°F ambient used for months with average maximum high over 90°F (June, July, August, September)	Normal Operation - Minimum Compliance Load 102°F ambient used for months with average maximum high over 90°F (June, July, August, September)
			Auxiliary Boiler	0.18	2.20E-02	13.70	422.04	15.24	0.76	Operation for 12 hours	
			Emergency Fire Pump	0.01	1.42E-03	10.67	809.26	65.23	0.13	Operation for 4 hours	
			Cooling Tower <sup>a</sup>	0.10	1.22E-02	14.00	294.26	8.59	10.00	Operation for 24 hours	
	Annual	Class I Increment	Turbines and Duct Burners	7.14	9.00E-01	54.86	355.23	18.10	5.49	Annual average	Weighted average stack parameters 59°F ambient
			Auxiliary Boiler	0.02	2.27E-03	13.70	422.04	15.24	0.76	Annual average	
			Emergency Fire Pump	0.0008	9.73E-05	10.67	809.26	65.23	0.13	Annual average	
			Cooling Tower <sup>a</sup>	0.10	1.22E-02	14.00	294.26	8.59	10.00	Annual average	

Pollutant	Averaging Periods	Modeling Scenario(s)	Emission Unit	Emission Rate (lb/hour)	Emission Rate (g/sec)	Stack Height (m)	Stack Exit Temperature (K)	Exit Velocity (m/sec)	Stack Diameter (m)	Operating Scenario for Emissions	Stack Parameter Scenario
PM2.5	24-hour (Scenario 1)	Class I Increment	Turbines and Duct Burners	8.50	1.07E+00	54.86	352.71	21.33	5.49	Normal Operation - 10°F ambient, 100% load with duct firing used for months with average minimum temperature below freezing (December, January)	Normal Operation - 10°F ambient, 100% load with duct firing used for months with average minimum temperature below freezing (December, January)
				8.50	1.07E+00		352.87	19.81		Normal Operation - 59°F ambient, 100% load with duct firing used for months where 10°F or 102°F not used (February, March, April, May, October, November)	Normal Operation - 59°F ambient, 100% load with duct firing used for months where 10°F or 102°F not used (February, March, April, May, October, November)
				8.50	1.07E+00		353.76	18.90		Normal Operation - 102°F ambient, 100% load with duct firing used for months with average maximum high over 90°F (June, July, August, September)	Normal Operation - 102°F ambient, 100% load with duct firing used for months with average maximum high over 90°F (June, July, August, September)
			Auxiliary Boiler	0.18	2.20E-02	13.70	422.04	15.24	0.76	Assume Normal Operation for 12 hours	
			Emergency Fire Pump	0.01	1.42E-03	10.67	809.26	65.23	0.13	4 hours of operation	
			Cooling Tower <sup>a</sup>	0.05	5.83E-03	14.00	294.26	8.59	10.00	Normal Operation	
	24-hour (Scenario 2)	Class I Increment	Turbines and Duct Burners	6.50	8.19E-01	54.86	356.09	15.24	5.49	Normal Operation - Minimum Compliance Load 10°F ambient used for months with average minimum temperature below freezing (December, January)	Normal Operation - Minimum Compliance Load 10°F ambient used for months with average minimum temperature below freezing (December, January)
				6.50	8.19E-01		355.32	13.11		Normal Operation - Minimum Compliance Load 59°F ambient used for months where 10°F or 102°F not used (February, March, April, May, October, November)	Normal Operation - Minimum Compliance Load 59°F ambient used for months where 10°F or 102°F not used (February, March, April, May, October, November)
				6.50	8.19E-01		358.21	13.72		Normal Operation - Minimum Compliance Load 102°F ambient used for months with average maximum high over 90°F (June, July, August, September)	Normal Operation - Minimum Compliance Load 102°F ambient used for months with average maximum high over 90°F (June, July, August, September)
			Auxiliary Boiler	0.18	2.20E-02	13.70	422.04	15.24	0.76	Assume Normal Operation for 12 hours	
			Emergency Fire Pump	0.01	1.42E-03	10.67	809.26	65.23	0.13	4 hours of operation	
			Cooling Tower <sup>a</sup>	0.05	5.83E-03	14.00	294.26	8.59	10.00	Normal Operation	
	Annual	Class I Increment	Turbines and Duct Burners	7.14	9.00E-01	54.86	355.23	18.10	5.49	Annual average	Weighted average stack parameters 59°F ambient
			Auxiliary Boiler	0.02	2.27E-03	13.70	422.04	15.24	0.76	Annual average	
			Emergency Fire Pump	0.0008	9.73E-05	10.67	809.26	65.23	0.13	Annual average	
			Cooling Tower <sup>a</sup>	0.046	5.83E-03	14.00	294.26	8.59	10.00	Annual average	

Pollutant	Averaging Periods	Modeling Scenario(s)	Emission Unit	Emission Rate (lb/hour)	Emission Rate (g/sec)	Stack Height (m)	Stack Exit Temperature (K)	Exit Velocity (m/sec)	Stack Diameter (m)	Operating Scenario for Emissions	Stack Parameter Scenario	
NOx	24-hour (Scenario 3)	Class I PM2.5 Increment - Seasonal	Turbines and Duct Burners	22.00	2.77E+00	54.86	352.90	20.94	5.49	Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 10oF ambient	Weighted average stack parameters duct firing 10oF ambient used for months with average minimum temperature below freezing (December, January)	
				20.17	2.54E+00		353.12	19.43		Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 59oF ambient	Weighted average stack parameters duct firing 10oF ambient used for months with average minimum temperature below freezing (December, January)	
				19.94	2.51E+00		354.18	18.55		Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 102oF ambient	Weighted average stack parameters duct firing 102oF ambient used for months with average maximum high over 90oF (June, July, August, September)	
			Auxiliary Boiler	0.28	3.46E-02	13.70	422.04	15.24	0.76	Assume Normal Operation for 12 hours		
			Emergency Fire Pump	0.21	2.65E-02	10.67	809.26	65.23	0.13	4 hours of operation		
PM2.5			Turbines and Duct Burners	8.33	1.05E+00	54.86	352.90	20.94	5.49	Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 10oF ambient	Weighted average stack parameters duct firing 10oF ambient used for months with average minimum temperature below freezing (December, January)	
				8.33	1.05E+00		353.12	19.43		Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 59oF ambient	Weighted average stack parameters duct firing 10oF ambient used for months with average minimum temperature below freezing (December, January)	
				8.33	1.05E+00		354.18	18.55		Each turbine - 3 hot starts, 2 shutdowns, remaining hours normal operation maximum emission rate of 100% load with duct firing, all 102oF ambient	Weighted average stack parameters duct firing 102°F ambient used for months with average maximum high over 90°F (June, July, August, September)	
				Auxiliary Boiler	0.18	2.20E-02	13.70	422.04	15.24	0.76	Assume Normal Operation for 12 hours	
				Emergency Fire Pump	0.01	1.42E-03	10.67	809.26	65.23	0.13	4 hours of operation	
				Cooling Tower <sup>a</sup>	0.05	5.83E-03	14.00	294.26	8.59	10.00	Normal Operation	
PM10	Cooling Tower <sup>a</sup>	0.10		1.22E-02	54.86	352.90	0.00	5.49	Normal Operation			

<sup>a</sup>There are 9 cooling tower cells. Data shown are for each cell individually.

**BOWIE POWER STATION  
TURBINE AND DUCT BURNER WEIGHTED AVERAGE STACK PARAMETERS**

Annual		59°F		Hours per Year
Configuration	Load	Stack Temperature (K)	Exit Velocity (meters/sec)	
Cold Startup	Startup	356.04	15.94	325
Turbine + Duct Firing	100%	352.87	19.81	4224.0
Turbine	80%	357.87	16.46	3681.8
Turbine	Shutdown	355.32	13.11	91.3
Weighted Average		355.23	18.10	
		°F	feet/sec	
		179.75	59.40	

Assumed for all turbine-only hours  
Use for shutdown hours

**Three Hot Starts, Two Shutdowns + Turbine Operation at 100% Load + Duct Firing**

	10°F		59°F		102°F		Duration (hours)
	Stack Temperature (K)	Exit Velocity (meters/sec)	Stack Temperature (K)	Exit Velocity (meters/sec)	Stack Temperature (K)	Exit Velocity (meters/sec)	
Three Hot Starts	354.76	17.04	356.04	15.94	359.04	15.12	1.50
Two Shutdowns	356.09	15.24	355.32	13.11	358.21	13.72	0.50
Normal Operation with Duct Firing	352.71	21.33	352.87	19.81	353.76	18.90	22.00
Weighted Average	352.90	20.94	353.12	19.43	354.18	18.55	

Use Cold Start Data  
Use Minimum Compliance Load Data

Stack data is from "Turbine Stack Parameters" spreadsheet

Hours per year are from "Turbine and Duct Burner Annual" spreadsheet

Startup and shutdown durations are from "Turbine Startup Emissions" spreadsheet

Weighted Average Temperature =  $\frac{\sum(\text{Configuration Temperature} \times \text{Configuration Hours})}{\text{Total Hours}}$

Weighted Average Exit Velocity =  $\frac{\sum(\text{Configuration Exit Velocity} \times \text{Configuration Hours})}{\text{Total Hours}}$

$^{\circ}\text{F} = ((\text{K} - 273.15) \times \frac{9}{5}) + 32$

$\frac{\text{feet}}{\text{second}} = \frac{\text{meters}}{\text{second}} \times \frac{3.281 \text{ feet}}{\text{meters}}$