

**BART FIVE FACTOR ANALYSIS ■ KANSAS CITY POWER & LIGHT**  
LA CYGNE GENERATING STATION

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**VERSION 0**

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# 1. EXECUTIVE SUMMARY

This report documents the determination of the Best Available Retrofit Technology (BART) as proposed by Kansas City Power & Light (KCP&L) for the La Cygne Generating Station located in La Cygne, Kansas. There are two boilers at La Cygne. Unit 1 is an 840 MW supercritical cyclone coal boiler that was manufactured in 1973 by Babcock and Wilcox with a scrubber for sulfur dioxide (SO<sub>2</sub>) and particulate matter (PM) control and overfire air that minimizes the formation of thermal nitrogen oxides (NO<sub>x</sub>). Unit 2 is a 710 MW radiant opposed-fired pulverized coal (PC) boiler that was manufactured in 1976 by Babcock and Wilcox with an electrostatic precipitator (ESP) for PM control. Unit 1 burns a blend of Powder River Basin (PRB) coal and local coal. Unit 2 burns 100 percent PRB coal.

KCP&L has determined that the two boilers at the La Cygne Generating Station contribute greater than 0.5 deciviews (dv) to visibility impairment in a federally protected Class I area when compared to a natural background. Therefore, these two sources are subject to BART. A summary of the visibility impairment attributable to the boilers is provided in Table 1-1.

**TABLE 1-1. VISIBILITY IMPAIRMENT ATTRIBUTABLE TO LA CYGNE GENERATING STATION**

Class I Area	Visibility Impairment	
	98th % Δdv	Days > 0.5 Δdv
Wichita Mountains Wilderness	1.02	57
Hercules Glades Wilderness	1.74	138
Caney Creek Wilderness	1.14	63
Upper Buffalo Wilderness	1.92	125
Mingo Wilderness	0.92	62

KCP&L used the guidelines in 40 CFR Part 51<sup>1</sup> to determine BART for the boilers. Specifically, KCP&L conducted a five-step analysis to determine BART for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub> that included the following:

1. Identifying all available retrofit control technologies;
2. Eliminating technically infeasible control technologies;
3. Evaluating the control effectiveness of remaining control technologies;
4. Evaluating impacts and document the results;
5. Evaluating visibility impacts

Based on the five-step analysis, KCP&L proposes the following as BART:

- NO<sub>x</sub> – KCP&L proposes to meet the U.S. Environmental Protection Agency’s (EPA’s) presumptive BART limits of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively, by complying with a combined Unit 1 and Unit 2 weighted average limit. This

<sup>1</sup> 40 CFR 51, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations

will be achieved by operating the currently permitted SCR on Unit 1 and by installing NO<sub>x</sub> controls on Unit 2.

- SO<sub>2</sub> – KCP&L proposes to meet the U.S. EPA’s presumptive BART limit of 0.15 lb/MMBtu for Unit 1 and Unit 2 by complying with a combined Unit 1 and Unit 2 weighted average limit by installing either wet scrubbers or spray dryer absorbers (SDA) on both units.
- PM – KCP&L proposes that no additional PM controls are required for BART compliance because the PM controls would provide little visibility improvement while requiring significant capital expenditures. Although not required for BART compliance, KCP&L plans to install baghouses on Unit 1 and Unit 2 for compliance with other environmental regulations.

The proposed presumptive BART emission rates will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2. A summary of the visibility improvement based on the existing emission rates and presumptive BART emission rates is provided in Table 1-2.

**TABLE 1-2. VISIBILITY IMPAIRMENT IMPROVEMENT**

	Caney Creek Wilderness			Hercules Glades Wilderness			Mingo Wilderness			Upper Buffalo Wilderness			Wichita Mountains Wilderness		
	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement
Max Impact (Δv)	5.16	1.278	75%	4.479	0.998	78%	3.82	0.868	77%	6.359	1.563	75%	8.404	2.117	75%
98% Impact (Δv)	1.138	0.227	80%	1.738	0.357	79%	0.915	0.177	81%	1.923	0.415	78%	1.017	0.205	80%
Days > 0.5	63	5	92%	138	6	96%	62	3	95%	125	14	89%	57	7	88%

## 2. INTRODUCTION AND BACKGROUND

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On July 1, 1999, the U.S. Environmental Protection Agency (EPA) published the final Regional Haze Rule (RHR). The objective of the RHR is to improve visibility in 156 specific areas across with United States, known as Class I areas. The Clean Air Act defines Class I areas as certain national parks (over 6000 acres), wilderness areas (over 5000 acres), national memorial parks (over 5000 acres), and international parks that were in existence on August 7, 1977.

On July 6, 2005, the EPA published amendments to its 1999 RHR, often called the Best Available Retrofit Technology (BART) rule, which included guidance for making source-specific BART determinations. The BART rule defines BART-eligible sources as sources that meet the following criteria:

- (1) Have potential emissions of at least 250 tons per year of a visibility-impairing pollutant,
- (2) Began operation between August 7, 1962 and August 7, 1977, and
- (3) Are included as one of the 26 listed source categories in the guidance.

A BART-eligible source is subject to BART if the source is “reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area.” EPA has determined that a source is reasonably anticipated to cause or contribute to visibility impairment if the 98<sup>th</sup> percentile visibility impacts from the source are greater than 0.5 deciviews (dv) when compared against a natural background. Air quality modeling is the tool that is used to determine a source’s visibility impacts.

Once it is determined that a source is subject to BART, a BART determination must address air pollution control measures for the source. The visibility regulations define BART as follows:

*“...an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by...[a BART-eligible source]. The emission limitation must be established on a case-by-case basis, taking into consideration the technology available, the cost of compliance, the energy and non air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonable be anticipated to result from the use of such technology.*”

Specifically, the BART rule states that a BART determination should address the following five statutory factors:

1. Existing controls
2. Cost of controls
3. Energy and non-air quality environmental impacts
4. Remaining useful life of the source
5. Degree of visibility improvement as a result of controls

Further, the BART rule indicates that the five basic steps in a BART analysis can be summarized as follows:

1. Identify all available retrofit control technologies;
2. Eliminate technically infeasible control technologies;
3. Evaluate the control effectiveness of remaining control technologies;
4. Evaluate impacts and document the results;
5. Evaluate visibility impacts

A BART determination should be made for each visibility affecting pollutant (VAP) by following the five steps listed above for each VAP.

KCP&L performed a BART applicability analysis for La Cygne Unit 1 and Unit 2 and determined the units are subject to BART. The details of the applicability determination can be found in Section 3. Subsequently, KCP&L performed an analysis to determine BART for each VAP for Unit 1 and Unit 2. The VAPs emitted by La Cygne Unit 1 and Unit 2 include NO<sub>x</sub>, SO<sub>2</sub>, and particulate matter with a mass mean diameter smaller than ten microns (PM<sub>10</sub>) of various forms (filterable coarse particulate matter [PM<sub>c</sub>], filterable fine particle matter [PM<sub>f</sub>], elemental carbon [EC], inorganic condensable particulate matter [IOR CMP] as sulfates [SO<sub>4</sub>], and organic condensable particulate matter [OR CMP] also referred to as secondary organic aerosols [SOA]). The BART determinations for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub> can be found in Sections 4, 5, and 6, respectively.

## 2.1 PRESUMPTIVE LIMITS

EPA established presumptive limits in the BART guidelines for electric generating units (EGUs). The presumptive limits were established by reviewing BART-eligible units and determining a level of emissions reductions that would be cost effective. The EPA's BART guidelines state the following with regard to presumptive BART for SO<sub>2</sub>

*“You must require 750 MW power plants to meet specific control levels for SO<sub>2</sub> of either 95 percent control or 0.15 lb/MMBtu... For coal fired EGUs with an existing post combustion SO<sub>2</sub> controls achieving less than 50 percent removal efficiencies, we recommend that you evaluate construction a new FGD system to meet the same emission limit as above (95 percent removal or 0.15 lb/MMBtu)”*

For power plants greater than 750 MW, EPA requires that state agencies apply the presumptive BART limit as a floor for SO<sub>2</sub>. The SO<sub>2</sub> presumptive limit for both Unit 1 and Unit 2 is 0.15 lb/MMBtu.

Similarly for NO<sub>x</sub>, the guidelines state:

*“For coal-fired EGUs greater than 200 MW located at greater than 750 MW power plants and operating without post-combustion controls (i.e. selective catalytic reduction or selective non-catalytic reduction), we have provided presumptive NO<sub>x</sub> limits differentiated by boiler design and type of coal burned.”*

The guidelines go on to state for cyclone boilers:

*“Because of the relatively high NO<sub>x</sub> emission rates of cyclone units, SCR is more cost-effective than the use of current combustion control technology for these units. The use of SCRs at cyclone units burning bituminous coal, sub-bituminous coal, and lignite should enable the units to cost-effectively meet NO<sub>x</sub> rates of 0.10 lbs/MMBtu.*

*As a result, we are establishing a presumptive NO<sub>x</sub> limit of 0.10 lb/MMBtu based on the use of SCR for coal-fired cyclone units greater than 200 MW located at 750 MW power plants.*

Therefore, for units greater than 200 MW located at power plants greater than 750 MW, the presumptive limits are also a floor for NO<sub>x</sub>. Since La Cygne Unit 1 is a cyclone boiler, the presumptive limit is 0.10 lb/MMBtu. For La Cygne Unit 2, which is a dry-bottom wall-fired boiler combusting sub-bituminous coal, the NO<sub>x</sub> presumptive limit is 0.23 lb/MMBtu.

The BART guidelines do not specify presumptive BART limits for PM<sub>10</sub> emissions.

## **2.2 EXISTING CONTROLS**

La Cygne Unit 1 and Unit 2 have existing emission controls. Unit 1 is currently equipped with a scrubber for SO<sub>2</sub> and particulate control and overfire air that minimizes the formation of thermal NO<sub>x</sub>. KCPL is in the process of voluntarily constructing an SCR system for Unit 1 which will further reduce NO<sub>x</sub> emissions. The SCR project is scheduled to be operational by May 2007. Unit 2 is equipped with an electrostatic precipitator (ESP) for particulate control.

### 3. BART APPLICABILITY DETERMINATION

As stated in Section 2, a BART-eligible source is subject-to-BART if the source is “reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area.” EPA has determined that a source is reasonably anticipated to cause or contribute to visibility impairment if the 98<sup>th</sup> percentile of the visibility impacts from the source is greater than 0.5 deciviews (dv) when compared against a natural background. KCP&L conducted air quality modeling to predict the existing visibility impairment attributable to La Cygne Unit 1 and Unit 2 in the following Class I areas:

- ▲ Wichita Mountains Wilderness (Fish and Wildlife Service [FWS])
- ▲ Hercules Glades Wilderness (Forest Service [FS])
- ▲ Upper Buffalo Wilderness (FS)
- ▲ Caney Creek Wilderness (FS)
- ▲ Mingo Wilderness (FWS)

The modeling methods and procedures that were followed were provided to the Kansas Department of Health and Environment (KDHE) in a November 2006 modeling protocol. In response to comments provided to KCP&L by KDHE regarding the modeling protocol, the only change made to the modeling methods and procedures documented in the protocol was to correct a typographical error for the November monthly humidity factor for Mingo from 3.4 to the correct value of 3.1. Since this change did not warrant a new version of the protocol, the documentation of this change is provided in this report. Table 3-1 summarizes the emission rates that were modeled for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub>, including the speciated PM<sub>10</sub> emissions. The SO<sub>2</sub> and NO<sub>x</sub> emission rates are the highest actual 24-hour emission rates based on 2002-2004 continuous emissions monitoring system (CEMS) data. The PM<sub>10</sub> emission rates are the calculated highest emission rates based on fuel data from 2002-2004 and AP-42 emission factors. The total PM<sub>10</sub> emission rates include both the filterable and condensable fractions and are speciated into the following:

- ▲ Coarse particulate matter (PM<sub>c</sub>)
- ▲ Fine particulate matter (PM<sub>f</sub>)
- ▲ Sulfates (SO<sub>4</sub>)
- ▲ Secondary organic aerosols (SOA)
- ▲ Elemental carbon (EC)

**TABLE 3-1. HIGHEST ACTUAL 24-HOUR SO<sub>2</sub> AND NO<sub>x</sub> EMISSIONS AND CALCULATED HIGHEST PM<sub>10</sub> EMISSIONS (AS AN HOURLY EQUIVALENT)**

	SO <sub>2</sub>	NO <sub>x</sub>	Total PM <sub>10</sub>	SO <sub>4</sub>	PM <sub>c</sub>	PM <sub>f</sub>	SOA	EC
	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
La Cygne - Unit 1	6,151.15	11,589.52	53.79	34.37	4.92	5.68	8.59	0.22
La Cygne - Unit 2	8,316.15	3,543.47	94.92	28.12	33.20	25.58	7.03	0.98

Table 3-2 summarizes the stack parameters that were used to model La Cygne Unit 1 and Unit 2. It should be noted that the good engineering practice (GEP) stack heights were modeled instead of the actual stack heights since the GEP stack heights are less than the actual stack heights.

**TABLE 3-2. SUMMARY OF STACK PARAMETERS**

	La Cygne Unit 1	La Cygne Unit 2
Latitude (degrees)	38.3486	38.3476
Longitude (degrees)	-94.6456	-94.6456
Actual Stack height (ft)	700	700
GEP Stack height (ft)	591.2	597.8
Stack Diameter (ft)	23	24
Exhaust Velocity (ft/s)	92.7	100.8
Exhaust Temperature (F)	127	281

The results of the modeling indicate that the 98<sup>th</sup> percentile of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 are greater than 0.5  $\Delta dv$  when compared against a natural background. Since the visibility impacts are greater than 0.5  $\Delta dv$ , La Cygne Unit 1 and Unit 2 are subject to BART. The results of the modeling are summarized in Table 3-3.

**TABLE 3-3. SUMMARY OF 98<sup>TH</sup> PERCENTILE VISIBILITY IMPACTS AND NUMBER OF DAYS WITH VISIBILITY IMPACT GREATER THAN 0.5  $\Delta DV$**

Class I Area	Visibility Impairment	
	98th % $\Delta dv$	Days > 0.5 $\Delta dv$
Wichita Mountains Wilderness	1.02	57
Hercules Glades Wilderness	1.74	138
Caney Creek Wilderness	1.14	63
Upper Buffalo Wilderness	1.92	125
Mingo Wilderness	0.92	62

Table 3-4 provides a breakdown of the visibility impacts listed in Table 3-3 by each VAP.

**TABLE 3-4. BREAKDOWN OF POLLUTANT SPECIFIC CONTRIBUTIONS TO VISIBILITY**

Class I Area	Visibility Impairment Attributable to SO <sub>4</sub> (%)	Visibility Impairment Attributable to NO <sub>3</sub> (%)	Visibility Impairment Attributable to SOA (%)	Visibility Impairment Attributable to EC (%)	Visibility Impairment Attributable to PM <sub>c</sub> (%)	Visibility Impairment Attributable to PM <sub>f</sub> (%)	Total Visibility Impairment ( $\Delta dv$ )
Wichita Mountains Wilderness	82.89	17.02	0.05	0.01	0.01	0.03	1.017
Hercules Glades Wilderness	19.63	79.99	0.20	0.04	0.04	0.10	1.738
Caney Creek Wilderness	24.32	75.46	0.12	0.02	0.02	0.06	1.138
Upper Buffalo Wilderness	20.20	79.53	0.15	0.03	0.02	0.07	1.923
Mingo Wilderness	42.26	57.61	0.07	0.01	0.00	0.03	0.915

As shown in Table 3-4, the most significant contributors to the visibility impairment are sulfates (SO<sub>4</sub>) and nitrates (NO<sub>3</sub>). The SO<sub>4</sub> contribution is primarily from the chemical conversion of SO<sub>2</sub> emitted by Unit 1 and Unit 2 to SO<sub>4</sub>; a very small fraction is from SO<sub>4</sub> emitted as condensable particulate. The NO<sub>3</sub> contribution is entirely from the chemical conversion of NO<sub>x</sub> emitted from Unit

1 and Unit 2. The contribution of  $PM_{10}$  to the total visibility impairment can be estimated as the sum of the contributions from SOA, EC, PMc, and PMf. The  $PM_{10}$  contribution is much smaller (<1%) than the contribution from  $SO_2$  and  $NO_x$ .

## 4. SO<sub>2</sub> BART EVALUATION

SO<sub>2</sub> emissions at coal-fired EGUs are the result of the oxidation of the sulfur compounds in the coal during the combustion process.

The existing maximum 24-hour SO<sub>2</sub> emission rates that were modeled for the BART applicability determination are summarized in Table 4-1.

**TABLE 4-1. EXISTING MAXIMUM 24-HOUR SO<sub>2</sub> EMISSION RATES**

	Maximum 24-Hour Heat Input (MMBtu/24hr)	SO <sub>2</sub> Emission Rate (lb/hr)	SO <sub>2</sub> Emission Rate (lb/MMBtu)
La Cygne - Unit 1	223,488	6,151.15	0.66
La Cygne - Unit 2	198,911	8,316.15	1.00

### 4.1 IDENTIFICATION OF AVAILABLE RETROFIT SO<sub>2</sub> CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit SO<sub>2</sub> control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, control equipment vendor information, publicly-available air permits, applications, and BART analyses, and technical literature published by the U.S. EPA and Regional Planning Organizations (RPOs).

The available retrofit SO<sub>2</sub> control technologies are summarized in Table 4-2.

**TABLE 4-2. AVAILABLE SO<sub>2</sub> CONTROL TECHNOLOGIES**

SO <sub>2</sub> Control Technologies
Dry Sorbent Injection Spray Dryer Absorber (SDA) i.e., Semi-Dry Scrubber Wet Scrubber Circulating Dry Scrubber (CDS)

All of the technologies listed in Table 4-2 involve removing the SO<sub>2</sub> in the exhaust gas, which is also known as flue gas desulfurization (FGD).

### 4.2 ELIMINATE TECHNICALLY INFEASIBLE SO<sub>2</sub> CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible SO<sub>2</sub> control technologies that were identified in Step 1.

#### **4.2.1 DRY SORBENT INJECTION**

Dry sorbent injection involves the injection of a lime or limestone powder into the exhaust gas stream where SO<sub>2</sub> becomes entrained in the lime. The stream is then passed through a fabric filter to remove the sorbent and entrained SO<sub>2</sub>. The process was developed as a lower cost FGD option because the mixing of the SO<sub>2</sub> and lime occurs directly in the exhaust gas stream instead of in a separate tower. Depending on the residence time and gas stream temperature, sorbent injection control efficiency is typically between 40 and 60 percent.<sup>2</sup> This control is a technically feasible option for the control of SO<sub>2</sub> from La Cygne Unit 1 and Unit 2.

#### **4.2.2 SPRAY DRYER ABSORPTION (SDA)**

Spray dryer absorption is a semi-dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the SO<sub>2</sub> is absorbed by the slurry droplets. The absorption of the SO<sub>2</sub> leads to the formation of calcium sulfite and calcium sulfate within the droplets. The liquid-to-gas ratio is such that the heat from the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder which is carried out with the gas and collected with a fabric filter. Existing spray dryer absorption control efficiencies range from 60 to 95 percent.<sup>3</sup> This control is a technically feasible option for the control of SO<sub>2</sub> from La Cygne Unit 1 and Unit 2.

#### **4.2.3 WET SCRUBBER**

Wet scrubbing involves scrubbing the exhaust gas stream with a slurry comprised of lime or limestone in suspension. The process takes place in a wet scrubbing tower located downstream of a PM control device such as a fabric filter or an ESP to prevent the plugging of spray nozzles and other problems caused by the presence of particulates in the scrubber. Similarly to the chemistry illustrated above for spray dryer absorption, the SO<sub>2</sub> in the gas stream reacts with the lime or limestone slurry to form calcium sulfite and calcium sulfate. Wet lime scrubbing is capable of achieving 80-95 percent control.<sup>3</sup> This control is a technically feasible option for the control of SO<sub>2</sub> from La Cygne Unit 1 and Unit 2.

#### **4.2.4 CIRCULATING DRY SCRUBBER (CDS)**

In the circulating dry scrubbing process, the flue gas is introduced into the bottom of a reactor vessel at high velocity through a venturi nozzle; the exhaust is mixed with water, hydrated lime, recycled flyash and CDS reaction products. The intensive gas-solid mixing that occurs in the reactor promotes the reaction of sulfur oxides in the flue gas with the dry lime particles. The mixture of reaction products (calcium sulfite/sulfate), unreacted lime, and fly ash is carried out with the exhaust and collected in an ESP or fabric filter. A large portion of the collected particles is recycled to the reactor to sustain the bed and improve lime utilization. CDS absorbers have been installed with both fabric filters and ESPs for particulate control. The control efficiency of a CDS is similar to that of an SDA. This

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<sup>2</sup> "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005.

<sup>3</sup> EPA Module 6: Air Pollutants and Control Techniques

control is a technically feasible option for the control of SO<sub>2</sub> from La Cygne Unit 1 and Unit 2.

### 4.3 RANK OF TECHNICALLY FEASIBLE SO<sub>2</sub> CONTROL OPTIONS BY EFFECTIVENESS

The third step in the BART analysis is to rank the technically feasible options according to effectiveness. Table 4-3 provides a ranking of the control efficiencies for the controls listed in the previous section.

**TABLE 4-3. CONTROL EFFECTIVENESS OF TECHNICALLY FEASIBLE SO<sub>2</sub> CONTROL TECHNOLOGIES**

Control Technology	Estimated Control Efficiency
Wet Scrubber	~80-95%
Spray Dryer Absorber (SDA)	~60-95%
Circulating Dry Scrubber (CDS)	~60-95%
Dry Sorbent Injection	~40-60%

As seen in Table 4-3, dry sorbent injection has the lowest estimated control efficiency and will therefore no longer be considered for BART.

It should be noted that Unit 1 has an existing scrubber for SO<sub>2</sub> control; however, the current control efficiency of the scrubber is below the efficiencies for the FGD controls listed in Table 4-3.

### 4.4 EVALUATION OF IMPACTS FOR FEASIBLE SO<sub>2</sub> CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list the four factors to be considered in the impact analysis:

- ▲ Cost of compliance
- ▲ Energy impacts
- ▲ Non-air quality impacts; and
- ▲ The remaining useful life of the source

#### 4.4.1 COST OF COMPLIANCE

The cost of compliance was evaluated for the two technologies with the highest SO<sub>2</sub> control efficiencies: wet scrubbers and SDA systems. The typical annual cost effectiveness for both wet scrubbers and SDA systems is \$200 to \$500 per ton of SO<sub>2</sub> removed at the highest removal efficiencies. The cost effectiveness was estimated from a published cost in a technical paper.<sup>4</sup> This cost estimate is considered to be study grade, which is +/- 30 percent accuracy.

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<sup>4</sup> "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005.

In the BART guidelines, EPA calculated that that the majority of BART-eligible units could meet the presumptive limits at a cost of \$400 to \$2,000 per ton of SO<sub>2</sub> removed, based on the use of wet scrubbers and SDA systems. Based on EPA's guidelines as to what is considered cost effective for SO<sub>2</sub> removal and the annual cost effectiveness of \$200 to \$500 published in the technical paper, wet scrubbers and SDA systems are cost effective.

#### **4.4.2 ENERGY IMPACTS AND NON-AIR QUALITY IMPACTS**

FGD systems require electricity to operate the blowers and pumps needed for the operation of the scrubbers. The generation of the electricity will most likely involve fuel combustion, which will cause emissions. While the required electricity will result in emissions, the emissions should be small compared to the reduction in SO<sub>2</sub> that would be gained by operating an FGD system.

Wet FGD systems generate wastewater and sludge that must be treated. This places additional burdens on the wastewater treatment and solid waste management capabilities. If wet scrubbing produces calcium sulfite sludge, the sludge will be water-laden, and it must be stabilized for landfilling. If wet scrubbing produces calcium sulfate sludge, it is stable and easy to dewater. However, control costs will be higher because additional equipment is required.

Disposal of material from dry FGD systems is also required and will result in landfill impacts.

#### **4.4.3 REMAINING USEFUL LIFE**

The remaining useful life of Unit 1 and Unit 2 do not impact the annualized capital costs because the useful lives of the units are anticipated to be at least as long as the capital cost recovery period, which is 20 years.

### **4.5 EVALUATION OF VISIBILITY IMPACT OF FEASIBLE SO<sub>2</sub> CONTROLS**

The final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the presumptive BART emission rates. The existing and presumptive BART emission rates were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis. The BART rates are the presumptive limits (in lb/MMBtu) multiplied by the historical maximum daily heat inputs. A sample calculation of the SO<sub>2</sub> presumptive BART hourly equivalent emission rate for Unit 1 is provided as follows:

$$P * HI * \frac{day}{24hr} = 1,396.8 \text{ lb/hr}$$

Where:

P (Presumptive BART Emission Rate) = 0.15 lb/MMBtu

HI (2002-2004 maximum daily heat input) = 223,488 MMBtu/day

The existing and presumptive BART emission rates are summarized in Table 4-4.

**TABLE 4-4. EXISTING AND PRESUMPTIVE BART EMISSION RATES**

	Existing Emission Rate			Presumptive BART Emission Rate		
	SO <sub>2</sub> (lb/hr)	NO <sub>x</sub> (lb/hr)	PM <sub>10</sub> (lb/hr)	SO <sub>2</sub> (lb/hr)	NO <sub>x</sub> (lb/hr)	PM <sub>10</sub> (lb/hr)
La Cygne - Unit 1	6,151.15	11,589.52	53.79	1,396.80	931.20	53.79
La Cygne - Unit 2	8,316.15	3,543.47	94.92	1,243.19	1,906.23	94.92

The visibility improvement due to the presumptive BART limits was calculated as the difference between the existing visibility impairment and the visibility impairment for the presumptive rates. A comparison of the existing visibility impacts and the visibility impacts based on the presumptive BART emission rates, including the maximum modeled visibility impact, 98<sup>th</sup> percentile modeled visibility impact, and the number of days with a modeled visibility impact greater than 0.5 Δdv, for each Class I area is provided in Table 4-5. It should be noted that the visibility impacts presented in Table 4-5 are based on the application of the presumptive BART limits for both SO<sub>2</sub> and NO<sub>x</sub>. The analysis included the presumptive BART limits from both SO<sub>2</sub> and NO<sub>x</sub> in order to determine the overall visibility improvement that would be gained from applying BART to both pollutants. The presumptive BART limits for NO<sub>x</sub> are discussed in Section 5.

**TABLE 4-5. MODELED IMPACTS BASED ON EXISTING AND PRESUMPTIVE BART EMISSION RATES**

	Caney Creek Wilderness			Hercules Glades Wilderness			Mingo Wilderness			Upper Buffalo Wilderness			Wichita Mountains Wilderness		
	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement
Max Impact (Δdv)	5.16	1.28	75%	4.48	1.00	78%	3.82	0.87	77%	6.36	1.56	75%	8.40	2.12	75%
98% Impact (Δdv)	1.14	0.23	80%	1.74	0.36	79%	0.92	0.18	81%	1.92	0.42	78%	1.02	0.21	80%
Days > 0.5	63	5	92%	138	6	96%	62	3	95%	125	14	89%	57	7	88%

As seen in Table 4-5, the visibility impacts (the maximum visibility impact, 98<sup>th</sup> percentile visibility impact, and the number of days with a visibility impact greater than 0.5 Δdv) for each Class I area are lower for the presumptive BART emission rates than for the existing emission rates.

## 4.6 PROPOSED BART FOR SO<sub>2</sub>

KCP&L has determined that the SO<sub>2</sub> BART emission rate for Unit 1 and Unit 2 is the presumptive emission rate of 0.15 lb/MMBtu. KCP&L is proposing to meet the presumptive BART SO<sub>2</sub> emission rate of 0.15 lb/MMBtu for each unit by complying with a combined Unit 1 and Unit 2 weighted average limit. KCP&L will meet this limit by installing scrubbing technology (i.e., either wet scrubber or SDA). Wet scrubbers and SDA systems achieve the highest levels of SO<sub>2</sub> control. In addition, the costs of compliance associated with both controls are similar, so no cost effectiveness is

gained by choosing one control over the other. KCP&L will select one of these control options at a later date pending several factors, including anticipated performance, availability, and market conditions. Performance, availability, and market conditions at the time of the BART implementation may drive the selection of the control option. At that time, a more detailed study may determine that one control is more favorable than the other.

## 5. NO<sub>x</sub> BART EVALUATION

NO<sub>x</sub> from coal-fired EGUs is formed by three fundamentally different mechanisms. The principle NO<sub>x</sub> formation mechanism, thermal NO<sub>x</sub>, arises from the thermal dissociation and subsequent reaction of nitrogen (N<sub>2</sub>) and oxygen (O<sub>2</sub>) molecules in the combustion air. Most thermal NO<sub>x</sub> forms in the highest temperature regions of the combustion chamber (i.e., the air/fuel interface). The second NO<sub>x</sub> formation mechanism, prompt NO<sub>x</sub>, arises from early reactions of nitrogen intermediaries and hydrocarbon radicals in the fuel. The final NO<sub>x</sub> formation mechanism, fuel NO<sub>x</sub>, arises from the evolution and reaction of fuel bound nitrogen compounds with oxygen.

The existing maximum daily NO<sub>x</sub> emission rates that were modeled for the BART applicability determination are summarized in Table 5-1.

**TABLE 5-1. EXISTING MAXIMUM 24-HOUR NO<sub>x</sub> EMISSION RATE**

	Maximum 24-Hour Heat Input (MMBtu/24hr)	NO <sub>x</sub> Emission Rate (lb/hr)	NO <sub>x</sub> Emission Rate (lb/MMBtu)
La Cygne - Unit 1	223,488	11,589.52	1.24
La Cygne - Unit 2	198,911	3,543.47	0.43

### 5.1 IDENTIFICATION OF AVAILABLE RETROFIT NO<sub>x</sub> CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit NO<sub>x</sub> control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, control equipment vendor information, publicly-available air permits, applications, and BART analyses, and technical literature published by the U.S. EPA and the RPOs.

The available retrofit NO<sub>x</sub> control technologies are summarized in Table 5-2.

**TABLE 5-2. AVAILABLE NO<sub>x</sub> CONTROL TECHNOLOGIES**

NO <sub>x</sub> Control Technologies	
Combustion Controls	Flue Gas Recirculation (FGR)
	Overfire Air (OFA)
	Low NO <sub>x</sub> Burners (LNB) and Ultra Low NO <sub>x</sub> Burners (ULNB)
Post-Combustion Controls	Selective Catalytic Reduction (SCR)
	Selective Non-Catalytic Reduction (SNCR)

NO<sub>x</sub> emissions controls, as listed in Table 5-2, can be categorized as combustion or post-combustion controls. Combustion controls, including flue gas recirculation (FGR), overfire air (OFA), and Low

NO<sub>x</sub> Burners (LNB), reduce the peak flame temperature and excess air in the furnace which minimizes NO<sub>x</sub> formation. Post-combustion controls, such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) convert NO<sub>x</sub> in the flue gas to molecular nitrogen and water.

## **5.2 ELIMINATE TECHNICALLY INFEASIBLE NO<sub>x</sub> CONTROL TECHNOLOGIES**

Step 2 of the BART determination is to eliminate technically infeasible NO<sub>x</sub> control technologies that were identified in Step 1.

### **5.2.1 COMBUSTION CONTROLS**

#### **5.2.1.1 FLUE GAS RECIRCULATION (FGR)**

FGR uses flue gas as an inert material to reduce flame temperatures. In a typical flue gas recirculation system, flue gas is collected from the heater or stack and returned to the burner via a duct and blower. The addition of flue gas reduces the oxygen content of the "combustion air" (air + flue gas) in the burner. The lower oxygen level in the combustion zone reduces flame temperatures; which in turn reduces thermal NO<sub>x</sub> formation. When operated without additional controls, the NO<sub>x</sub> control efficiency range for FGR is 30 percent to 50 percent. When coupled with LNB the control efficiency increases to 50-72 percent.<sup>5</sup> This control is a technically feasible option for the control of NO<sub>x</sub> from La Cygne Unit 1 and Unit 2.

#### **5.2.1.2 OVERFIRE AIR (OFA)**

OFA diverts a portion of the total combustion air from the burners and injects it through separate air ports above the top level of burners. Staging of the combustion air creates an initial fuel-rich combustion zone with a lower peak flame temperature. This reduces the formation of thermal NO<sub>x</sub> by lowering combustion temperature and limiting the availability of oxygen in the combustion zone where NO<sub>x</sub> is most likely to be formed.

OFA as a single NO<sub>x</sub> control technique may reduce NO<sub>x</sub> emissions by 25 to 55 percent. When combined with LNB, reductions of up to 60 percent may result.<sup>6</sup> KCP&L currently uses OFA on La Cygne Unit 1, and this is a technically feasible option for the control of NO<sub>x</sub> from La Cygne Unit 2.

#### **5.2.1.3 LOW AND ULTRA LOW NO<sub>x</sub> BURNERS**

LNB technology utilizes advanced burner design to reduce NO<sub>x</sub> formation through the restriction of oxygen, lowering of flame temperature, and/or reduced residence time. LNB is a staged combustion process that is designed to

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<sup>5</sup> "Midwest Regional Planning Organization Boiler Best Available Retrofit Technology (BART) Engineering Analysis" MACTEC, March 30, 2005.

<sup>6</sup> "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005

split fuel combustion into two zones. In the primary zone, NO<sub>x</sub> formation is limited by either one of two methods. Under staged fuel-rich conditions, low oxygen levels limit flame temperatures resulting in less NO<sub>x</sub> formation. The primary zone is then followed by a secondary zone in which the incomplete combustion products formed in the primary zone act as reducing agents. Alternatively, under staged fuel-lean conditions, excess air will reduce flame temperature to reduce NO<sub>x</sub> formation. In the secondary zone, combustion products formed in the primary zone act to lower the local oxygen concentration, resulting in a decrease in NO<sub>x</sub> formation. The estimated NO<sub>x</sub> control efficiency for LNBs in high temperature applications is 25 percent. However when coupled with FGR or SNCR these efficiencies increase to 50-72 and 50-89 percent, respectively.<sup>7</sup>

ULNBs may incorporate a variety of techniques including induced FGR, steam injection, or a combination of techniques. These burners combine the benefits of flue gas recirculation and LNB control technologies. Rather than a system of fans and blowers (like FGR), the burner is designed to recirculate hot, oxygen depleted flue gas from the flame or firebox back into the combustion zone. This leads to a reduction in the average oxygen concentration in the flame without reducing the flame temperature below temperatures necessary for optimal combustion efficiency.

The estimated NO<sub>x</sub> control efficiency for ULNBs in high temperature applications is 50 percent. Newer designs have yielded efficiencies of between 75-85 percent. When coupled with SCR, efficiencies in the range of 85-97 percent can be obtained.<sup>8</sup>

LNBs and ULNBs are technically feasible for tangential and wall-fired boilers of various sizes, but are not feasible for other boiler types such as cyclone or stoker.<sup>9</sup> Since La Cygne Unit 1 is a cyclone boiler, LNBs and ULNBs are not technically feasible for the control of NO<sub>x</sub> from this boiler. LNBs and ULNBs are technically feasible for the control of NO<sub>x</sub> from La Cygne Unit 2.

## **5.2.2 POST COMBUSTION CONTROLS**

NO<sub>x</sub> can be reduced to molecular nitrogen (N<sub>2</sub>) in add-on systems located downstream of the furnace. The two main post-combustion control techniques in commercial service are SCR and SNCR.

### **5.2.2.1 SELECTIVE CATALYTIC REDUCTION**

SCR refers to the process in which NO<sub>x</sub> is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed

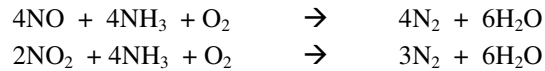
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<sup>7</sup> "Midwest Regional Planning Organization Boiler Best Available Retrofit Technology (BART) Engineering Analysis" MACTEC, March 30, 2005.

<sup>8</sup> Interim White Paper "Source Category: Electric Generating Units" Midwest RPO Candidate Control Measures, December 9, 2005

<sup>9</sup> AP 42, Fifth Edition, Volume I Chapter 1 Section 1.1.4.3

selective because the ammonia preferentially reacts with NO<sub>x</sub> rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions can be written:



The SCR process requires a reactor, a catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO<sub>x</sub> concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The NO<sub>x</sub> control efficiency range for SCR is 70 to 90 percent.<sup>10</sup> This control is a technically feasible option for the control of NO<sub>x</sub> from La Cygne Unit 1 and Unit 2.

#### **5.2.2.2 SELECTIVE NON-CATALYTIC REDUCTION**

In SNCR systems, a reagent is injected into the flue gas in the furnace within an appropriate temperature window. The NO<sub>x</sub> and reagent (ammonia or urea) react to form nitrogen and water. A typical SNCR system consists of reagent storage, multi-level reagent-injection equipment, and associated control instrumentation. The SNCR reagent storage and handling systems are similar to those for SCR systems. However, because of higher stoichiometric ratios, both ammonia and urea SNCR processes require three or four times as much reagent as SCR systems to achieve similar NO<sub>x</sub> reductions. The NO<sub>x</sub> control efficiency range for SNCR is 25 to 50 percent.<sup>11</sup> This control is a technically feasible option for the control of NO<sub>x</sub> from La Cygne Unit 1 and Unit 2.

### **5.3 RANK OF TECHNICALLY FEASIBLE NO<sub>x</sub> CONTROL OPTIONS BY EFFECTIVENESS**

The third step in the BART analysis is to rank the technically feasible options according to effectiveness.

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<sup>10</sup> Ibid.

<sup>11</sup> Interim White Paper "Source Category: Electric Generating Units" Midwest RPO Candidate Control Measures, December 9, 2005.

**TABLE 5-3. CONTROL EFFECTIVENESS OF TECHNICALLY FEASIBLE NO<sub>x</sub> CONTROL TECHNOLOGIES**

Control Technology	Estimated Control Efficiency (%)
SCR	~70-90
OFA/LNB*	~30-60
LNB*	~25-50
FGR	~30-50
SNCR	~25-50
OFA	~25-55

\*LNBs are technically feasible for La Cygne Unit 2 only, they are not technically feasible for La Cygne Unit 1.

## 5.4 EVALUATION OF IMPACTS FOR FEASIBLE NO<sub>x</sub> CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list four factors to be considered in the impact analysis:

- ▲ Cost of compliance
- ▲ Energy impacts
- ▲ Non-air quality impacts; and
- ▲ The remaining useful life of the source

### 5.4.1 COST OF COMPLIANCE

#### Control Costs

The capital costs, operating costs, and cost effectiveness for combustion controls and SCR were estimated for La Cygne Unit 2 using an EPA cost estimate method outlined in the document *Nitrogen Oxides (NO<sub>x</sub>), Why and How They Are Controlled*.<sup>12</sup> These control options were selected because they provide the highest levels of control and are commonly used for NO<sub>x</sub> control in large utility boilers. For the purposes of this analysis, LNB with OFA was used to represent a combustion controls system capable of achieving a NO<sub>x</sub> emission rate of 0.23 lb/MMBtu.

The EPA cost method relies on cost factors for capital costs, annual fixed operating and maintenance costs, and annual variable operating and maintenance costs for each of the control technologies. A summary of the cost factors is provided in Table 5-4.

<sup>12</sup> *Nitrogen Oxides (NO<sub>x</sub>), Why and How They Are Controlled*. EPA 456/F-99-006R, November 1999.

**TABLE 5-4. NO<sub>x</sub> CONTROL TECHNOLOGY COST FACTORS\***

Control Technology	Capacity (MW)	Capital Cost (\$/kW)	Fixed O&M (\$/kW/yr)	Variable O&M (mils/kWh)	Capital Cost (\$)	Annualized Capital Cost** (\$/yr)	Annual Fixed O&M Cost (\$/yr)	Annual Variable O&M Cost (\$/yr)	Total Annual Cost (\$/yr)
Combustion Controls System <sup>§</sup>	750	22.8	0.35	0.07	17,100,000	2,008,566	262,500	459,900	2,730,966
SCR	750	69.7	6.12	0.24	52,275,000	6,140,222	4,590,000	1,576,800	12,307,022

\*These cost factors are in 1997 dollars. Table 5-5 shows the capital costs, annual fixed O&M costs, and annual variable O&M costs in 2005 dollars.

\*\*The annualized cost is based on a recovery period of 20 years, assuming 10% interest. The capital recovery factor (CRF) of 0.11746 was obtained from EPA's Air Pollution Control Cost Manual, Sixth Edition. EPA 452/B-02-001, January 2002.

<sup>§</sup>For the purposes of this analysis, the cost of a combustion control system is represented by a LNB w/OFA system capable of achieving a NO<sub>x</sub> emission rate of 0.23 lb/MMBtu. As KCP&L is proposing not to commit to specific combustion controls at this time, KCP&L is using LNB w/ OFA to represent combustion control equipment that can achieve a NO<sub>x</sub> rate of 0.23 lb/MMBtu.

These cost estimates are considered to be study grade, which is +/- 30 percent accuracy. It is likely that these costs are low, since the costs may not reflect the current high market price for steel and other increased costs associated with high demand.

KCP&L is in the process of constructing an SCR system on La Cygne Unit 1. Since SCR provides the highest level of control there is no need to evaluate the cost for other controls. Construction on the SCR system is scheduled to be operational in May 2007.

#### Annual Tons Reduced

The annual tons reduced that were used in the cost effectiveness calculations for NO<sub>x</sub> controls on La Cygne Unit 2 were estimated by subtracting the estimated controlled annual emission rates from the existing annual emission rates. The existing annual emission rates were the highest 365-day rolling totals as determined from CEMS data from 2002-2004.

The controlled annual emission rates were estimated based on the controlled NO<sub>x</sub> emission rates for each control method in lb/MMBtu. These emission rates were multiplied by the maximum 365-day rolling heat input as determined from CEMS data from 2002-2004.

A sample of the controlled annual emission rate is provided below for combustion controls with a controlled emission rate of 0.23 lb/MMBtu:

$$0.23lb / MMBtu \times 63,507,314MMBtu / yr \div 2,000lb / ton = 7,303 \text{ tpy}$$

#### Cost Effectiveness

The capital costs were annualized over a 20-year period and then added to the annual operating costs to obtain the total annualized costs for each technology. The cost effectiveness for a combustion controls system (represented by LNB with OFA) and SCR were determined by dividing the total annualized cost by the annual tons reduced. The control technology costs are summarized for Unit 2 in Table 5-5.

In the BART guidelines, EPA calculated that for all types of boilers other than cyclone boilers, combustion control technology is generally more cost-effective than post-combustion controls. EPA estimates that approximately 75 percent of the BART units (non-cyclone) could meet the presumptive NO<sub>x</sub> limits at a cost of \$100 to \$1,000 per ton of NO<sub>x</sub> removed based on the use of combustion control technology. For the units that could not meet the presumptive limits using combustion control technology, EPA estimates that almost all of these sources could meet the presumptive limits using advanced combustion controls; the EPA estimates that the cost of such controls are usually less than \$1,500 per ton removed.

Table 5-5 indicates that the cost effectiveness of a combustion controls system (represented by LNB with OFA) for La Cygne Unit 2 is less than \$1,500 per ton of NO<sub>x</sub> removed; however, the cost for SCR is over \$1500 per ton of NO<sub>x</sub> removed, which is greater than EPA's cost estimate for advanced combustion controls.

**TABLE 5-5. NO<sub>x</sub> CONTROL TECHNOLOGY COST SUMMARY (IN 2005 DOLLARS) FOR LA CYGNE UNIT 2**

	Current Annual Emission Rate	Estimated Controlled Emission Rate		Annual Emissions Reduced	Capital Cost	Annualized Fixed O&M	Annualized Variable O&M	Total Annualized Cost*	Cost Effectiveness
	(tpy)	(lb/MMBtu)	(tpy)	(ton/yr)	(\$)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/ton)
Combustion Controls System**	10,669	0.23	7,303	3,365	20,714,670	317,988	557,116	3,308,249	983
SCR	10,669	0.10	3,175	7,493	63,325,110	5,560,254	1,910,111	14,908,532	1,990

\*The costs are annualized in 2005 dollars.

\*\* For the purposes of this analysis, the cost of a combustion control system is represented by a LNB w/OFA system capable of achieving a NO<sub>x</sub> emission rate of 0.23 lb/MMBtu.

**5.4.2 ENERGY IMPACTS & NON-AIR IMPACTS**

SCR systems require electricity to operate the blowers and pumps needed to operate the systems. The generation of the electricity will most likely involve fuel combustion, which will cause emissions. While the required electricity will result in the emissions, the emissions should be small compared to the reduction in NO<sub>x</sub> that would be gained by operating an SCR system

SCR can potentially cause significant environmental impacts related to the usage and storage of ammonia. Storage of aqueous ammonia above 10,000 lbs is regulated by a risk management program (RMP), since the accidental release of ammonia has the potential to cause serious injury and death to persons in the vicinity of the release. Ammonia can also be emitted in the exhaust of boilers that operate with SCR or SNCR for NO<sub>x</sub> control due to ammonia slip.

Ammonia slip from SCR and SNCR systems occurs either from ammonia injection at temperatures too low for effective reaction with NO<sub>x</sub>, leading to an excess of unreacted ammonia, or from over-injection of reagent leading to uneven distribution; which also leads to an excess of unreacted ammonia. Ammonia released from SCR and SNCR systems will react with sulfates and nitrates in the atmosphere to form ammonium sulfate. Together, ammonium sulfate and ammonium nitrate are the predominant sources of regional haze.

**5.4.3 REMAINING USEFUL LIFE**

The remaining useful life of Unit 1 and Unit 2 do not impact the annualized capital costs of potential controls because the useful lives of the units are anticipated to be at least as long as the capital cost recovery period, which is 20 years.

**5.5 EVALUATION OF FEASIBLE NO<sub>x</sub> CONTROLS IMPACT ON VISIBILITY**

The final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the presumptive BART emission rates. The existing and presumptive BART emission levels were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis. The BART rates are the presumptive limits (in lb/MMBtu) multiplied by the historical maximum daily heat inputs. The existing and BART emission rates are summarized in Table 5-6.

**TABLE 5-6. EXISTING AND PRESUMPTIVE BART EMISSION RATES**

	Existing Emission Rate			Presumptive BART Emission Rate		
	SO <sub>2</sub> (lb/hr)	NO <sub>x</sub> (lb/hr)	PM <sub>10</sub> (lb/hr)	SO <sub>2</sub> (lb/hr)	NO <sub>x</sub> (lb/hr)	PM <sub>10</sub> (lb/hr)
La Cygne - Unit 1	6,151.15	11,589.52	53.79	1,396.80	931.20	53.79
La Cygne - Unit 2	8,316.15	3,543.47	94.92	1,243.19	1,906.23	94.92

The visibility improvement due to the presumptive BART limits was calculated as the difference between the existing visibility impairment and the visibility impairment for the presumptive rates. A comparison of the existing visibility impacts and the visibility impacts based on the presumptive BART emission rates, including the maximum modeled visibility impact, 98<sup>th</sup> percentile modeled visibility impact, and the modeled number of days with a modeled visibility impact greater than 0.5 Δdv, for each Class I area is provided in Table 5-7. It should be noted that the visibility impacts presented in Table 5-7 are based on the application of the presumptive BART limits for both SO<sub>2</sub> and NO<sub>x</sub>. The analysis included the presumptive BART limits from both SO<sub>2</sub> and NO<sub>x</sub> in order to determine the overall visibility improvement that would be gained from applying BART to both pollutants. The presumptive BART limits for SO<sub>2</sub> are discussed in Section 4.

**TABLE 5-7. MODELED IMPACTS BASED ON EXISTING AND PRESUMPTIVE BART EMISSION RATES**

	Caney Creek Wilderness			Hercules Glades Wilderness			Mingo Wilderness			Upper Buffalo Wilderness			Wichita Mountains Wilderness		
	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement	Existing	BART	Improvement
Max Impact (Δdv)	5.16	1.28	75%	4.48	1.00	78%	3.82	0.87	77%	6.36	1.56	75%	8.40	2.12	75%
98% Impact (Δdv)	1.14	0.23	80%	1.74	0.36	79%	0.92	0.18	81%	1.92	0.42	78%	1.02	0.21	80%
Days > 0.5	63	5	92%	138	6	96%	62	3	95%	125	14	89%	57	7	88%

As seen in Table 5-6, the visibility impacts (the maximum visibility impact, 98<sup>th</sup> percentile visibility impact, and the number of days with a visibility impact greater than 0.5 Δdv) for each Class I area are lower for the presumptive BART emission rates than for the existing emission rates.

## 5.6 PROPOSED BART FOR NO<sub>x</sub>

KCP&L has determined that the NO<sub>x</sub> BART emission rates are the presumptive emission rates of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively. The presumptive NO<sub>x</sub> limit of 0.10 lb/MMBtu for cyclone units is based on the use of SCR and the NO<sub>x</sub> limit of 0.23 lb/MMBtu is based on combustion controls. Therefore, KCP&L proposes that the currently permitted SCR is equivalent to BART controls for Unit 1 and that combustion controls, such as LNB or LNB and OFA, or post-combustion controls, such as an SCR, are equivalent to BART controls for Unit 2.

Although KCP&L proposes that combustion controls are equivalent to BART for Unit 2, KCP&L proposes to install an SCR for Unit 2 and further study the installation of combustion controls on Unit 2. KCP&L will further study combustion control options at a later date pending several factors, including other regulatory requirements, availability, and market conditions. The concerns surrounding these factors are described below.

La Cygne Generating Station is located just south of the Kansas City metropolitan area. Based on ozone monitoring data for the past several ozone seasons, KCP&L anticipates that the Kansas City metropolitan area may soon implement regulatory requirements to reduce volatile organic compound (VOC) and NO<sub>x</sub> emissions in the area in order to avoid designation as a nonattainment area for the

ozone National Ambient Air Quality Standard (NAAQS). Controls at La Cygne Generating Station have already been proposed as part of the Kansas City Ozone Maintenance Plan, which has been submitted and approved by EPA. This may require KCP&L to install NO<sub>x</sub> controls sooner than the BART deadline for controls implementation. The extent of NO<sub>x</sub> reductions and the exact timeline for implementation that would be required are unknown at this time. KCP&L would like to retain the flexibility to choose a control option based on upcoming ozone standard regulatory requirements that may require additional NO<sub>x</sub> controls prior to the BART deadline.

Lastly, market conditions and vendor availability at the time of the BART implementation may drive the selection of combustion control options. At that time, a more detailed study analysis may determine that one combustion control is more favorable than the other.

Additional details on the proposed compliance demonstration methods are provided in Section 7.

## 6. PM BART EVALUATION

The primary source of PM from Unit 1 and Unit 2 is the fly ash in the flue gas. Other sources of PM include unburned carbon present in the flue gas, which is the result of incomplete combustion, and reactions of SO<sub>2</sub> and NO<sub>x</sub> compounds to form fine PM in the form of nitrates, sulfur trioxide, sulfates, and sulfuric acid mist.

The maximum daily PM<sub>10</sub> emission rates that were modeled for the BART applicability determination are summarized in Table 6-1.

**TABLE 6-1. HISTORICAL MAXIMUM 24-HOUR PM<sub>10</sub> EMISSION RATE**

	Maximum 24-Hour Heat Input (MMBtu/24hr)	PM <sub>10</sub> Emission Rate (lb/hr)	PM <sub>10</sub> Emission Rate (lb/MMBtu)
La Cygne - Unit 1	223,488	53.79	0.006
La Cygne - Unit 2	198,911	94.92	0.011

From Table 6-1 it can be seen that the current PM<sub>10</sub> emission rates for Unit 1 and Unit 2 are much less than the current emission rates of SO<sub>2</sub> and NO<sub>x</sub>. The low PM<sub>10</sub> emission rates correspond to very low visibility impacts attributable to PM<sub>10</sub> when compared to the impacts attributable to SO<sub>2</sub> and NO<sub>x</sub>, as shown in Table 6-2.

**TABLE 6-2. VISIBILITY IMPAIRMENT CONTRIBUTIONS**

Year	Visibility Impairment Attributable to SO <sub>4</sub> <sup>1</sup> (%)	Visibility Impairment Attributable to NO <sub>3</sub> <sup>2</sup> (%)	Visibility Impairment Attributable to PM <sub>10</sub> <sup>2</sup> (%)
Wichita Mountains	82.89	17.02	0.10
Hercules Glades	19.63	79.99	0.38
Caney Creek	24.32	75.46	0.22
Upper Buffalo	20.20	79.53	0.27
Mingo Wildlife	42.26	57.61	0.11

<sup>1</sup> The visibility impairment attributable to SO<sub>4</sub> is primarily from SO<sub>2</sub> emissions. A very small portion is from SO<sub>4</sub> emitted as condensable particulate.

<sup>2</sup> The visibility impairment attributable to NO<sub>3</sub> is entirely from NO<sub>x</sub> emissions.

<sup>3</sup> The visibility impairment attributable to PM<sub>10</sub> is the sum of the visibility impairment attributable to all modeled primary PM species (PMc, PMf, EC, and SOA).

Given the small PM<sub>10</sub> emission rates compared to SO<sub>2</sub> and NO<sub>x</sub> and the small contribution of PM<sub>10</sub> to the visibility impacts, any additional control technology would provide little visibility improvement and require significant capital expenditures. Therefore, additional control technologies would not be cost effective, and are not required as PM control technologies for BART compliance. Although not

required for BART compliance, KCP&L plans to install a baghouse on Unit 1 and Unit 2 for compliance with other environmental regulations.

## 7. PROPOSED BART LIMITS COMPLIANCE SUMMARY

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### 7.1 SO<sub>2</sub> BART COMPLIANCE SUMMARY

Based on the SO<sub>2</sub> BART analysis, KCP&L has determined that the BART limit for SO<sub>2</sub> for Unit 1 and Unit 2 is the presumptive emission limit of 0.15 lb/MMBtu. Per the BART guidelines, states may allow sources to “average” emissions across any set of BART-eligible emission units within a fenceline, so long as the emission reductions from each pollutant being controlled for BART would be equal to those reductions that would be obtained by simply controlling each of the BART-eligible units that constitute a BART-eligible source. The weighted average of the BART limits for Unit 1 and Unit 2 is 0.15 lbs/MMBtu.

Even though the weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.15 lb/MMBtu, KCP&L proposes to demonstrate compliance with a limit that is more stringent than this limit. Specifically, KCP&L proposes a weighted average limit of 0.10 lb/MMBtu on a 30-day rolling average for Unit 1 and Unit 2. The proposed weighted average emission limit is below the presumptive BART emission rates which will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 in excess of those indicated in Sections 4 and 5.

KCP&L proposes to demonstrate compliance with the Unit 1 and Unit 2 weighted average emission limit of 0.10 lbs/MMBtu using the existing CEMS with a new 30-day rolling average report. The CEMS software will be configured to generate a two unit weighted average. The daily average SO<sub>2</sub> rate for each unit will be the average of the hourly SO<sub>2</sub> rates for each hour of a particular boiler operating day, excluding periods of start-up and shut-down. A boiler operating day will be any day that the unit combusts fuel for any period of time, excluding periods of start-up and shut-down. The two-unit daily average will be calculated using the following equation:

$$\frac{((\text{SO}_2\text{Day}\#1 \times \text{HI}_{\text{sum-day}\#1}) + (\text{SO}_2\text{Day}\#2 \times \text{HI}_{\text{sum-day}\#2}))}{(\text{HI}_{\text{sum-day}\#1} + \text{HI}_{\text{sum-day}\#2})}$$

Where:

SO<sub>2</sub>day#1 = Daily average of hourly SO<sub>2</sub> rates for Unit 1

SO<sub>2</sub> day#2 = Daily average of hourly SO<sub>2</sub> rates for Unit 2

HI<sub>sum-day#1</sub> = Summation of hourly heat inputs for the day for Unit 1

HI<sub>sum-day#2</sub> = Summation of hourly heat inputs for the day for Unit 2

The 30-day rolling average will be the simple average of the last 30 days of two-unit daily averages and will be in compliance if it is less than 0.10 lbs/MMBtu, excluding periods of start-up and shut-down.

Periods of start-up and shut-down for Unit 1 and Unit 2 will be based on good industry practice or the manufacturer's recommendations.

## 7.2 NO<sub>x</sub> BART COMPLIANCE SUMMARY

Based on the NO<sub>x</sub> BART analysis, KCP&L has determined that the BART limits for NO<sub>x</sub> are the presumptive emission limits of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively. Per the BART guidelines, states may allow sources to “average” emissions across any set of BART-eligible emission units within a fenceline, so long as the emission reductions from each pollutant being controlled for BART would be equal to those reductions that would be obtained by simply controlling each of the BART-eligible units that constitute a BART-eligible source. The weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.16 lbs/MMBtu. The Unit 1 + Unit 2 weighted average emission limit has been calculated as follows:

$$\frac{\sum_{i=1}^2 R_{ip} \times HI_{im}}{\sum_i HI_{im}}$$

Where

R<sub>ip</sub> = Presumptive BART emission rate for unit i (lb/MMBtu)

HI<sub>im</sub> = Maximum daily heat input from 2002-2004 (MMBtu/day) for unit i

The detailed calculation of the weighted presumptive emission limit is shown below.

$$\frac{(R_{1p} \times HI_{1m}) + (R_{2p} \times HI_{2m})}{(HI_{1m} + HI_{2m})} = 0.16 \text{ lb/MMBtu}$$

Where:

R<sub>1p</sub> = Presumptive BART emission rate for Unit 1 (lb/MMBtu) = 0.10 lb/MMBtu

HI<sub>1m</sub> = Maximum daily heat input from 2002-2004 (MMBtu/day) for Unit 1 = 223,488 MMBtu/day

R<sub>2p</sub> = Presumptive BART emission rate for Unit 2 (lb/MMBtu) = 0.23 lb/MMBtu

HI<sub>2m</sub> = Maximum daily heat input from 2002-2004 (MMBtu/day) for Unit 2 = 198,911 MMBtu/day

Even though the weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.16 lb/MMBtu, KCP&L proposes to demonstrate compliance with a limit that is more stringent than this limit. Specifically, KCP&L proposes a weighted average limit of 0.13 lb/MMBtu on a 30-day rolling average for Unit 1 and Unit 2. The proposed weighted average emission limit is below the presumptive BART emission rates which will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 in excess of those indicated in Sections 4 and 5.

KCP&L proposes to demonstrate compliance with the Unit 1 and Unit 2 weighted average emission limit of 0.13 lbs/MMBtu using the existing CEMS with a new 30-day rolling average report. The CEMS software will be configured to generate a two unit weighted average. The daily average NO<sub>x</sub> rate for each unit will be the average of the hourly NO<sub>x</sub> rates for each hour of a particular boiler

operating day, excluding periods of start-up and shut-down. A boiler operating day will be any day that the unit combusts fuel for any period of time, excluding periods of start-up and shut-down. The two-unit daily average will be calculated using the following equation:

$$\frac{((\text{NO}_x\text{Day}\#1 \times \text{HI}_{\text{sum-day}\#1}) + (\text{NO}_x\text{Day}\#2 \times \text{HI}_{\text{sum-day}\#2}))}{(\text{HI}_{\text{sum-day}\#1} + \text{HI}_{\text{sum-day}\#2})}$$

Where:

$\text{NO}_{x\text{day}\#1}$  = Daily average of hourly  $\text{NO}_x$  rates for Unit 1

$\text{NO}_{x\text{ day}\#2}$  = Daily average of hourly  $\text{NO}_x$  rates for Unit 2

$\text{HI}_{\text{sum-day}\#1}$  = Summation of hourly heat inputs for the day for Unit 1

$\text{HI}_{\text{sum-day}\#2}$  = Summation of hourly heat inputs for the day for Unit 2

The 30-day rolling average will be the simple average of the last 30 days of two-unit daily averages and will be in compliance if it is less than 0.13 lbs/MMBtu, excluding periods of start-up and shut-down.

In the event of an extraordinary situation involving an extended outage of Unit 2 (duration in excess of 10 weeks) KCP&L will submit a plan to KDHE to achieve compliance with a La Cygne Unit 1  $\text{NO}_x$  presumptive limit of 0.10 lbs/MMBtu on a 30-day rolling average excluding periods of start-up and shut-down. The 10-week period is intended to cover all anticipated scheduled outages so that this scenario would only come up in the case of a unit retirement or a catastrophic loss of one unit.

Periods of start-up and shut-down for Unit 1 and Unit 2 will be based on good industry practice or the manufacturer's recommendations.

### 7.3 $\text{PM}_{10}$ BART COMPLIANCE SUMMARY

KCP&L proposes that no additional PM controls are required for BART compliance. Although not required for BART compliance, KCP&L plans to install a baghouse on Unit 1 and Unit 2 for compliance with other environmental regulations.

KCP&L proposes to demonstrate compliance with the La Cygne Unit 1 and Unit 2 average emission limit of 0.015 lbs/MMBtu for  $\text{PM}_{10}$  (filterable) and 0.024 lbs/MMBtu for  $\text{PM}_{10}$  (total) by conducting annual stack tests. Compliance is demonstrated if the weighted average stack test results of the two units combined meets the emission limits. Annual stack test results will be the average of three one-hour stack tests for each unit.