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ATTACHMENT 4

SO_2, NO_X, AND MERCURY REDUCTION STUDY

Docket No.
PU-11-163/ PU-11-165

OTP/MDU-105

Sargent & Lundy LLC

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September 24, 2010
Project No. 12715-001
Letter No. BSP-SL-OTP-0013

Otter Tail Power Company
Big Stone Plant

SL-010408 Draft Report
SO_2, NO_x, and Mercury Reduction Study
Conceptual Engineering Design Report

Mr. Mark Rolfes
Otter Tail Power Company
215 S. Cascade Street
Fergus Falls, MN 56538-0496

Dear Mr. Rolfes:

Enclosed is the draft SO_2, NO_x, and Mercury Reduction Study for your comments. We look forward to walking you through the results and answer any questions you may have.

Please do not hesitate contacting me if you have any questions.

Yours very truly,

Ken A. Mixer
Project Manager

KAM:km
Enclosure – All Recipients
File No. 2.03
BSP-SL-OTP-0013.doc

OTTER TAIL POWER COMPANY

BIG STONE PLANT

SO_2, NO_X, AND MERCURY REDUCTION STUDY

CONCEPTUAL ENGINEERING DESIGN REPORT

SL-010408
Draft Report

September 24, 2010
Project 12715-001

Prepared by

Sargent & Lundy LLC

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09-24-2010
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TABLES AND FIGURES

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APPENDIXES

ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Explanation
acfm	actual cubic feet per minute
ACI	activated carbon injection
AFUDC	allowance for funds used during construction
AHJ	Authority Having Jurisdiction
AIG	ammonia injection grid
AQCS	air quality control system
ARSD	Administrative Rules of South Dakota
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BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
BOP	balance-of-plant
Btu	British thermal unit
BC	brine concentrator
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CCR	coal combustion residual
CFB	circulating fluidized bed combustor or combustion
CFR	Code of Federal Regulations
CLS	cold-lime softener
CO	carbon monoxide
D/F	dioxin/furan
DCS	distributed control system
DENR	Department of Environment and Natural Resources (South Dakota)
EEGT	economizer exit gas temperature
EGU	electric generating unit
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
FD	forced draft
FGD	flue gas desulfurization
FGR	flue gas recirculation
FM	Factory Mutual
GA	general arrangement
GHG	greenhouse gas
H_2	hydrogen

ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Explanation
H_2O	water
HAP	hazardous air pollutant
HHV	higher heating value
HMI	human-machine interface
hp	horsepower
hr	hour
I/O	input/output
ICR	Information Collection Request
ID	induced draft
in. w.c.	inches water column
lb	pound
LPA	large-particle ash
LSD	lime spray dry
LSFO	limestone forced oxidation
MACT	Maximum Achievable Control Technology
MCR	maximum continuous rating
MBtu	million British thermal unit
MW	megawatt
MWh	megawatt-hour
N_2	nitrogen gas
NAAQS	National Ambient Air Quality Standard(s)
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NH_3	ammonia
NO_2	nitrogen dioxide
NOI	Notice of Intent
NO_X	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPRM	Notice of Proposed Rulemaking
NSPS	New Source Performance Standards
NSR	New Source Review
O&M	operations and maintenance
O_2	oxygen
OEM	original equipment manufacturer

ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Explanation
OFA	overfire air
OSHA	Occupational Safety and Health Administration
PAC	powder-activated carbon
PC	pulverized coal
PLC	programmable logic controller
PM	particulate matter
ppm	parts per million
ppmv	parts per million volume
PRB	Powder River Basin
PSD	Prevention of Significant Deterioration
psia	pounds per square inch absolute
psig	pounds per square inch gauge
RAT	reserve auxiliary transformer
RCRA	Resource Conservation and Recovery Act
RO	reverse osmosis
RPS	Renewable Portfolio Standards
RTD	resistance temperature detector
SCR	selective catalytic reduction
SDA	spray dry absorber
SIP	state implementation plan
SNCR	selective non-catalytic reduction
SNCR	selective non-catalytic reduction
SO_2	sulfur dioxide
SO_3	sulfur trioxide
SOFA	separated overfire air
SWD	surface water discharge
TiO_2	titanium oxide
UAT	unit auxiliary transformer
UPS	uninterruptible power supply
V_2O_4	vanadium tetroxide
V_2O_5	vanadium pentoxide
VFD	variable-frequency drive
wacfm	wet actual cubic feet per minute

1. EXECUTIVE SUMMARY

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Otter Tail Power Company (OTP) is required to install Air Quality Control System (AQCS) equipment at its Big Stone Plant (Big Stone or the plant) to reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) based on a Best Available Retrofit Technology (BART) determination filed by the South Dakota Department of Environment and Natural Resources (DENR). The BART requires the AQCS system to include flue gas desulfurization (FGD) for SO_2 reduction, and selective catalytic reduction (SCR) with separated overfire air (SOFA) for NO_X reduction. BART did not include mercury reduction requirements; however, because it is expected that the utility Maximum Achievable Control Technology (MACT) will require about reduction when implemented by the end of 2011, mercury reduction technology was also evaluated. The AQCS retrofit work is to be completed by the end of 2015 and the South Dakota DENR determination states that the retrofit AQCS system must be operational by January 15, 2016.

The AQCS system proposed for the conceptual design as presented herein will allow Big Stone to operate within the emissions limits listed in Table 1-1.

Table 1-1. Emission Levels

Parameter	Value
PM (filterable)	
SO_2	
NO_X	
Hg	

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At OTP's request, Sargent & Lundy, L.L.C. (S&L) conducted a conceptual design study and prepared estimated costs for the AQCS needed to comply with the South Dakota DENR BART determination. The AQCS retrofit proposed comprises a dry FGD system with new baghouse, SOFA, anhydrous-based SCR, ACI, and the associated ancillary balance-of-plant (BOP) systems.

The capital costs of the AQCS retrofit were estimated separately, one for NO_X-related work (SCR and SOFA) and one for SO_2 related work (dry FGD with a baghouse and ACI). The costs are summarized in Table 1-2.

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Table 1-2. Capital Cost Summary

Parameter	SCR	Dry FGD with New Baghouse
Direct and construction indirect cost,		
Indirect cost,		
Contingency @		
Escalation,		
Owner's cost,	Included in dry FGD	
Total project cost, $M		
Total AQCS Cost,		

The capital cost represents completion of installation in the summer of and a commercial operation date of . The estimate is based on current market prices and escalation is included to reflect the operation date. The estimate does not include extra contingency for escalation that can occur due to excessive cost increases in equipment, material, or labor. Such escalation occurred between 2005 and 2008, when all utility projects were paying premiums because of the excessive escalation that applied over all utility projects. The Big Stone AQCS project appears to be ahead of other potential AQCS projects that could be initiated as the environmental regulations become more defined in 2011. Specifically, it is anticipated that AQCS vendors and construction contractors will become increasingly busy as these new projects are initiated, which could result in market-related price increases. It is recommended that OTP consider steps to avoid or minimize the impact of market escalation. Awarding contracts as early as possible may position OTP ahead of the other utilities also retrofitting AQCS equipment.

The first-year and total levelized O&M costs are summarized in Table 1-3.

Table 1-3. First-Year O&M Costs

Parameter	SCR	Dry FGD with New Baghouse
First-Year Fixed O&M,		
First-Year Variable O&M,		
Total First-Year O&M,		
Levelized O&M,		

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The outage required in weeks. This outage is based on the boiler modifications being the critical path. The boiler modifications need to be evaluated in more detail if it is desired to shorten the outage length.

The permitting evaluation considered whether other environmental rules or regulations might alter the BART requirements for AQCS retrofit. In our opinion, the proposed dry FGD with baghouse and SCR could be considered Best Available Control Technology (BACT) for a new sub-bituminous-fired unit, and the ACI system should meet future MACT requirements. OTP installing dry FGD with baghouse, SCR, and ACI as a retrofit, in our judgment, will meet the regulations expected for the next years.

Two major issues needed evaluation in order to complete the above detailed conceptual design scenarios. A screening study was completed that evaluated (1) three options using wet FGD or dry FGD systems and (2) two locations where the SCR reactor could be built. With the detailed conceptual cost estimate completed, these decisions were reviewed to ensure that the decisions had not changed. The screening study cost results are shown in Table 1-4.

Table 1-4. Capital Cost Summary (All FGD Options with SCR Behind Boiler)

Parameter	Option 1, Dry FGD with Existing Baghouse and SCR	Option 2 Dry FGD with New Baghouse and SCR	Option 3 Wet FGD with Existing Baghouse and SCR
FGD,			
SCR,			
Total Capital Cost,			
Delta,			

TRADE SECRET DATA ENDS]

A dry FGD system that uses a new baghouse was the least-cost option for FGD. A second dry FGD option reuses the existing baghouse. As the costs used in the screening study did not change significantly, the previously determined cost difference remains. Dry FGD with a new baghouse is still the recommended FGD system for Big Stone. This technology option offers the lowest cost and lowest risk of cost increase due to unknowns associated with reinforcing a majority of the ductwork and structures, and will be able to follow load without significant O&M issues. The option of reusing the existing baghouse has significant cost issues related to reinforcing structures, has higher risk of cost increase and extending the outage, and has significant risk of increasing O&M because of the solids that could drop out in the ducts ahead of the baghouse.

The second major issue for the Big Stone AQCS retrofit is where to locate the SCR. The screening recommended the location the SCR immediately behind the boiler. This location usually is cost-effective when evaluating SCR on utility boilers. The concern was that if significant boiler steel had to be modified to tie in the SCR, this location's costs might increase. During the conceptual design, several trips were made to evaluate the SCR location and the conclusion is that it can be retrofit without the impacts that were initially considered problematic in the screening study. The detailed conceptual design confirms the SCR located behind the boiler is optimal.

Other screening studies were completed, and used to focus the conceptual design effort to a final general arrangement and design. While these screening studies did not have the impact of the wet versus dry FGD study, they were important to completing the effort. Table 1-5 below lists the mini studies and summarizes the major conclusions.

The next steps for moving the project forward are:

- Authorize the project to proceed with design of the AQCS retrofit
- Start permitting of the project
- Start detailed design of the project
- Review solutions to reduce the cost of lowering economizer outlet and SCR inlet services

Table 1-5. Summary of Screening Studies Completed for Conceptual Design

Study	Conclusion
Location of SCR (Appendix B)	The SCR reactor located behind the boiler is more cost-effective than located to the side of the unit (south).
SCR Reagent Study (Appendix E)	Using anhydrous ammonia is lowest cost compared with urea and aqueous ammonia. Anhydrous ammonia is potentially more dangerous, but when the safety features are factored in, is cost-effective. This study should consider when SOFA is used because the SCR will require less reagent.
In-Boiler NO_X Reduction (Appendix F)	Two SOFA approaches were developed. The greater capital cost approach was included because it allows the lowest economizer outlet NO_X. However, outlet NO_X level is only marginally lower, so these two systems will be evaluated in detailed design.
[TRADE SECRET DATA BEGINS	
Economizer Gas Outlet Temperature Reduction (Appendix F)	recommended several internal boiler modifications to control the temperature to between 750°F and 625°F. The modifications are expensive, at about in capital. These costs and alternative approaches will be considered during detail engineering.
Wet v. Dry FGD (Appendix B)	Dry FGD is significantly more cost-effective than wet FGD. The PRB fuel with low-sulfur content typically favors this outcome on middle-sized installations. A new baghouse is the lowest risk compared to reusing the existing baghouse. The costs are similar, but favor a new baghouse as well.
Solid Waste Handling (Appendix M)	A pneumatic solid waste handling system will transport solids (FGD waste and fly ash) to a new silo located next to the existing silo. Both silos will be used. Scrapers and articulated trucks will then be used to transport the ash to the onsite landfill. It is not cost-effective to transport the solids to the landfill pneumatically.
Water Balance and Brine Concentrator (Appendix D)	Installing a reverse osmosis system is cost-effective compared to continued operation of the brine concentrator. The brine uses considerably more power, which makes it more costly than building the new reverse osmosis (RO) system.
NFPA 85 Compliance (Appendix C)	Reinforcing the boiler and air heater is recommended to avoid the risk of implosion. The new fans will be capable of pulling double the negative pressure of the existing fans and this increases the risk of implosion. The current boiler is designed for a very low pressure, +3/-7, and using controls to protect the boiler is very risky. provided a budgetary cost of reinforcement, which is included in the cost estimate. TRADE SECRET DATA ENDS]
Selection of ID Fan (Appendix G)	Two centrifugal fans are recommended with variable-frequency drives (VFD). Two fans rather than four are less costly to install. Using VFD technology allows power savings at low load operation.
Mercury Reduction Evaluation (Appendix L)	Activated carbon injection (ACI) is the recommend method to reduce mercury. ACI can achieve 90% reduction when injected ahead of the dry FGD system with baghouse. Specific requirements for mercury reduction are not yet known, but are expected to be established in 2011, which would be applicable to the Big Stone retrofit work.

2. BASIS OF STUDY

2.1 PURPOSE

Prior to development of the conceptual engineering study as presented herein, S&L performed a screening study to determine which SO_2 technology (wet vs. dry) and which SCR location (behind the boiler vs. south of the boiler) would be the optimal choice for Big Stone. The screening study concluded that dry FGD with SCR located directly behind the boiler was the best approach. Details of the screening study (SL-010303) are provided in Appendix B.

The primary drivers for the project are the regulatory requirements associated with the Regional Haze Rule, which was promulgated to protect the visibility in national parks, national forests, and other national areas. OTP submitted a BART study to the South Dakota DENR that stated Big Stone needed to implement technology to reduce sulfur dioxide (SO_2) and oxides of nitrogen (NO_X) emissions.

The work was done using a step-by-step approach. The first step was to prepare several mini studies that focused on the overall conceptual design scope. Table 2-1 lists the mini studies and summarizes the major conclusions.

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Mercury Reduction Evaluation (Appendix L)	Activated carbon injection (ACI) is the recommend method to reduce mercury. ACI can achieve 90% reduction when injected ahead of the dry FGD system with baghouse. Specific requirements for mercury reduction are not yet known, but are expected to be established in 2011, which would be applicable to the Big Stone retrofit work.

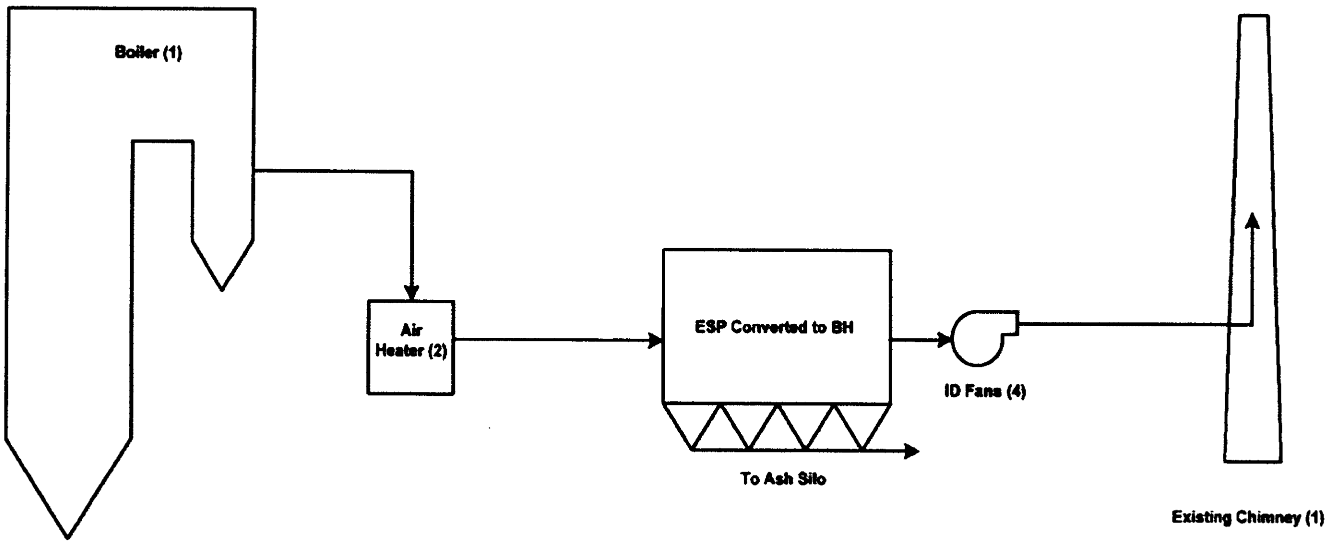
After completion of the mini studies, the conceptual design was completed as presented herein. This report addresses the following:

- Conceptual design with general arrangement (GA) drawings for dry FGD, SCR, and ACI, and technology screening and SCR location
- National Fire Protection Association (NFPA) 85 compliance
- Balance-of-plant (BOP) issues such as water treatment, ammonia delivery, boiler modifications, and fan selection
- Electrical single-line diagram
- Piping interconnection
- Implementation schedule and cash flow
- Capital and O&M cost estimates
- Permitting evaluation
- Constructibility review
- Next steps toward project implementation

2.2 EXISTING EQUIPMENT

Figure 2-1 depicts the existing equipment arrangement at Big Stone in the form of a simplified process flow diagram (PFD).

Figure 2-1. Existing Big Stone Equipment Arrangement



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The Big Stone boiler was originally designed to burn lignite fuel and began operation in 1975. Designed by , the boiler is a Caroline-type balanced-draft pump-assisted radiant machine. The cyclone furnace originally included a predry system with hammer mill crushers on each fuel delivery circuit. In 1995, the boiler was converted to burn Powder River Basin (PRB) fuel. With the conversion to PRB fuel, the NO_X emissions rose significantly and the predry system was removed to allow for a simplified SOFA system to be installed in the existing predry ports. The boiler also has a flue gas recirculation (FGR) system to control main steam and reheat temperatures. Since the FGR fan capacity was reduced, the unit operates using only one of the two gas recirculation fans.

From the boiler, flue gas travels to two regenerative-type, vertical-shaft air heaters, each equipped with secondary and primary air ducts. The unit was originally designed with an electrostatic precipitator (ESP). In 2001, the ESP was converted to an system, whereby it functioned both as an ESP and fabric filter for particulate control. This system was the first of its kind and the installation was to demonstrate the technology. However, there were operational problems with the demonstration

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technology, which resulted in conversion of the entire particulate collector to a conventional pulse-jet fabric filter in 2007. Ash is currently sent to a fly ash storage silo located directly south of the plant, where it is then trucked to a landfill. Flue gas from the fabric filter flows to four centrifugal induced draft (ID) fans. There were no ID fan changes at the time of the conversion of the ESP to a fabric filter. Currently, the unit is ID fan-limited and does not have the capability of being upgraded to overcome the additional pressure drop. The ID fans discharge the flue gas to the chimney, which has two breech openings.

2.3 UNIT DESIGN BASIS

Big Stone is a 495-MW (gross) cyclone furnace that fires PRB coal. S&L initiated its evaluation using the unit's maximum design permitted heat input, as provided by OTP, to generate mass balances. The heat input to the unit is a primary parameter used to calculate the quantity of flue gas that would need treatment. The amount of flue gas that needs to be treated is one of the parameters used to size various emission control technology equipment. Since the amount of flue gas would increase parallel with the heat input, the maximum design permitted heat input was used as the basis for the sizing of equipment and the capital cost estimates. The equipment sizing and design basis using the more typical operating heat input can be reviewed further during detail engineering. The design basis parameters used in this evaluation are listed in Table 2-2.

Note that Big Stone, designed for base load service, is located in a region with significant wind-generated power potential. With the development of wind farms, OTP anticipates a shift in the Big Stone load profile toward more frequent cycling duty, meaning daily operation at loads of 50% maximum continuous rating (MCR) and lower. This study takes into account daily cycling of the unit.

Table 2-2. Design Basis Parameters

Parameter	Value
MCR output, MW	495
Heat input, MBtu/hr	5,609
O_2 at economizer outlet, vol %	2.50
Air heater in-leakage, wt % of total	15
Humidity, lb/lb dry air	0.025
Fly ash/bottom ash split	50:50

2.4 FUEL INFORMATION

The conceptual engineering study is based on burning typical PRB coal. OTP provided numerous ultimate and proximate analyses to S&L, based on which, a typical operating coal was defined. Any of the options considered can provide good SO_2 control for the typical range of PRB coals available. Table 2-3 identifies the design fuel analysis used in the study.

Table 2-3. Design Fuel Analysis

Parameter	Value (wt%)
Carbon	49.86
Hydrogen	3.60
Nitrogen	0.72
Sulfur	0.40
Oxygen	12.05
Chlorine	0.01
Fluorine	0.01
Moisture	27.35
Ash	6.00
HHV, Btu/lbs	8,200

2.5 OPERATING CONDITIONS

The operating conditions used for the conceptual engineering study are defined in Table 2-4.

Table 2-4. Current Operating Conditions

Parameter	Value
Average SO_2 emissions, lbs/MBtu	0.92
Average NO_X emissions, lbs/MBtu	0.80
Average Hg emissions, lbs/TBtu	8.00
Startup fuel	#2 Fuel Oil

Parameter	Value
100% MCR:	
Coal feed rate (ton/hr)	685,000
Total flue gas flow at air heater outlet, acfm	2,427,000
Average flue gas temperature at air heater outlet, °F (±25°F)	325
Average pressure at air heater outlet, in. H_2O	-19.5
40% MCR (minimum load):	
Total flue gas flow at air heater outlet, acfm	878,000
Average flue gas temperature at air heater outlet, °F (±25°F)	250
Average flue gas pressure at air heater outlet, in. H_2O	-10.0

2.6 ECONOMIC INFORMATION

Table 2-5 lists the major economic parameters that were used in the variable O&M costs as well as the economic evaluations throughout the study. These values were developed both by OTP and S&L.

Table 2-5. Major Economic Parameters [TRADE SECRET DATA BEGINS

Parameter	Value
Amortization life,	
Interest rate for discounting,	
Capital escalation rate,	
O&M escalation rate,	
Levelized fixed charge rate,	
Capacity factor,	
Auxiliary electric power energy charge,	
Ash disposal cost (placement only),	
Water,	
Lime (truck delivery),	
Activated carbon (truck delivery),	
Anhydrous ammonia (truck delivery),	

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3. CONCEPTUAL DESIGN FOR SCR, DRY FGD, AND ACI

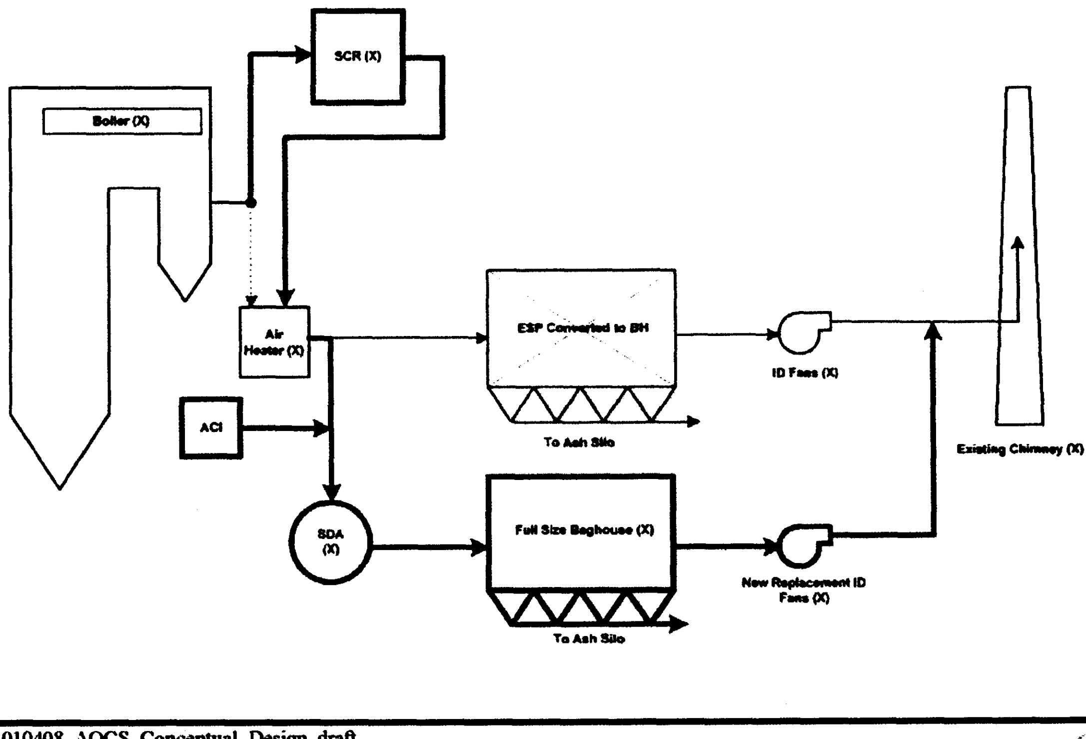
3.1 DESCRIPTION OF MODIFICATIONS

3.1.1 Process Flow

[TRADE SECRET DATA BEGINS

Figure 3-1 is a PFD depicting the installation of the SCR, dry FGD and ACI systems. The new equipment installed for the project is shown in blue and equipment taken out of service in red. Flue gas will travel from the two outlets of the economizer to SCR reactors. Ductwork will be routed from the outlet of the SCR back to the air heater. There will be no bypass around the SCR for startup or low-load operation. Flue gas will then travel from the outlet of the air heaters through a long duct to the spray dry absorbers (SDAs). Activated carbon will be injected in the ductwork ahead of the SDAs. The flow will then travel from the new SDAs to new baghouses, per absorber. Finally, the flue gas will travel to new replacement ID fans, per baghouse/absorber combination, then to the existing chimney. TRADE SECRET DATA ENDS]

Figure 3-1. SCR, Dry FGD, and ACI Process Flow Diagram



3.1.2 General Arrangements

A preliminary set of general arrangement (GA) drawings are shown in Appendix A. The drawings show the layout of the major AQCS equipment for the project based on preliminary sizing of the equipment, ductwork, and buildings. The existing and new structures were modeled three-dimensionally (3-D). Walkdowns were performed to ensure there were no major discrepancies between the existing design drawings and the actual conditions. In addition, a walkdown of the plant was performed specifically to review the constructibility of the new systems using the most up-to-date of these GA drawings.

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The GA drawings show the SCR installed after the economizer and before the air heater. The SCR system includes the SCR inlet ductwork, SCR reactors, SCR outlet ductwork, and an ammonia storage and forwarding system. The location of the SCR reactors is relatively close to the boiler economizer outlet on the west side of the boiler. SCR reactors are supported by structural steel trusses spanning north-south over the existing baghouse and baghouse inlet ductwork. There are catalyst levels in each SCR reactor, with sootblowers on the and sonic horns on . An enclosure (roof, siding, and floors) will surround all SCR access areas and the ammonia injection grid (AIG) area. The ammonia storage and forwarding system is located south of the plant near the other material loading and unloading areas. This location was chosen based on the prevailing wind directions shown on the wind rose in the area of Big Stone plant. The prevailing winds are generally in the plant east-west direction and in the event that there is an ammonia leak, plant personnel will frequently be outside of the immediate area of impact.

The dry FGD system, including new baghouses, blower building, and ID fans with variable-frequency drives (VFDs) are located south of the existing baghouse and chimney. The inlet ductwork for the dry FGD system will tie in at the existing baghouse inlet ductwork and the outlet of the new ID fans will tie in at the existing expansion joints located at the chimney breeching. These tie-ins will be performed during the spring plant outage. The existing baghouses and ID fans will be demolished starting with the spring outage. This will allow the space to be used for the water treatment building and a makeup water storage tank. TRADE SECRET DATA ENDS]

The lime storage system, reagent preparation (lime slurry and recycle ash) system, and solid waste storage system are located near the south side of the dry FGD and baghouse systems. With this arrangement, material loading and unloading is generally centralized in one location and these systems are readily accessible to the process equipment using the overhead pipe rack. As part of these systems, an enclosed slurry sump basin is shown west of the recycle building. The basin will be used for flushing, washdown, and clean out of the recycle and lime slurry systems. Once the solids in the basin settle, the water can be recovered and reused in the process and the solids can be sent to the landfill.

The ACI system silo and ACI prefabricated electrical building are located east of the dry FGD system inlet ductwork. The ACI injection grid is located to the north of the SDAs in the top of the inlet ductwork. Piping and conduit for the ACI system will be supported above grade by the ductwork support steel and, if necessary, by a short pipe rack from the ACI silo to the duct support steel.

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An auxiliary power upgrade is being provided for the AQCS equipment. New equipment for the auxiliary power upgrade is located east of the turbine building and consists of a 230-kV line coming in from the switchyard to a reserve auxiliary transformer (RAT) and a unit auxiliary transformer (UAT) that ties in to the existing isolated phase bus tap. These transformers will be connected by above-grade cable bus to 13.8-kV switchgear in the prefabricated main electrical power distribution building located along the south side of the boiler building. Electrical power distribution will be provided by electrical equipment located within prefabricated electrical power distribution buildings, which include the main electrical power distribution building, a lime preparation and recycle electrical building, and a baghouse electrical building. As shown on the GA drawings, these buildings are strategically located near the new electrical loads. Each of the prefabricated buildings will be elevated approximately 4-5 feet above grade to allow bottom-cable tray entry. TRADE SECRET DATA ENDS]

The main pipe rack shown on the GA drawings generally runs north-south between the equipment and buildings. The pipe rack will be used for routing above-ground piping, cable trays, and conduits.

Storage for the AQCS equipment spare parts will be provided in a new pre-engineered warehouse located northwest of the chimney and near the existing plant warehouse area.

All structures will be enclosed and access will be provided by stairways and walkways from the existing and new structures. One six-person elevator will also be provided near the north SDA, which will have elevator stops to the SDA penthouse and each of the SCR catalyst levels.

3.2 BOILER MODIFICATIONS

3.2.1 Separated Overfire Air

Operating cyclone-equipped boilers at reduced airflow or at substoichiometric conditions (less air than is theoretically required for complete combustion) substantially minimizes/reduces fuel NO_X formation. With the unique combustion characteristics of a cyclone furnace, significant NO_X reduction at an overall lower cost can be realized by air staging techniques.

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Based on a study conducted by (see Appendix F), two potential SOFA designs that provide optimum mixing of the balance of combustion air with the main combustion zone flue gas during the second stage of combustion with the furnace region (i.e., the burnout zone) were reviewed.

- Option 1 – SOFA at existing FGR elevation 1202'-9": 12 SOFA ports with windbox takeoffs.
- Option 2 – SOFA at higher elevation 1254'-0": 14 SOFA ports and duct runs with front and rear plenum plus platform and stairway additions/modifications.

The difference in NO_X performance between the two SOFA port elevation locations is currently projected to be only about . However, the estimated budgetary capital costs and schedule for the two options vary considerably as discussed in Appendix F. For the conceptual design, Option 2 was chosen and included in the capital cost estimate. During detail engineering, the lower-cost Option 1 will be evaluated further.

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3.2.2 Economizer Exit Gas Temperature Control

For the SCR catalyst to operate efficiently, the bulk average gas temperature leaving the economizer needs to be no greater than 750°F with variation of less than +20°F at a "dirty" boiler condition at full load (3,638,000 lbs/hr main steam flow) and greater than 625°F with variation of less than -20°F at a "clean" boiler condition at minimum load (1,627,000 lbs/hr main steam flow).

The economizer exit gas temperature (EEGT) at full load and clean boiler conditions is currently 792°F and the unit is not achieving the 1005°F steam temperatures. The EEGT at minimum load is currently 645°F. Therefore, in order to achieve an acceptable temperature range for the SCR catalyst to operate efficiently, convection pass modifications are required as shown in Appendix F.

The convection pass modifications consist of the following major modifications:

- New reheat and inlet bank, including an additional reheat pendant superheater bank for increased total surface area.
- New primary superheater, including an additional horizontal primary superheater bank for increased total surface area. [TRADE SECRET DATA BEGINS
- new economizer banks. TRADE SECRET DATA ENDS]
- Remove and not replace the small FGR economizers, pending confirmation that the FGR fan is compatible with the 750°F +20°F flue gas temperatures.
- The FGR intake "doghouses" will be lowered and redesigned with the addition of new support trusses.

The convection pass modifications recommended above are predicted to achieve an EEGT at full load (3,638,000 lbs/hr main steam flow) dirty condition of 733°F. At minimum load (1,627,000 lbs/hr main steam flow) clean, the achievable EEGT is predicted to be 635°F. These recommended modifications not only achieve the target EEGT range, but are also expected to attain desired superheat and reheat steam outlet temperatures. For the conceptual design, the costs for the modifications described above and shown in Appendix F were included in the capital cost estimate.

3.2.3 Boiler Reinforcement

The Big Stone AQCS project has various emission control options are under consideration that will add equipment to the flue gas path downstream of the boiler. The new emission control equipment will increase the system pressure drop and new ID fans will be used to provide the additional draft capacity needed to compensate for the pressure drop. The existing fans are capable of approximately 30" WG of static head, while the new fans will be capable of nearly double this amount. With such a large increase in ID fan capability, both the steady-state and transient pressures can increase to the level that the boiler, baghouse, and/or ducts are at risk of being imploded. A study of the risk of implosion was performed. The report from the study is provided in Appendix C.

The furnace section of the boiler has a steady-state deign pressure of +3"/-7" WG, but the transient pressure design of the furnace is unknown. Similarly, the economizer section of the boiler has a steady-state design pressure of -23" WG, but the transient pressure design limit of the furnace economizer section is unknown. The Big Stone furnace has experienced a master fuel trip (MFT) transient that exceeded -10" WG, and new larger ID fans will have the capability to generate transients with a greater magnitude than created by the current ID fans.

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As part of the evaluation, it was determined that the boiler would probably not have sufficient strength to withstand a future MFT event. Therefore, reinforcement of the boiler to withstand a reasonable negative pressure spike is recommended to minimize the risk of implosion. The furnace should be reinforced to withstand a transient of at least , the economizer to , and the air heater to . Other parts of the existing flue gas path would also require reinforcement to withstand a reasonable negative pressure, though many of these are being replaced with new duct.

Boiler manufacturers typically recommend reinforcing the furnace to WG, but insurance companies do not typically require furnace reinforcement to WG. Furnace reinforcement to WG is reasonable and the amount of reinforcement required can be minimized by using VFDs, for example, to help reduce the pressure transient. Insurance carriers have agreed with this level of protection on past projects. OTP should approach the insurance carrier with this proposed level of protection.

Based on the recommendation to reinforce the furnace to at least WG, NFPA 85 evaluations and studies of other similar boilers, and input from , the estimated budgetary capital costs and schedule for boiler reinforcement to WG are included in the capital cost estimate.

An estimated budgetary capital cost for furnace reinforcement to WG is not available without a more detailed study by the original boiler supplier ( ). However, the cost is expected to be significantly higher since furnace reinforcement to WG is expected to require buckstay replacement, roof support modifications, and windbox modifications. TRADE SECRET DATA ENDS]

A review of the proposed flue gas system hardware changes, software changes, control methodology, and conclusions in the report provided in Appendix C by the Authority Having Jurisdiction (AHJ), which is Factory Mutual (FM), is still required.

3.3 SCR REACTOR AND CATALYST

3.3.1 Design Summary

Table 3-1 identifies the major design parameters for the SCR reactor and catalyst.

Table 3-1. SCR Reactor Design Summary

Parameter	Performance
Volumetric flue gas flow	3,350,000 acfm
Inlet NO_X rate, average	0.80 lbs/MBtu
Design catalyst inlet velocity	16.5 ft/s
Economizer outlet temperature (full load)	750 (±20°F)
Economizer outlet temperature (low load)	625 ±20°F
SCR SO_2-to-SO_3 oxidation	2.0% [TRADE SECRET DATA BEGINS
NH_3 slip, maximum at end of catalyst life	
Design removal efficiency	
Number of catalyst layers per reactor	
Catalyst modules per layer	
Catalyst volume per layer	
Reactor	
Inlet riser	
Sootblower	
Sonic horns	TRADE SECRET DATA ENDS]
SCR hopper on outlet	Space allocated; need will be determined in detailed design

3.3.2 SCR Reactor [TRADE SECRET DATA BEGINS

Big Stone will have SCR reactors. The unit has air heaters; therefore, having reactor per air heater will ensure the best possible flow balance.

The cross-sectional area of the SCR reactor is set by the design volume of gas and the target catalyst inlet velocity and is not dependent on the inlet NO_X concentration. The design criterion for gas volume is 3,350,000 acfm at the economizer outlet and the target velocity at the catalyst inlet is a maximum of 18 ft/s. Although it would be ideal to have a square SCR reactor, the length-to-width ratio is determined by the physical dimensions of the catalyst modules that comprise each catalyst layer. Module sizes offered by SCR catalyst vendors are standardized to provide flexibility to utilities in choosing from a variety of catalyst vendors instead of being restricted to the initial catalyst supplier. They are approximately 950 mm in width and 1,900 mm in length. The design reactor cross-sectional area must also include space for the support steel needed to accommodate the catalyst layer. Because the reactor width and length are set by the physical design of the catalyst and support, the velocity at the catalyst inlet must be calculated from a proposed reactor configuration. Several iterations were performed to determine a configuration that meets the velocity criteria established.

The reactor height is set by the number of catalyst layers required, which is determined by the overall catalyst volume required to achieve the NO_X reduction guaranteed. The reactor will have levels for catalyst. The first layers initially will be supplied by the SCR vendor, and the layer will be a spare layer that will be loaded after approximately 16,000 hours of operation. Similar to the cross-sectional area dimensions of the reactor, the catalyst layer heights are bound by the height of the catalyst elements. The module heights will be limited to 5.5 feet to ensure that Big Stone will have the flexibility to load any catalyst supplier's modules. The SCR will be expected to operate within an 8" to 10" w.c. pressure drop range (large-particle ash [LPA] screen through SCR exit duct). TRADE SECRET DATA ENDS]

The SCR reactor will have an inlet and outlet sampling grid to measure the NO_X and NH_3 distributions at the SCR inlet and outlet. At a given location along the width of the reactor at the outlet, a bundle of sampling tubes is inserted and flanged to the reactor. Each tube in a bundle has different lengths that extend varying distances through the reactor. Several tube bundles are installed at the outlet in an arrangement that allows a "grid" to be formed of sampling locations. This sampling grid will be used to tune the ammonia injection grid (AIG) to optimize the NO_X/NH_3 distributions at the reactor outlet. The sampling grid at the outlet will also be used during performance testing to demonstrate that the Contractor's design meets the guaranteed performance. It is not expected to be used for continuous monitoring of the SCR.

3.3.3 Large-Particle Ash Screen

Most PRB coals produce large agglomerations of fly ash termed *popcorn ash*. Popcorn ash can have an impact on SCR performance if not removed before the catalyst. It can plug the openings in the catalyst and render those sections of catalyst ineffective for NO_X reduction.

The method most widely used to remove the popcorn ash has been the installation of a screen. This typically is a perforated plate coated with erosion-resistant material or thick wire screen, also coated with erosion-resistant material. However, based on the industry experience, the average velocity through the open area of the screen should not exceed 45-50 ft/sec. Installations, with 70-ft/sec or higher average velocity, have experienced severe erosion problems. Typical pressure drop across the screen (with 50-60% open screen) will be in the range of 0.5-0.75 inches w.c. The plugging of the screen can be detected by monitoring the pressure drop across the screen.

3.3.4 Internal Online Cleaning [TRADE SECRET DATA BEGINS

The sootblowers required for cleaning the catalyst beds typically use steam and are of the rake-type design. They would be located approximately 18-20 inches above the layer of catalyst and would be situated such that when fully retracted (approximately 6.5 feet), they provide access to the catalyst without requiring sootblower removal. The steam cleaning medium has a supply pressure of 35-60 psi, and superheat of 50°F. Typically, the total amount of sootblowing steam required for SCR systems is 40-50 lbs/hr of steam per megawatt. The sootblowers are not used continuously rather once per shift or once a day during initial operation and as required based on experience. The sootblower controls are typically programmable logic controller (PLC)-based with an operator interface in the main control room however can be integrated to the distributed control system (DCS) if required.
TRADE SECRET DATA ENDS]

A large number of high-dust SCR systems are retrofitted with air-powered sonic horns at each catalyst elevation to allow the removal of accumulated fly ash. Sonic horns have the advantage of eliminating the potential addition of moisture to the SCR system and operate at much lower power requirements than steam sootblowers. Sonic horns are recommended because of their lower installed cost and successful applications at similar installations. Due to

[TRADE SECRET DATA BEGINS

excessive ash buildup due to PRB coal ash characteristics, installation of sootblowers on the layer of the catalyst is recommended. TRADE SECRET DATA ENDS]

3.3.5 Catalyst

Catalyst formulation and type are the two primary design issues that need to be evaluated before selecting a catalyst. Catalyst formulation involves the selection of elements used to avoid the damaging effects of flue gas and ash constituents, as well as to provide operational stability in various temperatures. The coals and operating conditions at Big Stone do not require a unique catalyst formulation that would significantly affect the cost of the catalyst. However, significant boiler upgrade cost is being incurred to create a temperature range at the SCR inlet to allow conventional materials to be used.

The types of catalyst available include plate, corrugated, and honeycomb. The plate-type catalyst consists of a catalyst coating over a metal plate or wire mesh. The corrugated-type catalyst consists of catalyst coating over a fiberglass substrate. The honeycomb catalyst is manufactured as a homogeneous or coated catalyst. The homogeneous catalyst manufacturing process involves the mixing of titanium oxide (TiO_2) and vanadium oxide (V_2O_5) and extruding the mixture using a dye. The honeycomb catalyst, especially the extruded type, has a larger amount of catalyst per volume than the plate-type. The corrugated-type catalyst is a design variation of the honeycomb catalyst. This type of catalyst design reduces costs and space requirements of the reactor. However, the plate-type catalyst is more resistant to plugging because of its resistance to fly ash erosion and is more easily cleaned. Any of the three types of catalyst could be used at Big Stone and typically, the catalyst volume will not change based on the type of catalyst chosen. Recommendation on a specific type of catalyst will be made in detail engineering.

3.3.6 SCR Access and Catalyst Replacement [TRADE SECRET DATA BEGINS

The catalyst replacement features typically include either one or two doors and a trolley system or grating to move the catalyst into the reactor. Based on a previous time-motion study performed by S&L, it was determined that using a pallet truck to move the catalyst in the reactor offers the best approach to change-out catalyst and grating is used to support the catalyst and allow the pallet truck to move freely. The large reactor volume required at Big Stone will require doors at each catalyst level to move the catalyst in and out of reactor.
TRADE SECRET DATA ENDS]

Access to each layer of catalyst would be provided on one side of each reactor. The access doors would be at least four feet wide and seven feet tall and will be used to replace catalyst beds. Catalyst modules will be lifted from grade using an air-tugger or electric hoist and placed on the working elevation or directly onto a waiting pallet truck. Permanent gallery will be specified internal to the reactor such that pallet trucks can be moved inside through the loading doors to place the modules in position and remove them during replacement. No overhead trolleys or rails are necessary for loading of the catalyst modules inside the reactor.

The sootblowers would not have to be removed during catalyst replacement in that adequate access will be available by fully retracting the sootblowers during the replacement process. The sonic horns will also not interfere with catalyst replacement.

Access galleries will be provided at each catalyst level, at the AIG, at the sootblowers, and at the measurement grids. Smaller access doors would also be provided at each catalyst layer to allow for inspections and catalyst sampling.

3.4 SCR REAGENT SUPPLY

3.4.1 Description [TRADE SECRET DATA BEGINS

S&L conducted a study of ammonia delivery systems (report SL-010364 provided in Appendix E) that compared anhydrous ammonia, 19% aqueous ammonia, 29% aqueous ammonia and urea. The study concluded that the most cost-effective reagent to use for the SCR was anhydrous ammonia; however, it considered to highly hazardous by the Occupational Safety and Health Administration (OSHA) and is subject to the most stringent regulatory requirements. Consideration for plant personnel and public safety must be given in the final decision-making process. Note that the study assumed an inlet NO_X of 0.80 lbs/MBtu. The study (see Appendix F) shows that the installation of SOFA would reduce the NO_X at the inlet of the SCR to approximately NO_X. This will significantly reduce the amount of anhydrous ammonia injected and thereby reduce the O&M costs. During detail engineering, the impact of this lower inlet NO_X will be reviewed. TRADE SECRET DATA ENDS]

3.4.2 Design Summary

Table 3-2 identifies the major design parameters for the Big Stone anhydrous ammonia system. Note that the conceptual design and capital cost estimate of the anhydrous ammonia system include the use of vaporizers. The industry is starting to consider direct injection (elimination of the vaporizers) of anhydrous ammonia and this concept will be reviewed further in detail engineering. This would again favor the use of anhydrous ammonias the reagent of choice.

Table 3-2. Anhydrous Ammonia Design Summary

Parameter	Performance
Design ammonia feed rate	1,573 lbs/hr
Inlet NO_X rate, average	0.80 lbs/MBtu
NO and NO_2 distribution	95% NO/5%NO_2
Ammonia storage	[TRADE SECRET DATA BEGINS
Storage capacity	
Number of tanks	
Vaporization skid	
Pump skid	
Dilution air skid	
Number of anhydrous ammonia trucks/week	TRADE SECRET DATA ENDS]
Injection location	Ammonia injection grid located in SCR riser ductwork
Safety features	Portable eye wash station, shower and deluge near ammonia tanks, portable eyewash station near AIG

3.4.3 Ammonia Injection Grid

Ammonia would be distributed through an AIG. There are two types of AIG designs used in SCR technology - a multiple-zone tunable grid design and lances/injectors followed by static mixers.

The multiple-zone design includes hundreds of nozzles and valves that allow control of ammonia in an *X* x *Y* array such that the ammonia flow rate can be controlled to each zone to produce a uniform NO_X concentration at the catalyst outlet. This type of design had been used in SCR systems installed in Japan and Europe in the early 1980s to achieve 70-80% NO_X removal efficiency. The tunable-type of system is not usually used in U.S. installations, as utilities in the U.S. rely on a longer SCR inlet duct, injection lances, and static mixers to provide a uniform ammonia feed to the catalyst. The tunable-type system could be used when the inlet to the SCR is shorter.

Most SCR installations in the U.S. rely on static mixers to provide uniform distribution of the ammonia at the inlet of the first catalyst layer. After the flue gas is taken from the economizer, a long duct section is used to house the AIG and static mixers. The injection lances provide some uniformity of ammonia injection across the duct, but the static mixers closely follow and they mix the ammonia and flue gas so a uniform mixture reaches the catalyst. The SCR duct, mixers, and reactor are modeled using a physical model and the uniformity of ammonia distribution is verified. For high-efficiency SCR designs, static mixers with ammonia injectors or lances described above have been widely used. Utility installations have achieved 90% NO_X reduction with this approach.

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The conceptual design of the SCR systems at Big Stone has the AIG located approximately five feet after the last transition in the ductwork. This ensures that a proper flow pattern has developed prior to the ammonia being injected. The static mixers are located approximately 12 feet after the AIG. Static mixers are installed to achieve a uniform NO_X/NH_3 ratio and velocity distribution before entering the catalyst. It is generally recommended to include to hydraulic diameters between the AIG and the catalyst face to ensure sufficient mixing.

TRADE SECRET DATA ENDS]

3.5 FGD ABSORBERS

3.5.1 Description

S&L conducted a screening study SO_2 technology (wet vs. dry) that concluded dry FGD to be the optimal choice for Big Stone. Results of that screening study are included in Appendix B (SL-010303).

[TRADE SECRET DATA BEGINS

Big Stone Plant will have SDAs, with each absorber treating of the flue gas. The SDAs will be 62 feet in diameter. The absorber will be a vertical open-chamber, with cross-current contact between the lime slurry and flue gas. The SDAs will be constructed of carbon steel since the PRB coal fired at Big Stone does not pose a significant concern for chloride or SO_3 corrosion. Some utilities in the eastern U.S. have applied alloy wallpaper or a spray coat for corrosion protection. These measures are not included in this conceptual design. Each SDA will also have atomizers. The conceptual design of the Big Stone SDA includes atomizers per SDA. The number of atomizers varies between vendors; however, for the conceptual study, S&L used the more conservative design. Slurry atomization is the key performance criterion in reducing SO_2 from the flue gas. Slurry is introduced to each

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absorber as a fine mist of droplets. This fine mist of droplets creates a large surface area in which the flue gas can mix. Atomizers, either rotary or dual-fluid, produce the fine droplets needed for effective SO_2 removal in a spray dryer system. The conceptual design is based on a rotary atomizer in the SDA. The SDA will be expected to operate within at about 6" w.c. pressure drop. Duct to and from will add some more pressure drop.

[TRADE SECRET DATA BEGINS

absorbers will share a common penthouse for weather protection during maintenance activities on the atomizers. A spare atomizer will also be stored or will stand in the penthouse of each SDA. The penthouse will have a vacuum system to clean the area. Also, service water for hose stations will be provided to clean some areas that are susceptible to slurry spills. A drain to grade and a sump at grade to accumulate the washdown will be needed in these areas. The penthouse will require heating and ventilation. The penthouse walls will have two inches of insulation but no interior metal lagging. Additionally, insulation typically is not lagged on the interior of buildings. If the insulation becomes damaged, it would be visible to plant personnel and therefore should be repaired. There will be a jib crane and hoist, common to both SDAs, in the penthouse to raise and lower equipment and tools from grade. Also, a new elevator is included in the conceptual design located near the SDAs for personnel and maintenance access. A minimal amount of solids will fall out in the SDA hopper, and will have to be shoveled out. A new Dumpster is included in the conceptual cost estimate to collect these solids.

TRADE SECRET DATA ENDS]

3.5.2 Design Summary

Table 3-3 identifies the major design parameters for the Big Stone FGD absorbers.

Table 3-3. FGD Absorber Design Summary

Parameter	Performance
Volumetric flue gas flow	2,427,000 acfm
Inlet temperature	325°F
Inlet SO_2, average	0.92 lbs/MBtu [TRADE SECRET DATA BEGINS
Outlet SO_2	
Approach to adiabatic saturation	30°F
Number of SDAs	
Diameter of each SDA	
Number of rotary atomizers per SDA	TRADE SECRET DATA ENDS]
SDA residence time	Minimum of 10 seconds

3.6 PULSE-JET BAGHOUSE

3.6.1 Description

S&L's screening study (Appendix B, SL-010303) evaluated whether the existing baghouse could be reused. The existing baghouse at Big Stone is 37 years old and most baghouses and ESPs are typically replaced after 30-40 years. Per the screening evaluation, it was determined that the increase in negative pressure on the existing baghouse and ductwork will require extensive reinforcement from the addition of SO_2 and NO_X reduction AQCS technology.

The existing baghouse is designed to handle a continuous operating pressure of up to negative 25 inches w.c. and OTP currently operates the baghouse at approximately negative 28 inches w.c. For dry FGD technology, implementing an SDA could add up to 7-10 inches w.c. of additional negative pressure before the flue gas enters the baghouse. Installation of SCR will add even more negative pressure ahead of the baghouse (approximately 8-10 inches w.c.). The existing baghouse and ductwork remaining in place will be unable to handle the additional negative pressure. In addition, the existing baghouse fly ash handling system will also need major modifications due to the increased solid loading with an SDA. The screening study determined that it was more cost-effective to install a new baghouse than take risk in modifying the existing baghouse. Therefore, the conceptual design and cost-estimate includes a new baghouse.

[TRADE SECRET DATA BEGINS

The new baghouse will reduce emissions to less than of filterable particulate matter (PM). The opacity will be less than on a six-minute average. In addition to PM and opacity, the baghouse also removes of the overall SO_2 removed in the system due to the layer of sorbent on the surface of the bags and the intimate contact as gas passes through the cake. The baghouse is sized using a gross air-to-cloth ratio of 3.6 fpm. There is a spare compartment per casing, which allows the unit to operate with these compartments off line for maintenance. The baghouse will be expected to operate within a 6" to 8" w.c. pressure drop range (flange-to-flange) with all the compartments in service.

The collected solids will be removed from the baghouse hoppers with a pressurized material handling system. A vacuum pneumatic conveying system will be installed that requires 14' of clearance between the hopper room floor and the hopper outlet flange. The material handling system will be suspended from the hoppers to allow the material handling system to expand at the same temperature as the casing. There will be some solids that fall out in the hopper enclosure when the unit is off line and as hopper doors are opened, but this should be minimal. Dry deposits would be vacuumed up as part of house cleaning, but service water is also provided to wash down the area if needed.

Hoppers will have sledge plates, vibrators, and poke holes to keep the solids flowing in the hopper. These accessories will be accessed from grade and a hopper platform is not included. Hopper heaters will keep the lower third of the hopper warm and free from condensation. Additionally, the hopper is covered with of insulation, which is removable so the heaters can be changed-out without harm to the insulation.

The bags will be cleaned with dry and oil-free compressed air. blower and dryer trains will supply air to the penthouse of each of the casings. The blowers will be air-cooled and will have an inlet air duct from the outside of the enclosure. blower train will be located in the hopper enclosure area of each baghouse casing and there will be a crossover pipe between casings tying the systems together. Receivers to store the air will be included. These air systems will be sized to deliver the bag cleaning air, the motive air for the baghouse dampers, air for the ACI silo fluidization, control air for the material handling system in the hopper enclosure, and other

TRADE SECRET DATA ENDS]

miscellaneous systems. It is recommended that separate air receivers be used for the cleaning air and the damper air. This will ensure that air is available to operate the dampers if power is lost to the plant.
[TRADE SECRET DATA BEGINS

The baghouse plenum will either be a top-door-type or a walk-in plenum-type. The top-door design will allow staff to remove the door and step down onto the tube sheet for maintenance. A hoist system is provided to allow the large compartment door to be removed for access. A vacuum break is needed on each compartment to allow easy removal of the door. The walk-in plenum design will allow access to the tube sheet by access doors (x). The area above the tube sheet is a confined space and needs ventilation and special precautions. The advantage of the walk-in plenum is that air in leakage is minimized because the doors are smaller and can be tightly shut to seal air out. In comparison, the top-door design has a large perimeter of gasket that is difficult to keep in top condition, and allows in-leakage. Both designs work successfully after a dry FGD. TRADE SECRET DATA ENDS]

A penthouse will protect from elements of weather. Heat and ventilation will be included to control temperature to 10°F above ambient temperature or 55°F, whichever is greater. The outlet and bypass dampers operators will be accessible within the penthouse, as well as the bag-cleaning air-pulsing header. A jib crane and hoist by the original equipment manufacturer (OEM) will enable boxes of bags, cages, or tool-boxes to be lifted to the penthouse and to lower pneumatic operators to grade.

Utility baghouses have inlet and outlet dampers for each baghouse compartment, which will allow for a compartment to be taken off line and for plant staff to enter the compartment to check for bag leaks. The ducts and compartments are all normally under negative pressure so the typical utility design allows safe entry into the compartments.

3.6.2 Design Summary

Table 3-4 identifies the major design parameters for the Big Stone pulse-jet baghouses.

Table 3-4. Pulse-Jet Baghouse Design Summary

Parameter	Performance
Volumetric flue gas flow	2,141,000 acfm
Particulate load	231,000 lbs/hr
Inlet temperature	167°F
	[TRADE SECRET DATA BEGINS
Casings	
Compartments per casing	
Baghouse footprint	
Number of bags	
Air-to-cloth with all compartments on line	3.60
Air-to-cloth with one compartment off line per casing	4.10
Bag length	
Bag material	PPS
Size and velocity of inlet plenum	
	Velocity = 3,600 fpm
Size and velocity of outlet plenum	18' x18'
	Velocity = 3,600 fpm
Number of hoppers	
Insulation	TRADE SECRET DATA ENDS]

3.7 LIME RECEIVING AND PREPARATION

3.7.1 Description [TRADE SECRET DATA BEGINS

The conceptual design is based on lime being delivered to Big Stone via truck. The plant will have lime silo with bin vent filters for dust control when it is being filled. The silos will be adjacent to the unloading area. The trucks will have on-board blowers that will pneumatically convey lime to the long-term storage silo. One lime truck will be unloaded in approximately 1-2 hours. If the silo design calls for a taller silo or faster unloading is needed, a

TRADE SECRET DATA ENDS]

stationary truck unloader can be added. Rail deliveries could also be studied further to allow for lower lime cost. However, rail deliveries would require significantly more capital cost for rail spurs and equipment.

Lime will gravity-feed from the silo hopper into the slakers in the reagent preparation building. The slakers can either be the ball mill- or detention-type. The primary function of the slaker is to hydrate the dry pebble lime into a slurry and create fine particles of $Ca(OH)_2$. The hydrated form of lime is the most reactive form and is necessary for high levels of SO_2 removal. The slurry from the slakers will discharge through grit screens into lime slurry storage tanks and will be agitated until needed for injection into the SDA. This system can also provide slurry to the existing cold-lime softener (CLS) so that the lime storage and slurry system there can be eliminated. Costs for demolition of the existing lime storage and slurry system have not been included in the estimate.

Removing grit is very important in the dry FGD process because it can plug the atomizer nozzles. Each slaker will have an external classifier or grit removal screen, whose main function is to separate large oversized grit and impurities from the slurry solution. Eventually, the oversized grit will be rejected from the system. The grit will be placed in Dumpsters and eventually hauled away. With the design coal and high-quality lime, a Dumpster should be adequate, but in some instances Dumpsters may not be sufficient to handle the volumes, and a grit pit might be needed. A front-end loader would be used to scoop and place the grit in a truck for disposal. The conceptual design is based on detention slakers, which would have piles of grit dumped to grade that would then need to be hauled off to disposal each day.

3.7.2 Design Summary

Table 3-5 identifies the major design parameters for the Big Stone lime receiving and preparation system.

Table 3-5. Lime Receiving and Preparation Design Summary

Parameter	Performance
	[TRADE SECRET DATA BEGINS
Lime silo storage	
Lime silo capacity	
Pebble lime quality	90% CaO minimum
	¾" x 0" lump size
Fresh lime feed	
Slaker	
Lime slurry storage tank	
Lime slurry transfer pumps	
Lime slurry, wt% solids	20%
Makeup water tank (use in recycle system)	
Slurry sump basin	
Slurry makeup water tank (use in slaker)	
Slaker water requirement	76 gpm
Slaking temperature requirement	170°F minimum
Number of lime trucks/week	17
Lime preparation building	TRADE SECRET DATA ENDS]

3.8 RECYCLE SOLIDS PREPARATION

3.8.1 Description

The recycle slurry is recycled to the SDAs to reduce lime consumption. There is residual activity and alkalinity left in the lime after it has been passed through the system once; therefore, it is re-introduced to gain additional lime utilization. Also, a droplet of ash and lime mixture dries faster than a droplet of lime alone. This will reduce the time required to dry the slurry in the absorber and also prevent localized lime droplets coming in contact with the SDA walls.

Waste solids will be collected in the new pulse-jet baghouse. The solids will be transported to either the recycle silo or to the waste silo. The system will be controlled to send ash to the dry FGD recycle silo until full, and then to send the waste to the waste silo until the recycle silo needs more waste. Solids primarily will be sent to the recycle silo, but about 25% of the time will be sent to the waste silo.

The recycle system is located in its own building. A portion of the waste solids from the baghouse will be sent to a recycle silo located within this building. The dry waste from this silo flows to a premix tank, where it is combined with water. The slurry overflows to a recycle holding tank, which then overflows into a recycle slurry storage tank. Mixing in the premix tank is difficult due to a dry, dusty waste being mixed with water. The material in the premix tank has the consistency of a paste-like material and, therefore, requires more maintenance than other parts of the system. This recycle system allows the lime to be passed through the SDA several times, which allows each particle of lime to be utilized more. Thus, the lime particles that did not absorb SO_2 the first time through the system have the chance to do so several more times. The dry FGD recycle system will require significant maintenance because mixing a dry powder with water is more troublesome than slaking lime. The recycle premix tank, if not agitated continuously, can set up to the consistency of concrete and require a jackhammer in order to clean out.

3.8.2 Design Summary

Table 3-6 identifies the major design parameters for the Big Stone recycle lime receiving and preparation system.

Table 3-6. Lime Receiving and Preparation Design Summary

Parameter	Performance
	[TRADE SECRET DATA BEGINS
Recycle silo storage	
Recycle slurry mix tank	
Recycle slurry storage tank	
Recycle slurry pumps	
Recycle slurry, wt% solids	40%
Makeup water requirement	556 gpm
Solids to recycle silo	196,000 lbs/hr
Recycle building	TRADE SECRET DATA ENDS]

3.9 SOLID WASTE HANDLING

3.9.1 Description [TRADE SECRET DATA BEGINS

The dry FGD process adds several times more solids to the inlet of the baghouse, and these solids must be transported to either the recycle or the waste silo. The new solid waste handling system will collect waste from the hoppers in the new baghouses. The waste will be pneumatically conveyed from the baghouse hoppers to either the existing ash silo or the new waste silo. Both silos will be used. silo will have bin vent filter. The existing silo bin vent filter is not large enough for the increased waste that will be sent to it; therefore a new bin vent filter is included. Since one silo will be operated at any given time, the redundancy requirement for the bin vent filter has been built in. TRADE SECRET DATA ENDS]

Detailed information on the ash handling system and solid waste disposal is provided in Appendix M (SL-010402). In addition, the report identified the most cost-effective method to transport the ash to the existing landfill. A new landfill will not be required as there is sufficient capacity in the existing landfill. The study recommended transport of the waste by truck with the ejector feature. However, OTP would prefer using scrapers in lieu of the trucks since this is the current practice at Big Stone.

3.9.2 Design Summary

Table 3-7 identifies the major design parameters for the Big Stone solid waste handling system.

Table 3-7. Solid Waste Handling Design Summary

Parameter	Performance
Coal, HHV	8,200 Btu/lb
Ash content	6%
Bottom to fly ash split	50/50
Distance from baghouse to fly ash silos	[TRADE SECRET DATA BEGINS
Ash piping	
Total solids to hoppers	231,000 lbs/hr
Solids to storage silos	35,000 lbs/hr
Fly ash transport rate	Two times the make rate TRADE SECRET DATA ENDS]

[TRADE SECRET DATA BEGINS

Parameter	Performance
Dry ash density	45 lbs/ft^3
Ash Haul Equipment	
Bin vent filters (one per silo)	
Waste storage silo	
Waste blower building	TRADE SECRET DATA ENDS]

3.10 ACI SYSTEM FOR MERCURY REDUCTION

3.10.1 Description

[TRADE SECRET DATA BEGINS

An ACI system will be provided that is designed for mercury removal. Appendix L provides details on the mercury control evaluation (SL-010393). For the ACI efficiency, the SO_3 needs to be at or less where the carbon is injected. Since Big Stone burns PRB, staying below the level will not be an issue. Also, experience has shown that with PRB fuels, halogenated powder-activated carbon (PAC) is more effective than non-halogenated PAC.

The carbon is injected prior to the SDA. Injecting before the SDA helps to oxidize some of the elemental mercury to oxidized mercury since the chlorides have not been removed yet. Injecting before the spray dryer also increases the residence time for the carbon to react with the mercury. However, the greatest amount of mercury is removed in the baghouse. The carbon uniformly accumulates on the bags in the baghouse and creates a cake with the fly ash. The flue gas gets pulled through the carbon accumulation and this is where the majority of the mercury is removed.

The GA drawing in Appendix A shows the ACI silo located directly south of the boiler building and west of the SDAs. This location reduces the length of piping needed to the injection location. The silo will be filled by trucks, which will pull up next to the silo and use their onboard blowers to unload the carbon into the silo. The truck's driver will have a control panel that connects to the operating room. Operators will send a signal alerting the truck driver to fill the silo. As trucks carry about 40,000 lbs of carbon, the silo will hold about truck loads of carbon and the plant will need about truck delivery per week. TRADE SECRET DATA ENDS]

3.10.2 Design Summary

Table 3-8 identifies the major design parameters for the Big Stone ACI system.

[TRADE SECRET DATA BEGINS

Table 3-8. ACI Design Summary

Parameter	Performance
Design injection rate	which is 5 lbs/mmacf halogenated PAC
Expected Injection rate	lbs/hr which is 2 lbs/mmacf halogenated PAC
Number of silos	
Silo size	
Silo storage quantity	
ACI electrical building	
Injection trains	
Safety features	Portable eye was station in base of silo
	Grating on top of silo, but no enclosure
Injection location	At least 60', 1 second prior to the SDA
Piping	
Level detectors	One radar detector to measure carbon level

TRADE SECRET DATA ENDS]

3.11 ID FANS

3.11.1 Description

The new SCR and dry FGD equipment and the new interconnecting ductwork will add pressure drop to the Big Stone flue gas draft system. The existing ID fans do not have the capability of pulling the additional draft necessary; therefore, the fans will be removed from service and new replacement fans will be installed after the new baghouse to handle the entire flue gas path. The replacement fans would be designed to overcome the draft loss of the boiler, SCR, air heater, SDA, baghouse and ductwork/dampers. Appendix G provides details on fan design alternatives (SL-010396). Two fan arrangements and two fan technologies were evaluated:

[TRADE SECRET DATA BEGINS

- centrifugal fans with variable-frequency drive (VFD).
- centrifugal fans with VFDs or axial fans with variable-pitch blades.

Inlet dampers and variable inlet vane flow controls were not considered with the centrifugal fans due to their rapid fall-off in operating efficiency when volume flows are reduced below 85% of the normal full load flow. The results of the study concluded that OTP should install centrifugal fans with VFDs based on installation, operating and maintenance advantages. TRADE SECRET DATA ENDS]

3.11.2 Design Summary

Table 3-9 identifies the major design parameters for the Big Stone ID fans.

Table 3-9. ID Fan Design Summary

Parameter	Performance
Percent of total flow per fan	[TRADE SECRET DATA BEGINS
Number of fans	TRADE SECRET DATA ENDS]
Fan type	Centrifugal with variable frequency drives
Test block condition:	
Flow	2,052,000 acfm
Static pressure	50" w.g. (static rise for test block flow plus 10%)
Motor size	12,000 horsepower (hp)

3.12 DUCTWORK

3.12.1 Description

The ductwork system is generally categorized in two ways – hot-side and cold-side, based on the location in the flue gas route and the operating temperature to which it is subjected. In addition to discussions of standard hot- and cold-side ductwork arrangements, the study also considered the use of SCR reactor boxes in relation to those arrangements, as discussed below.

[TRADE SECRET DATA BEGINS

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Parameter	Performance
Percent of total flow per fan	[TRADE SECRET DATA BEGINS
Number of fans	TRADE SECRET DATA ENDS]
Fan type	Centrifugal with variable frequency drives
Test block condition:	
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3.12.1.1 Hot-Side Ductwork [TRADE SECRET DATA BEGINS

The first part of ductwork in the flue gas route is from economizer outlet to SCR reactor inlet and from the SCR reactor outlet to air heater inlet. This section consists of isolated parallel routes from each economizer to the SCR reactor and back to air heater. It is subjected to high operating temperature of about 750°F. As a result, material, which has a better strength under the elevated temperature than standard carbon steel, is typically utilized for the plates, stiffeners, and other internal structural elements, such as internal trusses, in the hot-side ductwork.

It is desirable from performance and economical standpoints for this section of duct to be as short as possible. Locating the SCR immediately west of boiler building will offer the shortest distance. The duct starts from the economizer outlet and travels horizontally straight west out of boiler building. Because the coal tripper room is running north-south at the west end of boiler building, the ducts to and from SCR would have to straddle vertically above and below the tripper room. Several air heater support steels on column row J2 and boiler building steels on column row K may have to be reconfigured to provide the necessary clearance to the new duct route. After exiting the boiler building, the ducts turn vertically and rise to the top of the SCR reactors. The ammonia injection grid (AIG) typically is located in the lower portion of this vertical duct. Downstream of the AIG, or levels of static mixers will provide for even mix and distribution of flue gas and ammonia injection over the cross-section of ducts. This is important in maximizing SCR performance when the flue gas passes through the catalyst in the reactors. In SCR outlet ducts, hoppers maybe installed at the horizontal runs if the ash drop-out is determined to be excessive. This section of ductwork will end at the existing expansion joints, just above the air heaters.

TRADE SECRET DATA ENDS]

3.12.1.2 Cold-Side Ductwork

The second part of ductwork includes the flue gas route from the air heater outlet to SDA inlet, from the SDA outlet to the baghouse inlet, from the baghouse outlet to the ID fan inlet, and from the ID fan outlet to the chimney breechings. The 300°F operating temperature of this section is much lower than the hot-side, and could drop to about 160°F after the SDA. Special care must be taken in controlling the flue gas temperature and maintaining good insulation to safeguard the risk of duct corrosion due to below-dew-point condensation. Carbon steel material is typically used in the cold-side ductwork.

[TRADE SECRET DATA BEGINS

It is recommended to run the existing air heater outlet ducts inside the forced draft (FD) fan enclosure in order to avoid modifying the enclosure structure. The tie-in for bringing the flue gas to the new SDA will then be west of FD fan enclosure. Ducts from two air heaters will first be joined together as a combined header running to the south and then split just before each SDA. SDA inlets typically rise vertically, depending on the requirements of SDA supplier. Since the SDA and baghouse are supplied by the same manufacturer and are close-coupled together physically, the SDA outlet and baghouse inlet duct could be a short, straight piece, designed and supplied as part of SDA with baghouse scope of work to ensure a performance guarantee. Exiting the baghouse, the baghouse outlet will drop vertically directly into ID fan inlet pant-legs. ID fans are located such that the ID fan outlets are aligned with the chimney breechings to avoid ductwork kinks. of the ID fan outlets, however, does have to loop around the backside of chimney in order to enter from the north breeching. TRADE SECRET DATA ENDS]

3.12.1.3 SCR Reactor Boxes

[TRADE SECRET DATA BEGINS

reactor boxes are elevated to the west of existing boiler building. Similar to hot-side ductwork, the reactor boxes are subjected to high temperature and the same pressure conditions. Therefore, the same material and design allowable and overstress considerations will apply. The major differences between the reactor box design and the standard duct are the weight of the catalyst and its required support scheme. Typically, a box consists of external skin and internal catalyst support frames. The external skin has plate girders at the bent line to carry the entire reactor loads to the surrounding support steel structure. Large collector beams will be used above the plate girders for the upper levels. Together, the collector beams and plate girders provide the supports to the internal catalyst support frame. Platework and internal stiffeners will finish up the remaining of skin construction. The internal catalyst support frame at each level typically consists of a number of W24 to W30 parallel beams spanning from one side of box to the other for supporting the catalyst modules. The beam spacing will match approximately to the length of catalyst modules. Gratings thick will be used on top of the internal frame at each catalyst level. This grating floor will allow for pallet-truck traffic during the catalyst replacement, thus, eliminating the need for trolleys and hoists and associated headroom at each level. Baffle plates will be provided at the edge of boxes and between the modules to guide the flue gas through the catalyst and to prevent ash accumulation in the corners. Often, baffle plates are also used under the catalyst support beams to mitigate flow turbulence.

TRADE SECRET DATA ENDS]

A hopper will be attached to the bottom of reactor box and will guide the exiting flue gas to the air heater inlet ducts. The hopper design will follow standard ductwork construction with stiffeners being located outside of duct plates.

3.12.2 Design Summary

The function of ductwork is to form a flue gas path from the boiler to the chimney. Unlike regular structural elements, which are typically subjected to ambient temperature only, the ductwork design must address the thermal effect, which includes the reduced material strength under the elevated temperature, thermal expansion and contraction, thermal friction forces, and creep rupture for progressive long-term deformation. Two levels of design temperatures should be considered, i.e., operating and excursion cases. Under the operating case, the ductwork should not exceed code-allowed stresses from both short-term yielding and long-term creep rupture perspectives. Under the excursion case, since this typically occurs in a relatively short duration before the creep rupture can develop, the long-term creep rupture effect does not need to be considered. Associated with elevated temperatures, the ductwork will have to be designed for the accompanying pressures. Different allowable stresses and overstress factors should be used for operating and excursion cases.

[TRADE SECRET DATA BEGINS

The entire ductwork system includes structural and non-structural elements. Structural elements should form a determinate system to avoid arching effects and the uncertainty of load distribution, especially under elevated temperatures. The elements typically consist of plate work, stiffeners, internal trusses, balancing struts, stub columns, sliding-plate assemblies, hold-down details, and lateral restraints. Structural elements are designed for bending and squashing effects, and for unbalanced forces due to internal pressure, self weight of duct, ash accumulation, and wind or seismic lateral transient forces. Typically, a truss will develop from the plates and stiffeners to carry the self weight, ash loads and wind or seismic forces to the supports. Non-structural elements include flow devices, turning vanes, splitter plates, dampers, expansion joints, access doors, and external insulations and laggings. TRADE SECRET DATA ENDS]

The duct route typically divides into to many segments separated by expansion joints. The size of each segment should be carefully selected to minimize the unbalanced forces and to facilitate fabrication and installation. In general, a single duct segment should not exceed 60-80' in length due to transportation limitations and construction crane size consideration.

3.13 CHIMNEY

Big Stone has a 498-foot-tall concrete chimney. The liner is made of carbon steel with the top 40 feet lined with stainless steel. With the addition of dry FGD, and operation of the flue at 30°F above saturation, the top one diameter of the inside of the liner needs to be coated to negate any potential impact of sulfurous acid condensation. Condensation can occur if cool ambient air is pulled down into the top of the liner under certain atmospheric conditions. However, because top one diameter of the Big Stone chimney is stainless steel, this coating will not be required and is not been included in the cost estimate.

3.14 WATER TREATMENT

3.14.1 Description [TRADE SECRET DATA BEGINS

Big Stone currently operates a brine concentrator (BC) to treat water from the cooling pond. The treated water is used in the Big Stone demineralizers and is sent to the ethanol facility. Due to high operating costs to run the BC, OTP requested S&L to review options for future operation of Big Stone without the BC. The installation of the dry FGD system could allow the BC to be taken out of service; however another treatment process would be needed to supply water to the demineralizers and . Appendix D (SL-010348) provides a summary report discussing all the options that were analyzed. The report identified that the most cost-effective solution for Big Stone is replacement of the BC with a new reverse osmosis (RO) system that would supply water to the Big Stone demineralizers only (Case 6). The facility would need to install additional RO system capacity and would have to obtain more water from the cooling pond and discharge more reject to the dry FGD system. A portion of the existing cold-lime softener (CLS) effluent will be the source of makeup for the new water treatment system. The treated water (permeate) will become the source of makeup to the existing Big Stone demineralizer and will also be used for lime slaking after blending with service water. The RO waste stream (reject) will be used as a source of makeup to the recycle solids dilution system. TRADE SECRET DATA ENDS]

The water treatment building is located in the area of the existing baghouse. The existing baghouse will have to be demolished in order to make room for this building. However, note that the water treatment system does not necessarily have to be operational when the dry FGD and SCR come on line. OTP could still rely on the BC and install the new water treatment system later.

3.14.2 Design Summary

Table 3-10 identifies the major design parameters for the Big Stone RO system.

Table 3-10. Reverse Osmosis Design Summary

Parameter	Performance
Feed to RO system	Existing CLS plant effluent [TRADE SECRET DATA BEGINS
Ultra filtration system	
Filtered water storage tank	
First-pass RO system, including booster pumps	
Second-pass RO system, including booster pumps	
Chemical dosing systems	
Control system	PLC
Water treatment building	TRADE SECRET DATA ENDS]
Treated water	300 gpm used as makeup to Big Stone demineralizer and dry FGD lime slaker (after blending with service water)
RO reject water plus ultra filtration backwash	50 gpm used as makeup to dry FGD recycle solids dilution system
Routing of treated water and waste streams	See interconnect diagram in Appendix Q

3.15 MECHANICAL BOP

Conceptual locations for process piping and piping extensions for interconnection with existing plant services are based on the arrangement of equipment illustrated on the GA drawings in Appendix A. An interconnect diagram displaying all the various air, water, steam, slurry, ammonia, etc., is provided as Appendix Q.

3.15.1 Pipe Racks and Corridors

The active ash and service water lines routed to the exiting fly ash silo will be relocated to facilitate construction of the new FGD system. The new lines will be located along the planned north-south pipe corridor separating the SDA modules and baghouse casings. During construction of the FGD system, a pipe rack will be installed along this corridor. This pipe rack will support the SDA lime and recycle slurry piping, baghouse-collected solid waste piping, FGD area steam heating piping, SCR ammonia piping, and service and instrument air pipe headers. FGD area service water and sump discharge lines will be located either underground along this same corridor or above ground supported on the pipe rack.

The FGD area pipe rack will extend to the SCR structural support steel. Ammonia supply piping for the SCR, steam piping to the FGD area, and a small lime slurry line to the CLS will be routed on this section of the pipe rack.

3.15.2 Air Supply System [TRADE SECRET DATA BEGINS

Each baghouse will be furnished with -capacity air-cooled compressors to provide baghouse cleaning air and the balance of instrument and service air to the FGD system equipment. An air receiver will be provided along with -capacity air dryers at each baghouse. Service and instrument air for the water treatment building and SCR will be extended from the existing station air systems. Air receivers will be located in the water treatment building and at the SCR reactors to accommodate short-term, peak air demand.
TRADE SECRET DATA ENDS]

The existing station compressed air system will be extended to provide service and instrument air to the SCR area and the new water treatment building. SCR sonic horns will require instrument air at about 70-80 psig.

3.15.3 Water Supply System

3.15.3.1 FGD Process Water

FGD system process water is required for lime slaking and lime slurry production, recycle solids slurry production, pump seals, and slurry line flushing. The source of process water for lime slaking, lime slurry production, and pump seals will be effluent from the BC or RO system permeate once the new water treatment system is operational.
[TRADE SECRET DATA BEGINS

There will be multiple sources for water for the production of recycle solids slurry. Initially, water from the blowdown holding pond and facility RO reject line will be routed separately to the recycle process water storage tank. Blowdown holding pond water will be routed through a new pipe connected to RW-9-APC
TRADE SECRET DATA ENDS]

located at the BC. It may be possible to use some or all of the existing, unused brine waste line routed between the sludge pond area and the fly ash silo.

Later, RO reject from the new Big Stone water treatment system will be routed to the recycle process water storage tank replacing the blowdown hold pond as the primary source of recycle process water. When the Big Stone unit is off line, RO reject will be routed to the BC sludge pond.

3.15.3.2 Service Water [TRADE SECRET DATA BEGINS

Service water to FGD area hose stations and pump seals will be provided through the relocated high-pressure service water line to the existing fly ash silo. This line, which originates in the vicinity of the north and south slag tanks, will be enlarged from to at the time of relocation to provide increased capacity for the new hose stations and new solid waste silo. TRADE SECRET DATA ENDS]

Service water to the water treatment building will be extended from an existing service water line in that area.

3.15.3.3 Domestic (Potable) Water

Domestic water for lavatory facilities and eyewash and safety shower stations located at the FGD system, ammonia storage area, and SCR ammonia vaporization skids will be extended from the existing station domestic water system.

3.15.4 Wastewater System

FGD area washdown and backflush wastewater, pump seal water, and miscellaneous drains will be collected in trenches and routed to sumps located at each SDA, in the lime slurry preparation building, and in the recycle ash preparation building. Sump pumps will transfer the wastewater to the slurry sump basin, where solids will settle out. Water in the slurry sump basin will be pumped back to the recycle process water storage tank. Periodically, solids will be removed from the slurry sump basin and hauled by truck to the dry waste disposal area.

3.15.5 Steam System [TRADE SECRET DATA BEGINS

Steam service will be provided for anhydrous ammonia vaporization, slaker and recycle solids slurry water preheating, sootblowers on the first layer of catalyst, and space heating for the FGD area process buildings and water treatment building. The source of steam will be the auxiliary steam header located in the vicinity of the auxiliary boiler.

3.15.6 Fire Protection

The existing underground fire protection header system will be extended to provide fire protection service to the FGD system and ACI silo and to the suppression spray water system at the anhydrous ammonia storage tanks.

3.15.7 SCR Ash Hopper Sluice System

Flow modeling may demonstrate that an ash hopper is required in the horizontal length of each SCR reactor outlet duct. If these hoppers are required, ash would be removed by extending the economizer sluice water supply piping to each hopper and returning the SCR ash hopper discharge sluice lines to the existing economizer ash discharge sluice lines. Isolation knife gate valves would be installed in each extended sluice water line and in each SCR ash hopper discharge sluice line. TRADE SECRET DATA ENDS]

3.16 CIVIL BOP

3.16.1 Description

Throughout the project construction, several civil features will be disturbed or will need to be reconfigured. Areas affected are not limited to the locations of final AQCS equipment. Civil scope should also cover construction laydown areas, trailers, contractor parking, ground assembling, staging, crane setting, etc.

The civil work would include construction sedimentation and erosion control; topsoil striping and rough grading; excavation and gravel surfacing; surface storm water drainage, including adding slopes, ditches, and culverts, oily water waste sewer and sanitary sewer installation; fence and gates; road work reconfiguration and surface pavement; and final grading.

3.16.2 Design Summary

3.16.2.1 Sedimentation and Erosion Control

A construction permit is typically required to outline the installation procedure and maintenance schedule for site protection. The program will span from the beginning of construction through completion.

3.16.2.2 Top-Soil Striping and Rough Grading [TRADE SECRET DATA BEGINS

Removal of to of top soil and vegetation and leveling of the areas to suitable elevation for the foundation installation and for construction activities such as trailers, contractor parking, laydown, ground assembling, staging and crane setting. This initial site work should also include laying down the gravel sub-base and base course of roadwork required to support the traffic and transportation of equipment during the construction.
TRADE SECRET DATA ENDS]

3.16.2.3 Surface Storm Water Drainage

The site is currently using a surface drainage system to dispose the storm water runoff. New storm water management should include proper surface slopes, ditches, and culverts across the roadwork for the construction and for the permanent operating.

3.16.2.4 Oily Water Waste Sewer and Sanitary Sewer Installation

Additional underground oily water waste sewers and man-holes must be installed to connect the new potential oil sources to the existing oil water separator. The potential oil sources include transformers, motors, and pumps where cooling oil or lube oil exists. A sanitary sewer should also be added to connect the new toilet facility to the existing sanitary discharge. Further study is required to identify the tie-in point of existing sanitary discharge, septic tank, or drain field.

3.16.2.5 Fence and Gates

Aside from final installation of permanent fence and gates, temporary fence and gates are required to define the construction zone, and isolate it from the plant operation area. Temporary fence and gates will also provide authorized access to the construction zone and safeguard the construction materials and equipment.

3.16.2.6 Road Work Reconfiguration and Pavement Surfacing

Throughout the construction, gravel road sub-base and base courses will need to be maintained. In the final stage, permanent roadwork will receive the surface asphalt pavement based on the new design configuration.

3.16.2.7 Final Site Grading

Prior to the completion of construction, the site must be re-graded to repair any damage caused by the construction. Typically, gravel will be added adjacent to the equipment installation and sod is applied on the balance of disturbed area outside of the loop road.

3.17 STRUCTURAL

3.17.1 Foundation [TRADE SECRET DATA BEGINS

A soil investigation report was prepared for the original plant construction that concluded that either shallow mats or deep friction piles could be used for the main power block foundations, which have very substantial magnitude of load and are generally in the same area as the new AQCS equipment. The mat foundations have an ultimate bearing capacity of , while a group of forty-five -long piles could provide an ultimate bearing capacity of . Since the original plant design adopted the shallow foundation approach, a similar type of foundation will be suggested for the new AQCS equipment. Using shallow foundations also eliminates the risk of impacting the operating unit and the need of high head room typically associated with a pile installation. However, because the original soil investigation was focused on the different area, it is recommended that a new soil investigation program be developed specifically for the location and loads of the new AQCS equipment.

Preliminary assessment shows that using an ultimate bearing capacity of with a conservative factor of safety of , the shallow foundation approach is still a feasible scheme. This basic assumption is reflected in the budgetary cost estimate. The frost depth of about observed in the region must be reached for a shallow foundation construction to avoid frost heave. This thick concrete block will also provide large stiffness, thus reducing the differential settlement between the adjacent support points. TRADE SECRET DATA ENDS]

3.17.2 Support Steel

There are several support steel structures required for new AQCS project. Some of the steel structures will be under the equipment contractor scope of design and supply. This includes the SDA support steel and baghouse support steel. The balance of support steel and structures consists of a pipe rack connecting from the south of the existing baghouse to the existing ash silo; ductwork support steel from west of the boiler building to the SDA and from the baghouse to the ID fans and chimney breechings; SCR support steel; recycle ash and lime preparation building; and electrical cable rack connecting the main AQCS electrical building to various electrical buildings and AQCS equipment.

3.17.2.1 Pipe Rack and Electrical Cable Rack

The pipe rack will serve as the main artery for the routes of ash, slurry, water and air supply, lime slurry, electrical cable trays or conduits, and instrumentation and controls (I&C) interconnections between various AQCS equipment. It must be designed and installed to allow the existing ash pipe be rerouted on it, thus providing space for SDA construction. The pipe rack will have a minimum of 20' clear head room to allow ash, lime, and ammonia trucks to pass under. Multiple levels are expected to be needed to carry all the above piping and cables. Cable bus racks are required when there are no adjacent steel structures available. The width and size of cable racks are much smaller in comparison to the pipe rack.

3.17.2.2 Ductwork Support Steel

New support steel structures will be the concentrated, braced frame-type. Differential settlements at the duct support points must be minimized. Typically, tie beams are used to balance the thermal loads at the duct support level. Modification to the existing air heater and boiler building steels are required to provide the necessary clearance to ducts between the economizer and SCR system and between the SCR system and air heater. New vertical bracing members should also be added to span the tripper room over the removed columns. Because the existing structures will be significantly modified and altered, it is expected that the existing air heater and boiler building structures will need to be checked for current code compliance.

3.17.2.3 SCR Support Steel [TRADE SECRET DATA BEGINS

SCR support steel typically supports the reactors, inlet riser ducts, inlet horizontal ducts over the reactors, and the surrounding platforms for catalyst replacement. SCR support steel will also provide support for sonic horn, sootblower, and AIG access and O&M. Because the SCR reactors are situated high above the existing baghouse inlet ducts, a baseline approach is to erect two supporting tower outside of existing baghouse and allow the baghouse to continue to operate until the tie-in outage. A span space truss will be used to bridge over the supporting towers. A possible alternative would be to add columns in the middle of truss span. However, these internal columns will attract a significant amount of loads. The feasibility of constructing a suitably size foundation in the congested courtyard will have to be further studied in the detailed design stage. If adding internal columns is feasible, the truss span will be reduced by about half, thus decreasing the size of trusses and the tonnage of steel.

3.17.2.4 Recycle Ash Slurry and Lime Preparation Building

This building will support or house the recycle ash silo, premix tanks, slurry storage tanks, and associated pumps for processing the recycle ash, lime, and slurry.

Aside from several major steel structures mentioned above, cable bus supports from the unit auxiliary transformer (UAT) or reserve auxiliary transformer (RAT) to the main AQCS electrical building is assumed to be within the scope of work of cable bus supply contract.

3.17.3 Galleries

Several galleries are proposed for the AQCS project to provide access to areas for O&M. The galleries proposed are summarized below.

3.17.3.1 SCR Catalyst Platforms

The catalyst platforms are on the outboard side of SCR reactors. Hoist and trolleys are devices used to lift the new catalysts up to the change-out level and to lower the old catalysts down to trucks waiting on the ground. Once lifted to the change-out level, pallet trucks will move the catalyst to the reactor through the change-out doors located on the outboard face of reactors. To facilitate pallet-truck traffic, the entire platforms will be covered with gratings.
TRADE SECRET DATA ENDS]

3.17.3.2 SCR soot blower and sonic horn platforms [TRADE SECRET DATA BEGINS

Soot blowers are installed on the west face of level only. Sonic horns are installed on the north and south face of levels of each reactor. This platform is an integral part of platform system surrounding the SCR.

3.17.3.3 AIG platform

AIG platform is located to the east of SCR inlet duct. It provides the access to AIG piping and valves.

3.17.3.4 Sky bridges

sky bridges connecting the boiler building and SCR platforms are provided. The existing boiler building elevator could then be used to gain access to the SCR through the sky bridges.

3.17.3.5 SCR Stair Towers and Elevators

stair tower is located at the north of platform near the hoist zone. Another stair tower is located at the south of platform adjacent to the elevator. This south stair tower could also be used to gain access to the SDA penthouse and to the baghouse penthouse. Similarly, the elevator could have multiple stops to serve the SDA, baghouse as well as three levels of SCR platforms.

3.17.3.6 ID Fan and Motor Galleries

Galleries are typically provided around the ID fan and motor.

3.17.3.7 Other Miscellaneous Galleries

Miscellaneous galleries will be provided at the valve station, AIG, top of tanks, silos, and along the pipe rack.

The SCR platforms should be within in a weather enclosure. This includes roof panels above the top level, side panels on all sides of platforms, and checkered plates on grating on the level floor.

TRADE SECRET DATA ENDS]

3.18 ELECTRICAL

3.18.1 Description

The new AQCS equipment will require additional auxiliary power. As the mechanical systems are in the conceptual design phase, the proposed electrical power system design will reflect a conservative approach for providing power to the new system loads based on estimated loads as well as proven design concepts that have been successfully implemented on similar AQCS installations. In order to optimize system design, refinements and options will be explored during detailed design as specific vendor design data are developed.

3.18.2 New ID Fans [TRADE SECRET DATA BEGINS

In order to support the new AQCS systems, the four existing 4,000-hp ID fans will be replaced with new larger fans. The fan study (Appendix G, SL-010396) recommends a minimum of approximately for the motors of each new fan. However, experience has been that as detailed design progresses, this preliminary horsepower requirement typically increases. Additional design margins for future ductwork leakage and air heater pluggage can also contribute to this increase.

At this stage of conceptual design, in order to ensure that the electrical system can accommodate worst-case loading conditions, a conservative rating of for each fan will be assumed. The added margin does not change the approach to providing power to the AQCS equipment and fans but includes some margin in the size of the transformers. TRADE SECRET DATA ENDS]

3.18.3 Existing Plant Auxiliary Power System

If the new AQCS loads, including the new replacement ID fans, were added to the existing auxiliary power system, the net additional load would be approximately .

[TRADE SECRET DATA BEGINS
An examination of the capacity of the existing UAT (normal source) and the interchange transformer (startup and reserve source) was performed. The existing UAT top capacity rating is . Based on historical data and previous system study models, the current UAT maximum loading is . The remaining transformer capacity is . TRADE SECRET DATA ENDS]

[TRADE SECRET DATA BEGINS

The existing interchange transformer tertiary winding capacity rating is . Based on historical data and previous system study models, the current transformer maximum loading is . The remaining transformer tertiary winding capacity is .

Compared with the estimated additional loading of , the remaining capacities of the transformers are not adequate to support the new loads. TRADE SECRET DATA ENDS]

3.18.4 AQCS Auxiliary Power System

As the existing power system is not adequate to provide power to all of the new loads, either replacement of the existing UAT and interchange transformers and their related power equipment or the addition of a new supplemental 13.8-kV system would be required.

Replacement of the existing main and startup/reserve systems would be extensive in that it would require replacement of upstream and downstream connections and equipment. The modifications would also have to be performed as part of an extended outage.

The installation of a separate AQCS system would be performed as a part of the pre-outage activities. The system would be installed, tested, and available for AQCS system pre-outage checkout and subsequent startup and commissioning. Based on the above, it is recommended that a separate new 13.8-kV system be used for this installation. Appendix J shows the new AQCS power system configuration.

The new system would include a new UAT connected to the existing isolated phase bus. A tap for this service near the existing UAT is already in place. For purposes of this conceptual design, a new startup/reserve source would be provided from a new 230-kV breaker in the switchyard connected to a new RAT located near the turbine building area via a 230-kV overhead line.

[TRADE SECRET DATA BEGINS

transformers would be connected to 13.8-kV switchgear main busses similar to the existing plant configuration. The transformers would be connected to the new switchgear via above grade cable bus. The 13.8-kV buses would provide power to double-ended 480-V substations, which would serve the loads for the SDA, SCR, lime preparation, and recycle systems. The new baghouse and associated fly ash loads would be fed from double-ended 480-V substations fed from the existing 13.8-kV baghouse feeds.

TRADE SECRET DATA ENDS]

The new ID fans would also be fed from the 13.8-kV buses. As described in the fan study, VFDs will be used for fan speed control. The drives have the added advantage of limiting motor starting current and short circuit contribution to the power system. The drives would be located in prefabricated buildings near the fans.

As confirmed with OTP, a new diesel generator will not be required.

3.18.5 Electrical Power Distribution [TRADE SECRET DATA BEGINS

The new electrical equipment would be housed in prefabricated electrical power distribution buildings strategically located near the new loads. They consist of a main electrical power distribution building, a lime preparation and recycle electrical building, and a baghouse electrical building. The locations are shown on the GA drawing in Appendix A. TRADE SECRET DATA ENDS]

The main AQCS electrical power distribution building would include a new 125-VDC control battery and uninterruptible power supply (UPS) and would house the new 13.8-kV switchgear lineups.

Cabling between the electrical buildings and the loads would be routed in above grade cable tray supported on new pipe racks or other structures as required. Once the cables were in the vicinity of buildings, the cables would enter the bottom of the building for ease of construction and maintenance.

3.19 CONTROLS

3.19.1 Description

The new AQCS systems will require additional controls for the new equipment and subsystems. The following describes the recommended conceptual design covering the control philosophy and strategy to incorporate the required controls.

3.19.2 DCS and Control Philosophy [TRADE SECRET DATA BEGINS

The new dry FGD, baghouse/SCR systems, and all BOP systems, including the electrical auxiliary power system, would be controlled and monitored in the DCS. The existing plant DCS would be extended with new controllers and inputs/outputs (I/O) to be provided for the dry FGD, baghouse, SCR, and other systems. They TRADE SECRET DATA ENDS]

[TRADE SECRET DATA BEGINS

would be located remotely in the three new electrical equipment buildings. The exact number of new controllers will be determined after actual I/O count is finalized. The estimated I/O count for the project is approximately . It is recommended that a maximum of hardwired I/O be dedicated to each controller. The new DCS remote controllers and I/O would communicate with the plant main control room over redundant fiber optic data highways. TRADE SECRET DATA ENDS]

The new ID fans and associated equipment would be controlled from the existing unit furnace draft DCS controller with new remote I/O located near the fans in the baghouse area electrical building. The furnace draft controls logic will be upgraded to protect the gas path from implosion.

Human-machine interface (HMI) for the new dry FGD, baghouse, and all BOP systems would be from the existing operator consoles in the plant control room. New display/control screens and logic would be developed and installed in the DCS. New operator consoles would be added if needed dependent upon available space.

3.19.3 Instrumentation Philosophy

Wherever possible, transmitters would be used instead of switches. In general, transmitters would be the smart-type, two-wire design with National Electrical Manufacturers Association (NEMA) 4X enclosures.

Temperature instruments would be either thermocouples or resistance temperature detectors (RTDs) directly wired to the DCS without intermediate transducers. Thermocouples would be either Type E or Type K. RTDs would be 100 ohm.

Redundant instruments would be provided for critical services. As an example, triple-redundant transmitters for measuring ID fan outlet duct pressure for inlet vane control would be implemented.

[TRADE SECRET DATA BEGINS

Pneumatic modulating control valves would be provided with smart-type positioners, e.g., with outputs capable of directly communicating with the DCS. TRADE SECRET DATA ENDS]

3.20 DEMOLITION AND RELOCATION ACTIVITIES

The demolition and relocation activities anticipated to be performed throughout construction of the project are summarized below.

3.20.1 Demolition of Existing Baghouse and ID Fans [TRADE SECRET DATA BEGINS

The existing baghouse is required to remain active until the tie-in outage in . After the new baghouse is successfully brought in service, the existing baghouse and ID fans should be demolished as a post-outage activity to provide space for installing water treatment facilities. The demolition of the baghouse should include all inlet and outlet ductwork, walkways, galleries, and platforms supported off the baghouse structure.

TRADE SECRET DATA ENDS]

3.20.2 Demolition of Transformers East of Baghouse and Jamestown Boiler

The mentioned transformers and boiler should be removed if internal SCR support columns are to be installed.

3.20.3 Rerouting of Ash Pipe from Existing Baghouse to Ash Silo

The relocation of ash pipe onto the new pipe rack should be completed as an early activity to provide space for installing SDA foundations.

3.20.4 Modification and Extension of Existing Auxiliary Boiler Stack

The exhaust stack of existing auxiliary boiler will have to be kinked north to clear the SCR and extended above the top SCR platform level for safety reasons.

3.20.5 Demolition of Existing Breeching Ducts

Breeching openings of existing chimney will continue to be used for the new flue gas route. As a result, the existing breeching piece will have to be reconfigured as part of new ductwork.

3.20.6 Modification of Air Heater and Boiler Building Steel

As mentioned above in subsection 3.17.2, the existing structure would have to be modified for stability and for space clearance requirement.

3.21 CONSTRUCTIBILITY

3.21.1 Description

The constructibility review process should be continued through the detailed design process and through the bidding process to contract award. Any subsequent design changes should then be evaluated from a constructibility standpoint. Note that all directions noted below are grid (plant) directions.

Constructibility of a new SDA, SCR, and baghouse, along with demolition of the existing baghouse is enhanced by:

- Open areas where the new FGD, baghouse and support equipment are to be located.
- Open areas adjacent to each side of the boiler building to use as cranes operations and pick areas.

A challenging issue will be coordination of outage work in the area just north of boiler building column row K. A detailed plan will need to be developed for outage work, including equipment handling sequences for baghouse demolition, SCR ductwork connection, and boiler modifications. With boiler modification work and other outage work planned in parallel with SCR ductwork connection, it is advisable to establish a single point of contact as the person to ensure that as overhead loads are secured, others are notified that they can resume work. This will minimize the risk of outage delays due to inefficient communications.

3.21.2 Site Access

Due to the 48th Avenue railroad above the road, equipment delivery traffic will be from the east on 144th St. Route 109 bridge load capacity should be checked by the General Work Contractor when planning special permit heavy loads.

[TRADE SECRET DATA BEGINS

Rail access is also available with a separate "spur siding" that can be dedicated for staging new plant equipment prior to off-loading. The off-loading flexibility due to this isolated spur siding should be of value for the installation contractors. The condition of the spur siding should be determined and a cost estimate made for any refurbishment required. During the bidding process for the installation work, the bidders should indicate the value of the spur siding in order to provide cost savings input into the decision to refurbish the track. The capital cost estimate assumes that equipment and material will be delivered to the site via truck. There could be cost savings between deliveries via truck versus rail (   ); however, this can be reviewed further in detail engineering.

TRADE SECRET DATA ENDS]

Onsite roadways are in good condition. Grades and turning radii are suitable for heavy hauling and large-piece transport.

3.21.3 Construction Facilities [TRADE SECRET DATA BEGINS

Construction facilities, including laydown and staging areas, are depicted on the mark-up of the aerial photograph provided as Appendix O. The basic intent is to keep construction work force, estimated to peak at , on the south side of the plant, with the only exception being the demolition scrap material salvage area at the northeast corner of the site. TRADE SECRET DATA ENDS]

3.21.4 Crane Sizing and Selection

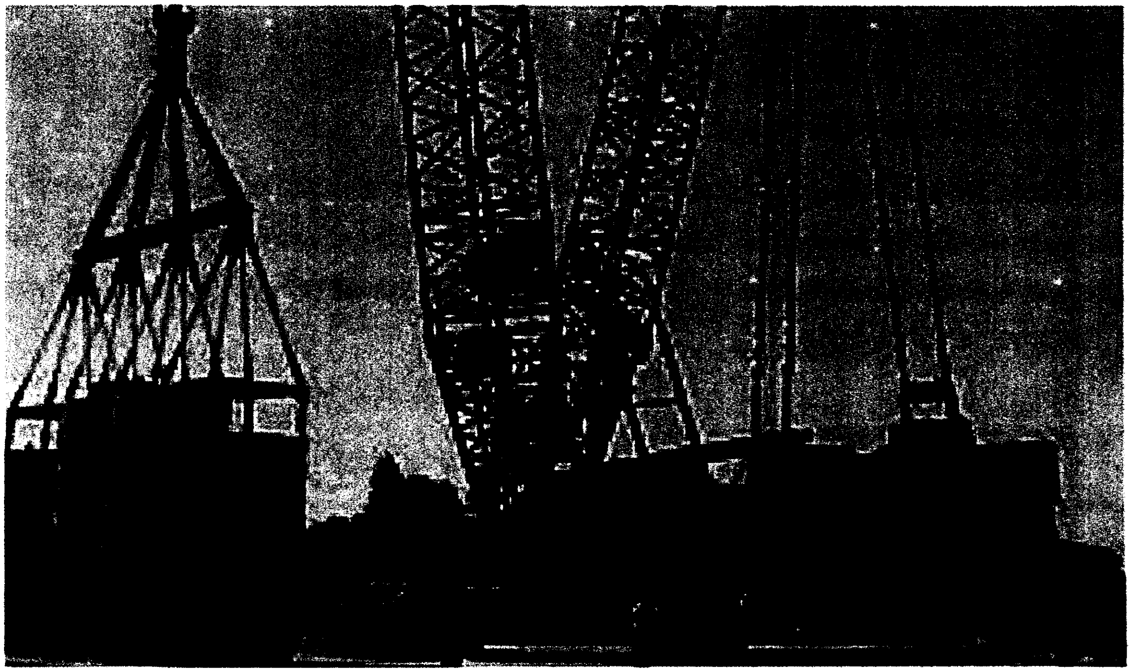
To increase efficiency and reduce cost, current AQCS demolition and installation trends involve the development of detailed, engineered lift plans for removal and installation of equipment and ductwork in large pieces. Each large piece lift would be approximately 15-20 tons at a boom radius in excess of 200 feet. The demolition and/or installation contactor will select its own equipment to perform the work and should be required by contract to identify and locate buried utilities and equipment to protect from crane ground bearing pressures. Appendix P shows crane operations and equipment staging areas from an equipment GA plan view.

3.21.4.1 West Side Crane [TRADE SECRET DATA BEGINS

The area due west of the boiler building is a key area for a crane operations and picking loads not only during the non-outage time period but also during the SDA and SCR tie-in outage. In support of large-piece non-outage and outage work plans, an 800-ton-class crane would be located in this area in order to build the SDA units and the SCR non-outage and would be critical for duct piece handling during the tie-in outage. A typical crane of this size used today is a with a counterweight attachment (illustrated in Figure 3-2). A crane operations area is depicted in the marked up GA drawing. TRADE SECRET DATA ENDS]

[TRADE SECRET DATA BEGINS

Figure 3-2. with Counterweight Attachment



3.21.4.2 East Side Crane

The aisle way due east of the boiler building is an area that can be used for non-outage SCR installation on the east side and would be essential to support tie-in outage activities by easing the burden of the west side crane. A 250-ton-class crane, such as a , would be used. The crane operations area will be limited by the narrow aisle way created by the existing makeup water tank and the new stairway gallery for the new SCR. If the duct tie-in work is critical path for the outage (not the boiler modification work), a larger crane would be required (such as a) to handle large duct segments on the east side and to reduce outage time. The installation of the SCR stairway gallery can be postponed and the makeup water tank could be temporarily (or permanently) relocated in order to increase the width of the aisle way for crane operations. The crane will impede maintenance shop access and FD fan room access at times but those impediments can be scheduled.

TRADE SECRET DATA ENDS]

3.21.4.3 SDA and SCR Support Process Areas

Smaller-size lattice boom cranes or hydraulic truck cranes would be used to erect the various SDA and SCR support equipment.

3.21.5 Tie-In Outage

The final tie-in outage will involve four major activities:

- Existing baghouse ductwork, ID fan, and ID fan ductwork demolition and removal
- New SDA tie-in ductwork installation
- New SCR tie-in ductwork installation
- Boiler modifications

Cranes on each side of the boiler building would be shared for equipment handling for all of the outage activities. Openings in the boiler building north wall for SCR duct connections would be installed pre-outage. Any construction openings required in the north wall for boiler modification work would also be made pre-outage. The outage is discussed in more detail in Section 4 of this report.

Figure 3-3. Boiler Building Wall Openings

It is assumed at this time that the installing contractor would prefer north side boiler building access above the economizer discharge for movement and replacement of boiler modification equipment and components (boiler tubing panels). Due to the number and duration of outage activities required to install the SCR connecting ductwork in this area, consideration should be given to loading and removing boiler modification equipment and components into the east and west sides of the boiler building. Weld-out time to secure SCR duct connection pieces in order to release the crane may cause delays in moving boiler modification equipment and components.

Figure 3-4. Example of SCR Inlet Duct Installation During Plant Outage

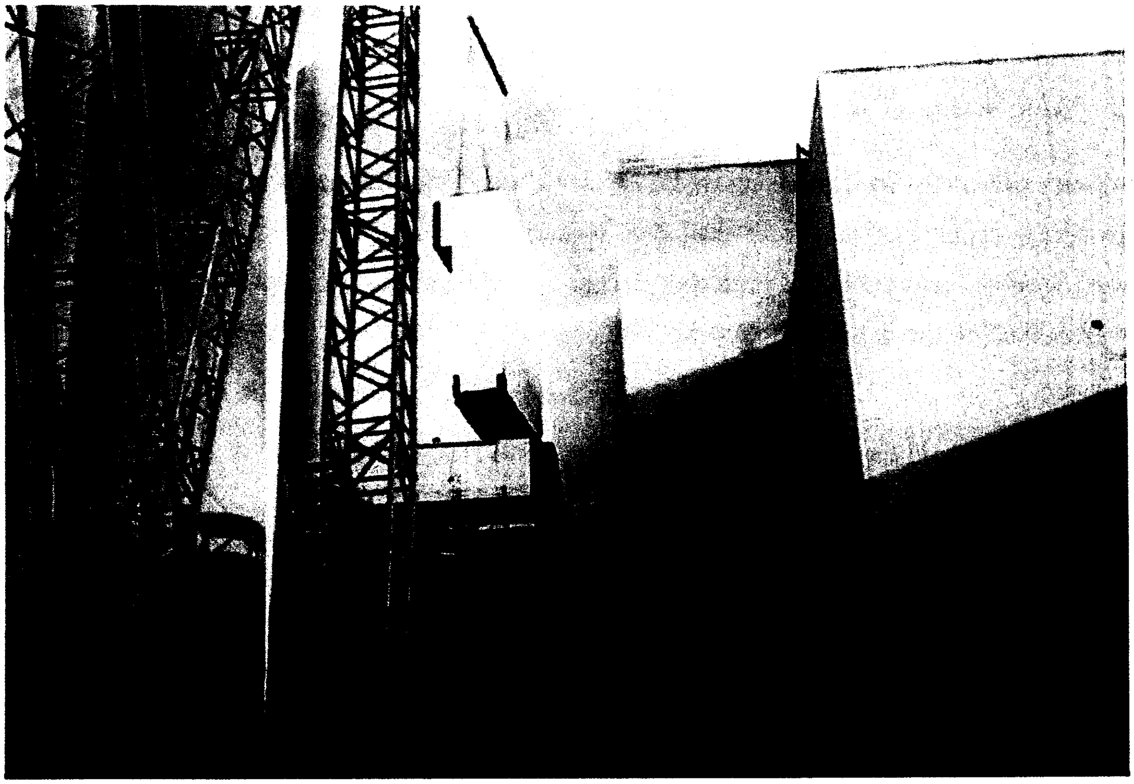
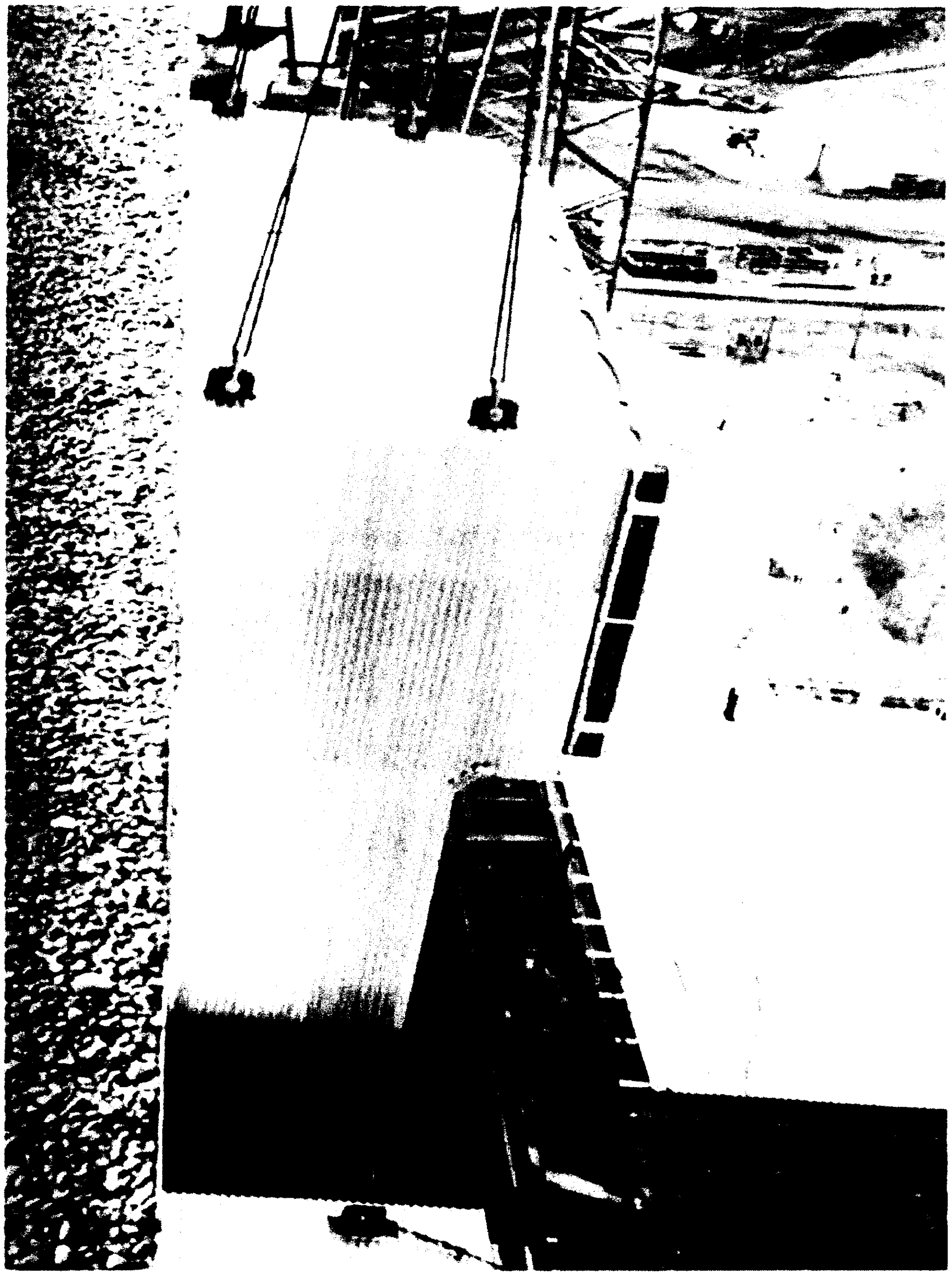


Figure 3-5. Example of SCR Inlet Duct Lowering Into Position



If boiler modification work has to be performed from the north side in parallel with existing baghouse duct demolition and SCR ductwork connection during the outage, it would be advisable to establish a single point of contact as the person to ensure that as overhead loads are secured, others are notified that they can resume work. This will increase efficiency in work suspension required when overhead loads are suspended on a crane hook.

The tie-in outage sequence for the AQCS equipment is basically to:

- Remove the existing baghouse ductwork and ID fan outlet ducts.
- Install the new SDA and new ID fans tie-in ductwork.
- Install the new SCR discharge (lower) tie-in ductwork.
- Install the new SCR inlet (upper) tie-in ductwork.

Duct weld-out activities will be performed in parallel to the extent possible during periods when live loads are not suspended overhead.

With detailed advance planning, proper coordination of all outage activities in the congested area north of column row K, along with inclement winter weather protection, the outage work scope should be completed within the currently proposed schedule.

4. SCHEDULE

4.1 SCR AND FGD INSTALLED FOR SAME OUTAGE

The Level I implementation schedule shown in Appendix K is based on one major tie-in outage. This conceptual schedule was developed using the following input as a minimum: [TRADE SECRET DATA BEGINS

- Milestones provided by OTP during the June 8-9, 2010 kickoff meeting at the site.
- S&L in-house data and vendor input on current equipment procurement durations.
- The engineering study report provided in Appendix F.

The Level I implementation schedule (Appendix K) currently shows when engineering activities need to begin in order to support the award of the major equipment and installation procurements. These engineering activities will continue as necessary in order to complete the BOP engineering, procure remaining equipment, perform vendor drawing reviews, and support construction/startup and commissioning activities.

Only the major critical equipment and installation procurements were included in the schedule. For the AQCS project, a total of contracts will be developed. As shown in the Level I implementation schedule, procurement of the SCR catalyst and the dry FGD system, including baghouse equipment, need to start in . The SCR catalyst will be awarded with a limited notice to proceed to initiate the flow model scope of work and in order to hold all major expenditures of the project until after . Design input from these two contracts is required for the BOP engineering and to support the General Work Contract (GWC) specification bid issue in .

The schedule shows an award of one GWC Contract in early to allow the major underground and foundation work to be performed starting in through . The contracting strategy for the GWC Contract is currently planned to be a " ." Based on a review of the Level I implementation schedule, the civil and structural scope of work required for the project will be well-defined and site-specific. The mechanical and electrical scope of work will be based on the best available information and estimated material quantities. As the project progresses into the design and a more detailed level 3 schedule is developed, splitting the installation

TRADE SECRET DATA ENDS]

[TRADE SECRET DATA BEGINS

into GWC Contracts (e.g., underground and above ground) may be economically justified along with the contracting strategy. Issuing an above ground GWC specification for bids to months later than the underground GWC specification would allow the mechanical and electrical scope of work to be more complete and better defined.

The critical path for the outage construction is the boiler and air heater modifications, which are expected to take from the Contractor's access to the work. The schedule currently shows the maximum duration of weeks for this work (line item in the schedule). As a result, the finish date of the outage needs to move out into . The plant is loaded in and and the earliest the plant outage can start is in .

For startup and commissioning, approximately months is required after the unit goes back on line. Therefore, the earliest commercial operation date expected is in , which allows approximately months of float from the date mandated by law to have the AQCS in operation, . TRADE SECRET DATA ENDS]

4.2 FGD INSTALLATION FOLLOWED BY SCR INSTALLATION

[TRADE SECRET DATA BEGINS

During the screening study review, the feasibility of tie-in outages was discussed. Phasing the dry FGD system, including the baghouse system and ID fans with VFDs, into operation prior to the installation of the SCR system would be worth pursuing if capital costs could be reduced. At that time, the extent of the boiler modifications was unknown and more conceptual work needed to be performed. Based on further review of the Level I implementation schedule for one tie-in outage, a more detailed structural evaluation, and the length of the outage required for the boiler modifications, minimal capital cost savings, if any, are anticipated. Therefore, this option was not pursued further. TRADE SECRET DATA ENDS]

4.3 CASH FLOW

Appendix K to this report includes OTP's Level I implementation schedule for the project. The Big Stone Plant AQCS cash flow was developed based on the duration and sequence of the activities as dictated by the OTP schedule. In addition to the schedule, Appendix K also provides two plots that depict the cash flow and quarterly spending analyses. One scenario excludes allowance for funds used during construction (AFUDC) and the other excludes contingency, escalation, and AFUDC. The Direct and Construction Indirect Costs (Code of Account Line

[TRADE SECRET DATA BEGINS

Item in the Cost Estimates, Appendix H) were distributed based on a percent per month payment release typical to the contract type. A percentage was allocated for the award through the vendor drawing review and approval process, mobilization, pre-outage construction, and outage construction. Other project costs were distributed based on similar historical project cost distribution and customized for the project based on the OTP-provided dates for critical milestones: first major expenditure, outage durations, and seasonal weather conditions as they affect construction. TRADE SECRET DATA ENDS]

5. CAPITAL COST EVALUATION [TRADE SECRET DATA BEGINS

S&L estimated the capital cost for retrofitting dry FGD with new baghouse, dry FGD with reuse of the existing baghouse, wet FGD, and SCR. Estimated capital costs include the equipment, material, and labor based on . The underlying assumption is that the contracting arrangement for the project is on a multiple lump sum (not EPC) basis. The capital costs provided herein are based on burning 100% PRB coal and include the following:

- Equipment and material
- Installation labor
- Erection contractor profit
- General and administration
- Freight
- Sales tax
- Startup and commissioning
- Spare parts
- Indirect field costs and BOP engineering
- Contingency
- Owner's Engineer cost
- Escalation
- AFUDC

Costs for license fees and royalties are not included.

The installed capital costs are based on S&L in-house cost data from similar projects as well as vendor-supplied budgetary quotations. Based on the conceptual design that has been done, the costs have an accuracy of .

TRADE SECRET DATA ENDS]

Two estimates were prepared, one for the SCR and one for the dry FGD with baghouse. The costs are summarized in Table 5-1.

[TRADE SECRET DATA BEGINS

Table 5-1. Capital Cost Summary

Parameter	SCR	Dry FGD with New Baghouse
Direct and construction indirect cost,		
Indirect cost,		
Contingency @		
Escalation,		
Owner's cost,	Included in dry FGD	
Total project cost,		
Total AQCS Cost,		

TRADE SECRET DATA ENDS]

Detailed capital cost estimates for installing dry FGD and SCR at Big Stone, including major equipment, site modifications, and material items, are presented in Appendix H.

6. O&M COST EVALUATION

6.1 FIXED AND VARIABLE OPERATING COSTS [TRADE SECRET DATA BEGINS

The fixed O&M costs determined for this study consist of operating labor, maintenance labor, maintenance material, and administrative labor. The dry FGD will require an estimated additional full-time operators and maintenance personnel. Typical maintenance items for the dry FGD system would include the slakers, changing of atomizers, baghouse air compressors, booster fans, and recycle handling system. The SCR will require part-time operator to check the sonic horns, sootblowers, and ammonia system once per shift.

Annual maintenance material and labor costs shown herein are estimated based on technology operating experience in the U.S. The annual maintenance cost includes maintenance material for various subsystems and the labor required to perform the maintenance. The annual maintenance material and labor for the dry FGD technology is estimated to be of the direct and construction indirect cost. The annual maintenance material and labor for the SCR technology is estimated to be of the direct and construction indirect cost.

6.2 VARIABLE OPERATING COSTS

Variable O&M costs determined for each option include consumables, including reagent (lime and ammonia), byproduct management, bag replacement for the baghouse, catalyst, water, and power requirements. These costs were calculated at a unit capacity factor of . TRADE SECRET DATA ENDS]

Table 6-1 lists the major economic parameters that were used in the variable O&M costs as well as the economic evaluation. These values were developed both by OTP and S&L.

[TRADE SECRET DATA BEGINS

Table 6-1. Major Economic Parameters

Parameter	Value
Amortization life,	
Interest rate for discounting,	
Capital escalation rate,	
O&M escalation rate,	
Levelized fixed charge rate,	
Capacity factor,	
Auxiliary electric power energy charge,	
Ash disposal cost (placement only),	
Water,	
Lime (truck delivery),	
Activated carbon (truck delivery),	
Anhydrous ammonia (truck delivery),	

The variable cost for the dry FGD assumes that all generated fly ash solid waste will be land-filled and the current revenue stream for selling fly ash will be lost.

The variable O&M costs, such as reagent consumption, are associated with reducing the inlet sulfur to SO_2/MBtu and reducing the inlet NO_X to .

Auxiliary power costs developed reflect the increase in power requirements associated with the new ID fans as well as the estimated power consumption for the SCR, absorber, reagent preparation, and byproduct handling areas.

The fixed and variable O&M costs are summarized in Table 6-2.

Table 6-2. Fixed and Variable O&M Costs

Parameter	SCR	Dry FGD with New Baghouse
Fixed O&M,		
Variable O&M,		
Subtotal O&M,		
Total AQCS O&M,		

Detailed fixed and variable O&M costs for installing dry FGD and SCR at Big Stone are presented in Appendix I.

6.3 LEVELIZED COSTS [TRADE SECRET DATA BEGINS

Table 6-3 provides the annual, levelized cost for the dry FGD and SCR.

Table 6-3. Levelized Cost Summary

Parameter	SCR	Dry FGD with New Baghouse
Levelized investment,		
Levelized fixed O&M,		
Levelized variable O&M,		
Levelized subtotal cost,		
Levelized Total AQCS Cost,		

TRADE SECRET DATA ENDS]

7. PERMITTING CONSIDERATIONS

As described herein, OTP has initiated an AQCS retrofit program for Big Stone. The project includes the installation of advanced air pollution control systems, and is being initiated to ensure compliance with the anticipated South Dakota Regional Haze Rule. South Dakota published its Draft Regional Haze State Implementation Plan (SIP) in August 2010. The proposed regional haze regulations are included in the Administrative Rules of South Dakota (ARSD) Article 75:36. The proposed regulations require OTP to control NO_X, SO_2, and PM emissions from Big Stone using Best Available Retrofit Technology (BART).

Air pollution control systems proposed as part of the project include a selective catalytic reduction (SCR) system and separated overfire air (SOFA) for NO_X control, a dry flue gas desulfurization (FGD) system for SO_2 control, and a new fabric filter for PM control. While the existing fabric filter already meets the proposed BART requirements, replacing it as part of the overall AQCS project reduces the total project cost. The plans also incorporate activated carbon injection (ACI) for mercury control, although its installation is contingent upon EPA Maximum Available Control Technology (MACT) rulemaking.

Modifications to an existing stationary emissions source, including the installation of air pollution control systems, can trigger environmental permitting and approval requirements. Permitting requirements can include, but are not necessarily limited to, air, water, storm water, wastewater discharge, and solid waste handling and disposal permitting.

7.1 PERMITTING REQUIREMENTS

A report reviewing the environmental permits that may be required to implement the Big Stone AQCS project is provided in Appendix N to this report. Potential environmental permits include:

- South Dakota Air Construction Permit (ARSD Chapters 74:36:20 and 74:36:21)
- General Permit For Storm Water Discharges Associated With Construction Activities
- Revision to the facility's existing Solid Waste Permit

7.1.1 Air Permitting Summary

The South Dakota Regional Haze Program (ARSD Chapter 74:36:21) requires submittal of an application for an air permit to construct in accordance with ARSD Chapter 74:36:20. The air permit application will include information describing the air pollution control systems as well as information describing any new emission sources associated with the project (i.e., material handling sources). New emission point sources associated with the proposed material handling system include the:

- Lime storage silo
- Activated carbon storage silo
- FGD recycle solids storage silo
- FGD waste storage silo

Additionally, there will be new fugitive dust emissions associated with truck delivery of lime, anhydrous ammonia, and activated carbon to the plant; as well as truck delivery of FGD solids and fly ash from the storage silo to the landfill. Information describing the new emission points and fugitive dust sources must be included in the air permit application and is included in Appendix N to this report.

7.1.2 Wastewater and Storm Water Permitting Summary

South Dakota administers the National Pollutant Discharge Elimination System (NPDES) permitting requirements. Surface water discharge (SWD) permitting regulations are included in ARSD Chapter 74:52. In South Dakota, no person may directly discharge pollutants from any point source into surface waters of the state without a valid SWD permit (ARSD Chapter 74:52:01:04).

Big Stone is designed and operated as a zero process wastewater discharge facility; thus, an NPDES permit is not required for plant operation. OTP is proposing to install a spray dry absorber (SDA) FGD as part of the AQCS project. There are no liquid wastes generated from an SDA control system, as all water used in the control system is evaporated. Because the AQCS project retains the zero-liquid discharge design and operating criteria, the NPDES permitting requirements in ARSD Chapter 74:52 are not applicable to the project.

However, the NPDES Program also includes provisions for control of storm water discharges from industrial sources and storm water discharges associated with construction activities. In South Dakota, any construction activity disturbing one or more acres must have coverage under a storm water permit. On December 31, 2009, the South Dakota DENR reissued a General Permit for Storm Water Discharges Associated with Construction Activity. The storm water general permit includes runoff control requirements and work practices (e.g., grading and drainage requirements, silt fences, and retention ponds) designed to minimize impacts on surface waters associated with storm water runoff during construction activities. OTP will need to file a Notification of Construction Activity and develop a Storm Water Pollution Prevention Plan as required by the General Permit. The facility must complete and submit a Notice of Intent (NOI) prior to commencing construction activities.

All storm water discharges associated with industrial activities, including power generating facilities and chemical processing facilities, that discharge through municipal storm sewer systems or that discharge directly into the waters of the U.S. are required to obtain a NPDES storm water permit. The storm water control and discharge requirements will be included in the facility's NPDES discharge permit, and may require storm water retention, sampling, and analysis prior to discharge. In South Dakota, South Dakota DENR has a General Permit for Storm Water Discharges Associated with Industrial Activity. The permit covers any party meeting the conditions of the general permit. Upon completion of the AQCS project, the facility will be required to submit a Notice of Intent to apply for coverage under the General Permit for Storm Water Discharges Associated with Industrial Activity.

7.1.3 Solid Waste Permitting Summary

South Dakota Codified Law 34A-6 requires that for the purposes of proper, effective, and safe disposal of solid waste, any person intending to dispose of solid waste within South Dakota must comply with the provisions of state law. These provisions require a solid waste permit and establish requirements and procedures for obtaining the permit. The regulations developed to implement the solid waste statutes are found in ARSD Article 73:27. A permit from the South Dakota DENR Solid Waste Management Program is required prior to the construction of a solid waste disposal facility (ARSD Chapter 74:27:08:01). Permits are required before construction of the facility begins. Applications must address requirements listed in Chapter 74:27:09.

Based on information provided by OTP, the facility has an existing solid waste disposal facility permitted to accept coal combustion residues, including gypsum/sludge solids generated as part of the now canceled Big Stone I/Big Stone II common wet FGD system project. A Solid Waste Permit revision will likely be necessary to include reference to semi-dry FGD residue in the plant landfill and to remove references to the Big Stone I/Big Stone II common wet FGD system from the permit. It is anticipated that the permit revisions will be made during the scheduled permit renewal process.

7.2 PERMITTING EFFICIENCY AND TIMELINE

The overall goal of the environmental permitting program is to secure all of the permits and approvals needed to commence construction and operation of a proposed new source or modification to an existing source. From a regulatory standpoint, authorities use the permitting process to define legally binding requirements for individual sources to ensure compliance with the applicable environmental rules and regulations. The environmental permitting program should be implemented to support the overall project objectives and implementation schedule. To the extent possible, environmental permitting should not become the critical path or delay construction. Emission limits, discharge limits, environmental controls, and monitoring requirements in the final permit should, to the extent possible, be achievable and support the overall goals of the project. It is important that permit provisions align with technical capabilities of the environmental control systems being proposed (i.e., the technology must be capable of meeting the proposed permit limits). Failure to align permit provisions with control technology capabilities increases the risk of potential future compliance issues.

To minimize permitting risks and potential project delays it is important, as an initial step, to identify all of the environmental permits and approvals required to construct and operate the proposed facility or modification. This step requires the scope of the project to be fully defined and consideration of potential air, water, and solid waste implications of a proposed project. Failure to completely define the scope of the project, including potential impacts to all environmental media, increases the risk of missing a required permit and could lead to significant delays in the permitting process, legal challenges, and jeopardize start of construction and/or operation of the project.

Communication between the project proponent, third-party engineering and environmental consultants, and the permitting agency is also a necessary element of a successful permitting program. It is important to develop a clear division of responsibility and identify the parties responsible for developing the technical and environmental information needed to support the permit application. Environmental permitting regulations are designed to require a transparent review and decision making process, and typically include provisions for review and comment from interested parties. The permitting agency is required to develop a complete administrative record of the permitting process, and to make an informed decision based on the technical/environmental information in the record.

Therefore, it is important to establish clear lines of communications with the agency throughout the permitting process to ensure the agency receives the technical/environmental information needed to support its permit decisions.

Appendix N provides a report reviewing the environmental permits that may be required to implement the Big Stone AQCS retrofit project. Potential environmental permits include:

- South Dakota Air Construction Permit (ARSD Chapters 74:36:20 and 74:36:21)
- General Permit for Storm Water Discharges Associated with Construction Activities
- Revision to the facility's existing Solid Waste Permit

The most significant environmental permit needed for the proposed AQCS project is the Chapter 74:36:20 air construction permit for new sources or modifications; therefore, the remainder of this subsection focuses on preparation and submittal of the air construction permit application. The proposed South Dakota BART regulations require the Owner or operator of any BART-eligible source to submit an application to modify its operation in accordance with Chapter 74:36:20. OTP will be required to submit an application for a permit to construct that must describe the new air pollution control systems, emission limits, and monitoring requirements for Unit 1 and the new material handling emission sources. A construction permit may be issued by the South Dakota ENR only if it has been shown that the operation of the new source, or modification to an existing source, will not prevent or interfere with the attainment or maintenance of an applicable National Ambient Air Quality Standard (NAAQS), and that each new or modified source will comply with all applicable emission limits and other requirements. A simplified flow diagram showing the Chapter 74:36:20 permitting process is provided in Figure 7-1. Timeframes associated with the permit application review process are summarized in Table 7-1.

Figure 7-1. Chapter 74:36:20 Air Construction Permitting Process

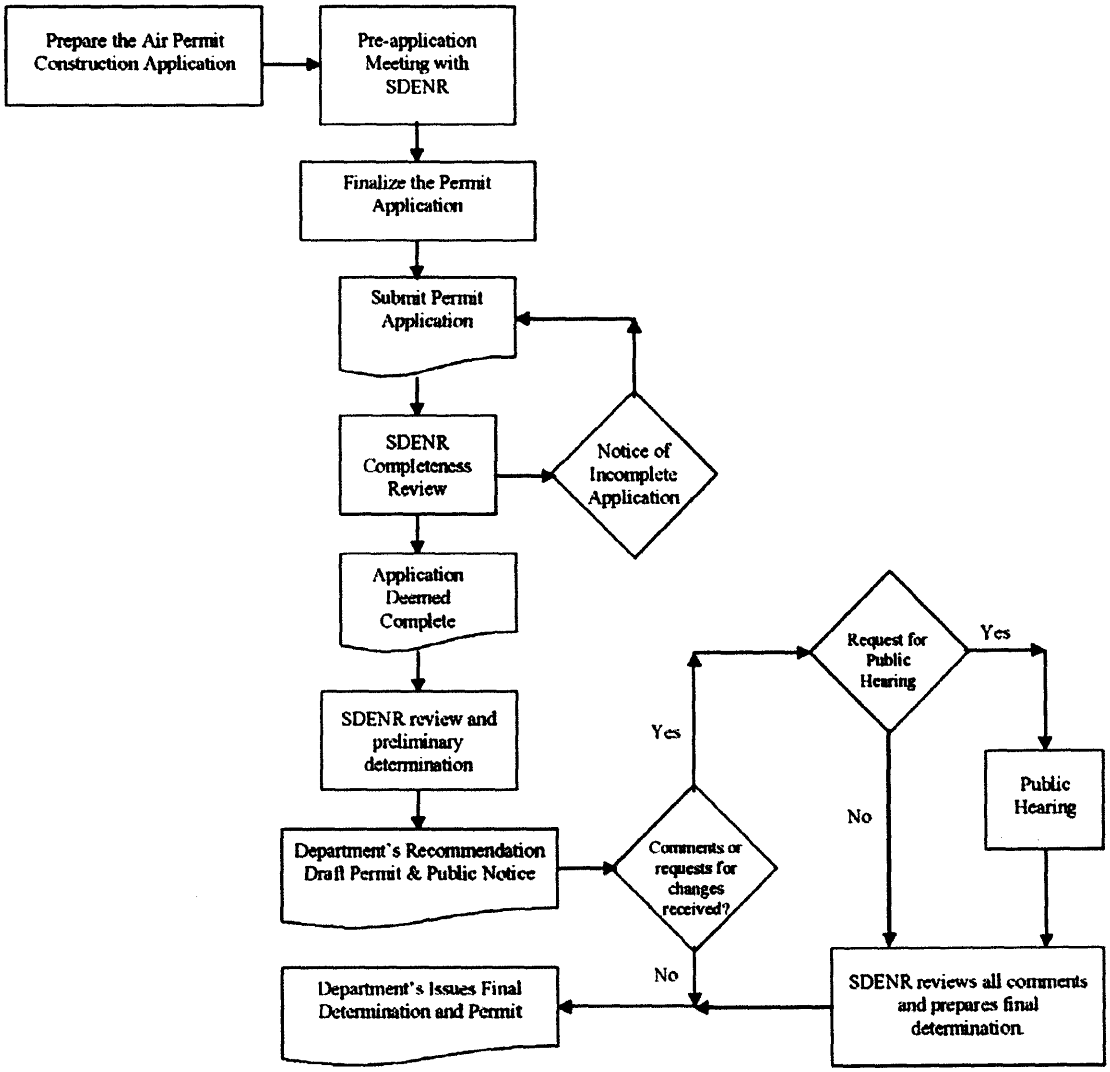


Table 7-1. Chapter 74:36:20 Air Construction Permitting Timeframes

Process/Chapter	Regulatory Requirement
Completeness Review 74:36:20:09	Within 30 days after submission of an application the department shall notify the applicant in writing whether or not the application is complete or incomplete. If the application is incomplete, the department shall identify the items required to complete the application. The applicant has 20 working days to submit the information, unless an extension beyond the 20 days is approved by the department. The department shall determine the adequacy of the applicant's response to each incomplete item within 15 days after receipt of the response and shall notify the applicant in writing if the application is or is not complete.
Department's Recommendation 74:36:20:10	The department shall recommend issuance or denial of a construction permit within 180 days after the submission of a complete application.
Public Participation 74:36:20:11 and 12	The department shall publish a public notice of the draft permit in a legal newspaper in the county where the source is located, including a statement that a person may submit comments or contest the draft permit within 30 days after the publication of the notice. During the public comment period, any interested person may submit written comments on the draft permit or request a contested hearing case.
Final Permit Decision 74:36:20:13	The department shall make its final permit decision within 30 days of the end of the public comment period on a draft permit. The department shall notify, in writing, the applicant and each person that submitted written comments. A final permit shall be issued within 30 days of the final decision, except under the following conditions: (1) A later effective date is specified in the final permit decision; (2) A contested case hearing is requested; or (3) No comments or request for changes in the draft permit were received during the public comment period on the draft permit. In this case, the draft permit automatically becomes the final permit decision and the final permit is issued at the end of the public comment period.
Right to Petition for Contested Case Hearing 74:36:20:14	The applicant or interested person may petition the board and obtain a contested case hearing to dispute the department's draft permit. Such petitions must comply with provisions of Chapter 74:09 and must be received by the department within 30-days after publication of the notice required by Chapter 74:36:20:11. An applicant or an interested person that comments on the draft permit may petition the board for and obtain a contested case hearing to dispute the department's final permit decision. Such petitions must comply with the provisions of Chapter 74:09 and must be received by the department within 30 days after receiving the department's final permit decision.

Chapter 74:36:20:06 requires any person who wishes to construct a new source or modify an existing source to submit a complete application to the South Dakota DENR at least 180 days before the estimated date of commencing construction of the new source or modification. Based on the review times summarized in Table 7-1, additional time should be added for the initial completeness review and the public participation process. A preliminary permitting timeline is summarized in Table 7-2.

Table 7-2. Preliminary Permitting Timeline

Activity	Days	Early Date	Late Date
Start Date	–	January 2011	January 2011
Prepare Permit Application	60 – 90		
Submit Permit Application	–	March 2011	April 2011
Initial Completeness Review	60 – 90		
Application Deemed Complete	–	May 2011	July 2011
Department Review	120 – 180		
Preliminary Determination/Draft Permit	–	September 2011	January 2012
Public Participation/Public Hearing	30 – 60		
End of Public Review Period	–	October 2011	March 2012
Department Review	30		
Final Determination	–	November 2011	April 2012

Because the department is under a regulatory mandate to issue its draft recommendation within 180 days of submission of a complete application, reaching "completeness" is critical to minimizing the overall permitting timeframe. Although the department is required to conduct its initial completeness review within 30 days of receiving an application, the department can return the application to the proponent during this period for additional details and information. Thus, to the extent possible, the applicant should endeavor to submit a thorough and complete application, including all of the technical/environmental information required by the department, to minimize the initial review period and start the 180-day countdown.

To be deemed complete, an air construction permit application submitted pursuant to Chapter 74:36:20 must include the following information:

- The following general company information:
  - The company name and address or the plant name and address if different from the company name.
  - The Owner's name and agent.
  - The plant site manager or contact.
- A description of the plant and its processes and products.
- The following information on emissions:
  - Identification and description of all emission units.
  - Fuels, fuel use, raw materials, and production rates.
  - Identification and description of air pollution control equipment.
  - Limitations on source operation affecting emissions or any work practice standards, if applicable, for all regulated air pollutants.
  - Other information required by any applicable requirements, including information related to stack height limits, such as the location of emission units, flow rates, building dimensions, and stack parameters, including height, diameter, and plume temperature for all pollutants regulated at the source.
- If available, a copy of any prepared plans and the specifications of any equipment or other facilities that may affect the source, including pollution control devices.
- A signed and notarized certification of applicant form.
- The results of any air dispersion modeling required by the department.
- The results of any stack performance testing required by the department.
- Any other information requested by the department that is relevant to determining compliance with the act or the Clean Air Act.

Finally, the potential for significant public interest in the permitting process must be taken into account when developing a permitting timeline. It is important to ensure that the department meets its public participation mandates, and to work with the department to address comments submitted during the public review process. Failure to assign an appropriate level of importance to public interest in a project can lead to permit application review delays, legal challenges, and jeopardize start of construction.

Chapter 74:36:20 provides two opportunities for interested parties to request a contested case hearing. First, the applicant or interested person may petition the Board of Minerals and Environment and obtain a contested case hearing to dispute the department's draft permit. Such petitions must be received by the department within 30 days after publication of the notice required by Chapter 74:36:20:11. Second, an applicant or interested person that comments on the draft permit may petition the Board and obtain a contested case hearing to dispute the department's final permit decision. Such petition must be received by the department within 30 days after receiving the department's final permit decision. Either petition must comply with the provisions of Chapter 74:09. Chapter 74:09 details the contested case hearing procedures, including timeframes for filing petitions, answers, pleading, motions, etc. Although the regulations provide specific timeframes, contested case hearings can add significantly to the overall permitting timeline, and should be considered a possibility in any permit application related to the construction or operation of a coal-fired electric generating unit (EGU).

7.3 FUTURE ENVIRONMENTAL REGULATIONS/LEGISLATION

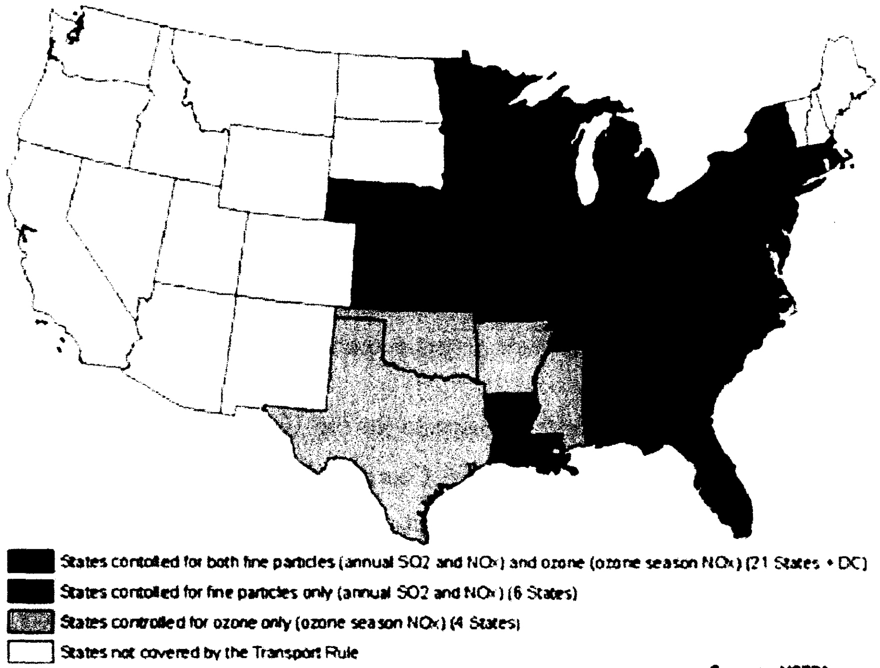
U.S.EPA is actively working on a number of environmental regulatory initiatives that may affect emissions from coal-fired electricity generating units such as Big Stone. This section of the report provides a summary of the future regulatory initiatives, and evaluates potential impacts to the AQCS project and operation of Big Stone.

7.3.1 Transport Rule

On July 6, 2010 EPA proposed the Transport Rule. The proposed rule would replace EPA's 2005 Clean Air Interstate Rule (CAIR). Both rules are intended to implement the Clean Air Act requirements concerning the transport of air pollutants across state boundaries, and assist downwind states to attain and maintain the NAAQS for ozone and fine particulate matter ($PM_{2.5}$). On July 11, 2008, the U.S. Court of Appeals for the D.C. Circuit vacated the 2005 CAIR in its entirety; however, after a rehearing of the case, the Court, on December 23, 2008, reinstated CAIR and directed the EPA to conduct further proceedings consistent with the Court's opinion in the case. As a result, CAIR went into effect in its entirety on January 1, 2009, and will remain in effect until the EPA re-writes the rule to address the flaws identified by the Court. The proposed Transport Rule responds to the court's concerns.

Specifically, the Transport Rule would require 31 states and the District of Columbia to reduce SO_2 and NO_X emissions from power plants that cross state lines and contribute to ozone and $PM_{2.5}$ NAAQS non-attainment in downwind states. Figure 7-2 shows the 31 states affected by the Transport Rule. Power plants located in South Dakota are not covered by the Transport Rule; therefore, the Transport Rule should have no impact on Big Stone operations.

Figure 7-2. States Affected by Transport Rule



Source: USEPA

7.3.2 Utility MACT

On December 14, 2000, EPA published a finding that the regulation of hazardous air pollutant (HAP) emissions from coal- and oil-fired utility steam electric generating units (EGUs) was appropriate and necessary, effectively adding coal- and oil-fired EGUs to the list of source categories under §112(c)(5) of the Clean Air Act.[1] On January 30, 2004 EPA published two alternative rules regulating mercury emissions from coal-fired EGUs.[2] The first proposal set mercury emission standards based on the maximum achieve control technology (MACT) developed pursuant to §112 of the Act (the "Proposed MACT Rule"). The alternative rule proposed revising EPA's December 20, 2000 regulatory finding, removing coal- and oil-fired EGUs from the list of source categories, and setting mercury emission standards for coal-fired EGUs pursuant to §111 of the Act. On March 29, 2005, EPA

[1] **See, 65 FR 79825. Historically, electric utility steam generating units (EGUs) like Big Stone Unit have been excluded from the 40 CFR 63 Subpart B maximum achievable control technology (MACT) requirements. The regulations state that "[t]he requirements of [40 CFR Part 63 Subpart B] do not apply to electric utility steam generating units unless and until such time as these units are added to the source category list pursuant to section 112(c)(5) of the Act." (40 CFR 63.40(a)).. The December 2000 finding effectively added EGUs to the list of source categories.**

published a final rule revising its December 2000 finding, concluding that is was neither appropriate nor necessary to regulate coal- and oil-fired EGUs pursuant to §112 (the "Revision Rule").[3] Based on this revised finding, EPA removed coal-fired utility units from the §112(c) list of source categories.

A final rule regulating mercury emissions from coal-fired EGUs was published on May 18, 2005.4 The Clean Air Mercury Rule (CAMR) established standards of performance for mercury emissions from both new and existing coal-fired utility units. Rather then regulating mercury pursuant to §112, CAMR was based on §111 of the Act. CAMR included a New Source Performance Standard (NSPS) for mercury emissions from new coal-fired units, and established a nationwide mercury cap-and-trade program applicable to both new and existing coal-fire units.

However, on February 8, 2008, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision vacating CAMR as well as EPA's Revision Rule.[5] The Court's ruling effectively vacated the CAMR regulations for both new and existing EGUs, and restored EPA's previous finding, published December 20, 2000, that the regulation of HAP emissions from coal- and oil-fired EGUs was appropriate and necessary. The Court's vacatur effectively reestablished coal- and oil-fired EGUs as a §112(c) source category of HAP emissions.

EPA is currently working on rewriting the Utility MACT Rule to address the Court's ruling. As part of this effort, EPA initiated an Information Collection Request (ICR), including a request that several existing coal fired EGUs conduct stack testing for a variety of HAP compounds. The ICR effort will provide EPA with the emissions data needed to establish the MACT emission limits, and will help EPA identify the MACT control technology requirements for new and existing coal-fired sources.[6] A proposed Utility MACT Rule is expected to be published by March 16, 2011, and a final Utility MACT rule is expected by November 16, 2011. The rule will include HAP emission standards for new and existing coal-fired EGUs, such as Big Stone.

It is not known how EPA will propose to regulate HAP emissions from coal-fired EGUs. However, based a review of the February 2008 Court of Appeals decision, it appears unlikely that the new rule would include an emissions trading program. Based on a review of the 2004 proposed Utility MACT Rule (69 FR 4652, January 2004), judicial

[2] 60 FR 4652 (January 30, 2004)
[3] 70 FR 15994, March 29, 2005),
[4] 70 FR 28606 (May 18, 2005)
[5] See, State of New Jersey v. Environmental Protection Agency, 517 F.3d 574 (D.C. Cir. 2008).
[6] More information on the Utility MACT ICR can be found at: http://utilitymacticr.rti.org/

[TRADE SECRET DATA BEGINS

decisions addressing MACT rules,[7] and the recently published proposed Industrial Boiler MACT rule (57 FR 32006, June 2010), it is likely that the new Utility MACT rule would include the following provisions:

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Although it is anticipated that that the Utility MACT rule will regulate a number of HAPs and HAP categories, and that the rule will likely include stringent MACT emission limits, it does not appear that the rule will trigger additional air pollution controls for Big Stone (beyond those proposed for the AQCS project). are captured in air pollution control systems designed to control SO_2 emissions. The proposed SDA with baghouse should provide the most effective , and should represent MACT for existing sources firing sub-bituminous coal. are effectively captured in particulate control systems, and the

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proposed fabric filter baghouse should represent MACT for . The SDA with baghouse coupled with the proposed ACI control system should represent MACT for mercury control. Finally, combustion controls should represent MACT for the . There is some concern that combustion systems designed for low-NO_X operation may not be able to simultaneously achieve . OTP should closely follow the Utility MACT rulemaking process to ascertain whether EPA will propose to limit emissions as a surrogate for , and determine whether any proposed limit is achievable with low-NO_X combustion.

TRADE SECRET DATA ENDS]

7.3.3 National Ambient Air Quality Standards

EPA has recently proposed and finalized several NAAQS revisions. The NAAQS revisions will likely increase the number of non-attainment areas in the U.S. The following subsections highlight NAAQS revisions that could impact OTP's pollution control strategy.

7.3.3.1 PM2.5 NAAQS

In 1997, EPA revised the NAAQS for PM to add new standards for fine particles, using $PM_{2.5}$ as the indicator. EPA established primary annual and 24-hour standards for $PM_{2.5}$ of 15 μg/m^3 and 65 μg/m^3, respectively. On October 17, 2006, EPA revised the primary and secondary NAAQS for $PM_{2.5}$. In that rulemaking, EPA reduced the 24-hour NAAQS for $PM_{2.5}$ to 35 μg/m^3, and retained the existing annual $PM_{2.5}$ NAAQS of 15 μg/m^3. On February 24, 2009, the U.S. Court of Appeals for the District of Columbia issued rulings on litigation involving the 2007 $PM_{2.5}$ NAAQS.[8] Among other things, the Court remanded the annual primary $PM_{2.5}$ standard of 15 μg/m^3 to EPA because the agency failed to explain adequately why this level is "requisite to protect the public health." In response to the Court's decision, EPA is considering lowering the annual $PM_{2.5}$ NAAQS to 12 - 14 μg/m^3. EPA is expected to issue a Notice of Proposed Rulemaking (NPRM) by the end of 2010.

Currently, all areas of South Dakota are in attainment with the 1997 and 2006 $PM_{2.5}$ NAAQS. If EPA proposes an annual standard that changes the status of areas in South Dakota to non-attainment, the state of South Dakota would be required to modify its State Implementation Plan (SIP) and could require OTP to install control equipment to

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reduce emissions of primary and secondary $PM_{2.5}$ (e.g., SO_2 and NO_X). However, even if EPA lowers the $PM_{2.5}$ NAAQS, it appears unlikely that any counties in South Dakota would be designated non-attainment, or that compliance with the more stringent NAAQS would require emission reductions from Big Stone beyond those required by BART. Assuming EPA revises the $PM_{2.5}$ NAAQS, a potential timeline could be as follows: (1) EPA issues the NPRM by the end of 2010; (2) EPA publishes a final rule by the end of 2011; (3) EPA issues final area designations by 2013; (4) EPA approves South Dakota's final SIP in 2016 (if any areas in South Dakota were designated non-attainment); and (5) emission controls on affected units would have to be installed in the 2019 timeframe.

7.3.3.2 Ozone NAAQS

In 2008, EPA reduced the 8-hour ozone NAAQS from 80-75 ppb. Final area designations are expected by March 2011. In a letter dated March 6, 2009, South Dakota's Secretary of DENR sent a letter to U.S. EPA with recommendations for designation of areas of the state for the 2008 revised 8-hour ozone NAAQS. In that letter, the Secretary proposed that all counties in South Dakota be designated in attainment with the 2008 8-hour ozone NAAQS.

On January 19, 2010, EPA proposed lowering the 8-hour ozone standard even further to 60-70 ppb. A lower 8-hour ozone standard would be expected to result in more non-attainment areas. A more stringent NAAQS would require the South Dakota to re-elevate the attainment status of areas within the state. However, based on the ambient ozone data included in South Dakota's March 6, 2009 letter to EPA, it appears that most of the state would be in attainment with the more stringent NAAQS. EPA intends to complete reconsideration of the 8-hour ozone NAAQS before the end of 2010. Even if EPA lowers the 8-hour ozone NAAQS, it appears unlikely that compliance with the more stringent NAAQS would require emission reductions from Big Stone beyond those required by BART.

7.3.3.3 Nitrogen Dioxide NAAQS

On February 9, 2010, EPA published its final nitrogen dioxide (NO_2) NAAQS rule, setting a new 1-hour NO_2 standard of 100 ppb, and retaining the current annual NO_2 standard of 53 ppb. The effective date of the new standard was April 12, 2010. All areas of South Dakota are currently in attainment with the annual NO_2 NAAQS; however, the State will be required to designate areas as attainment/non-attainment with the new 1-hour standard.

EPA expects to designate areas as attainment or non-attainment by January 2012 based on the existing community-wide ambient air quality monitoring network. In the event areas within South Dakota are designated non-attainment, the State would be required to modify its SIP and could require OTP to install control equipment to reduce emissions of NO_X. However, it appears unlikely that compliance with the more stringent NAAQS would require emission reductions from Big Stone beyond those required by BART. If EPA designates areas of South Dakota as non-attainment, EPA would be expected to approve the final South Dakota SIP by 2015 to 2016, and could require control technologies to be installed in the 2018 timeframe.

7.3.3.4 SO_2 NAAQS

On June 2, 2010 EPA published a final revision to the NAAQS for SO_2. In the final rule EPA revised the primary SO_2 standard by establishing a new 1-hour standard at a level of 75 ppb. EPA also revoked the two existing primary standards of 140 ppb (24 hours) and 30 ppb (annual) because it was determined that they would not add additional public health protection beyond that provided by the new 1-hour standard.

All areas of South Dakota were in attainment with the 24-hour and annual SO_2 NAAQS. South Dakota will be required to re-visit its designations for compliance with the new 1-hour standard. Unlike other NAAQS implementation rules, EPA plans to use refined dispersion modeling to determine if areas with sources that have the potential to cause or contribute to a violation of the new standard can comply with the standard. EPA intends to complete designations by June 2012, and anticipates designating areas based on 2008-2010 ambient air quality monitoring data and/or refined dispersion modeling results.

In the event areas of South Dakota are designated as non-attainment, the state would need to submit its revised SIP in 2014. SIP revisions would describe the actions that South Dakota would take to come into compliance with the new standard, and could require OTP to install control equipment to reduce emissions of SO_2. However, it appears unlikely that compliance with the more stringent NAAQS would require emission reductions from Big Stone beyond those required by BART. EPA would be expected to approve the final South Dakota SIP by 2015 to 2017, and could require control technologies to be installed in the 2018–2019 timeframe.

7.3.4 Status of Potential Future Greenhouse Gas Regulations

7.3.4.1 Greenhouse Gas Legislation

Over the past couple of years, several legislative initiatives have been introduced in Congress addressing greenhouse gas (GHG) emissions, clean energy technologies, climate change, and energy efficiency. To become law, any GHG legislation must be approved independently by both the House of Representatives and the Senate, coming together in conference committee to reconcile any differences. This process must be completed during the same two-year congressional session. The current congressional session ends December 2010.

In June 2009, the House of Representatives passed the American Clean Energy and Security Act of 2009 (H.R. 2454). The bill included a GHG cap-and-trade program that encompassed most large industrial sectors (including power plants), and included emission caps that would reduce aggregate GHG emissions to 3% below their 2005 levels in 2012; 17% below 2005 levels by 2020; 42% below 2005 levels by 2030, and 83% below 2005 levels by 2050. The bill also included provisions related to a federal renewable electricity and efficiency standard, carbon capture and storage technology development, performance standards for new coal-fired power plants, R&D support for electric vehicles, and support for deployment of smart grid advancement. The Senate has not, however, produced a companion bill. Several senate bills were considered in 2010, including the American Clean Energy Leadership Act (S.1462) and the American Power Act (S.1733). The American Clean Energy Leadership Act (sponsored by Senator Bingaman) sought to accelerate the introduction of new clean energy technologies and increase energy efficiency, but did not set a price on carbon and did not have quantifiable reductions in GHG emissions. The American Power Act (sponsored by Senators Kerry and Lieberman) sought to achieve aggregate GHG emission reductions of 20% below 2005 levels by 2020 and by 83% by 2050 through a nationwide cap-and-trade program. The bill also included provisions encouraging investments in clean energy technology and the creation of green jobs.

At present, it appears unlikely that Congress will pass GHG legislation during this congressional session. If the Senate does not act in the remaining months of 2010, both chambers must start the process from the beginning to pass new bills during the next session that begins January 2011.

7.3.4.2 Greenhouse Gas Regulations

Unless legal challenges or opposition in Congress succeed in stripping EPA of its authority to regulate GHG emissions under the Clean Air Act, EPA is expected to require major stationary sources to account for GHG emissions by early 2011. On May 13, 2010, U.S.EPA released a final rule intended to clarify how CAA permitting requirements, including the PSD program, will be applied to GHG emissions from power plants and other stationary facilities. The rule is commonly known as the "Tailoring Rule" because it adjusts the PSD threshold requirements applicable to other NSR-regulated pollutants to make them appropriate for GHG emissions.

The Tailoring Rule applies to six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Because some GHGs have greater potential to effect global warming than others, the rule expresses GHG emission thresholds in "carbon dioxide equivalents" or "CO2e." The CO2e metric translates emissions of gases other than CO_2 into the CO_2 equivalent based on the climate change potential of each gas. Total GHG emissions are calculated by summing the CO2e emissions of all six regulated GHGs.

The Tailoring Rule establishes two initial steps for phasing in regulation of GHGs:

- Step 1 (January 2, 2011, through June 30, 2011):
  - — GHGs must be addressed in PSD preconstruction permits for new or modified facilities that require a PSD permit based on their emissions of other regulated pollutants (SO_2, PM, etc.) and that increase net GHG emissions by at least 75,000 tons per year CO2e.
  - — GHGs must be addressed in Title V operating permits for all facilities that require a Title V permit based on their emissions of other regulated pollutants.
- Step 2 (July 1, 2011, through June 30, 2013):
  - — GHGs must be addressed in PSD preconstruction permits for new facilities that have the potential to emit at least 100,000 tons per year CO2e, even if they would not require a PSD permit based on their emissions of other regulated pollutants.
  - — GHGs must be addressed in PSD preconstruction permits for modifications of existing facilities that increase net GHG emissions by at least 75,000 tons per year CO2e, even if they would not require a PSD permit based on their emissions of other regulated pollutants.
  - — GHGs must be addressed in Title V operating permits for all facilities that have the potential to emit at least 100,000 tons per year CO2e, even if they would not require a Title V permit based on their emissions of other regulated pollutants.

Most power plants are already required to have a Title V Operating Permit based on emissions of other regulated pollutants, and have the potential to emit considerably more than 100,000 tons per year CO2e. Therefore, the facility will need to modify its existing Title V Operating Permit to address GHG emissions; however, this regulatory requirement is not part of the AQCS project.

7.3.5 Coal Combustion Residue Regulations

On May 4, 2010, the U.S. EPA proposed alternative approaches to regulate the disposal of coal combustion residuals (CCRs), including both ash and flue gas desulfurization wastes, generated by electric utilities and independent power producers. Beneficial use of CCRs in products such as concrete or wallboard would be not regulated under the proposal. Placement of CCRs as fill in quarries or gravel pits would be considered disposal and would be regulated, but placement in coal mine voids would not.

The proposal requests comments on two primary alternatives: one would regulate CCRs as "special wastes" under the hazardous waste provisions of Subtitle C of the Resource Conservation and Recovery Act (RCRA); the other would regulate CCRs under the non-hazardous waste provisions of RCRA Subtitle D. An important difference between the two is that the Subtitle C approach would regulate CCRs from the point of generation through the point of final disposal. This would include stringent requirements for facilities that generate, transport, store, treat, and dispose of CCRs. The Subtitle D approach, in contrast, would regulate only the disposal of CCRs. However, the disposal requirements of the two approaches have many similarities, including standards for siting, liners, groundwater monitoring, corrective action for releases, closure of disposal units, and post-closure care.

Other significant differences and similarities are summarized below:

- Effective Dates: Under Subtitle C, the effective date of the requirements would be variable, because each state would have to develop and promulgate its own implementing regulations. According to EPA, this process could take two years or more. Under Subtitle D, the proposed federal standards would take effect within 180 days after promulgation of the final rule.
- Enforcement: Subtitle C would allow for enforcement by EPA and state agencies, while Subtitle D would not be enforced by EPA. States could enforce their Subtitle D regulations, and citizens could file lawsuits against offending facilities.
- Permitting: Under Subtitle C, regulated facilities would be required to obtain permits for the units in which CCRs are disposed, treated, and stored. Under Subtitle D, there would be no federal permitting requirements, but states would be free to require permits under their own regulations.

- Existing Surface Impoundments: Under Subtitle C, surface impoundments constructed before the rule is finalized must either remove solids and retrofit the impoundment with a composite liner within five years of the effective date, or stop receiving CCRs within five years and then close the unit within two years thereafter. Under Subtitle D, existing surface impoundments must remove solids and retrofit with a composite liner, or stop receiving CCRs and close the unit within five years of the effective date.
- Existing Landfills: Under either Subtitle C or Subtitle D, landfills built before the rule is finalized are not required to retrofit with a new liner or leachate collection system. However, under either approach, an existing landfill must comply with groundwater monitoring requirements.
- New Surface Impoundments: Under either Subtitle C or Subtitle D, surface impoundments constructed after the rule is finalized are required to meet a new set of technological requirements specific to CCRs. These requirements include a composite liner and a leachate collection and removal system. Additionally, under Subtitle C, CCRs are subject to treatment requirements that EPA has stated are intended to phase out the use of new surface impoundments.
- New Landfills: Under either Subtitle C or Subtitle D, new landfills and lateral expansions of existing landfills must meet technological requirements that include composite liners, leachate collection and removal systems, and groundwater monitoring.

As stated above, the proposal does not intend to regulate the beneficial use of CCRs. However, industry representatives have raised concerns that the Subtitle C approach could have a detrimental effect on beneficial use, because of the permitting and technical requirements that might apply to the storage and transportation of CCRs before they are used. Additionally, the proposal requests comments on possible changes to the definition of beneficial use, intended to clarify when the use of CCRs constitutes an exempt beneficial use. Specifically, EPA has proposed to consider the following factors in deciding whether a use is beneficial: 1) the CCR used must provide a functional benefit; 2) the CCR used must substitute for the use of a natural material, thereby conserving a natural resource; and 3) CCRs would be expected to meet any applicable product specifications, regulatory standards, or relevant agricultural standards. EPA has not published an expected date for finalizing the rule after comments are considered.

As discussed above, the facility has an existing solid waste disposal system permitted to accept CCRs. Based on a review of the proposed CCR regulations, it does not appear that the proposed regulations would have a significant impact on the design or operation of the existing solid waste disposal facility if EPA chooses to regulate CCRs under the non-hazardous waste provisions of RCRA Subtitle D. However, regulating CCR as "special wastes" under the hazardous waste provisions of Subtitle C of RCRA could have a significant impact on the design and operation of the facility. OTP should continue to monitor the EPA's CCR rulemaking efforts.

8. NEXT STEPS

Items recommended as the next steps prior to detailed design are summarized below.

Development of a detailed procurement plan is an important next step. This plan will identify the contracting approach, number of contracts, long lead time equipment, and the division of responsibility for each contract. Additionally, the schedule can be developed in more detail and the cash flow formalized.

Conceptual engineering on the AQCS retrofit project should be initiated to refine items from the study and reduce risk on the cost estimate. This conceptual engineering should be initiated in 2010 and 2011 and should include:

- Evaluate a more typical heat input for equipment sizing.
- Evaluate cost-adder to operate the SCR up to 830°F versus boiler retrofits. [TRADE SECRET DATA BEGINS
- Revisit SCR reagent study based on SCR inlet NO$_X$.TRADE SECRET DATA ENDS]
- Federal, state, and local permit evaluations.
- Construction tie-in plans with diagrams, crane positions, and detailed outage schedules.
- Conceptual engineering of the auxiliary power supply system, including refinement of the single line, detailed evaluation of the auxiliary power supply system, and others.
- Investigations of the underground utilities and subsurface investigation.
- Flow model using mathematical model for the air preheater outlet duct and other areas.
- Layout and utility relocations.
- Piping and instrumentation diagrams to be prepared to define interconnections with existing plant systems.