**COMMONWEALTH OF KENTUCKY**

**BEFORE THE PUBLIC SERVICE COMMISSION**

**In the Matter of:**

| | | |
|---|---|---|
| **THE APPLICATION OF LOUISVILLE GAS AND ELECTRIC COMPANY TO MODIFY ITS CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY AS TO THE MILL CREEK UNIT 3 FLUE-GAS DESULFURIZATION UNIT** | **)<br>)<br>)<br>)<br>)** | **CASE NO. 2012-00469** |

<u>**APPLICATION**</u>

Louisville Gas and Electric Company ("LG&E"), pursuant to KRS 278.020(1), KRS 278.183, and 807 KAR 5:001, Sections 8 and 9, hereby petitions the Kentucky Public Service Commission ("Commission") by application to issue an order modifying the Certificate of Public Convenience and Necessity granted by the Commission in Case No. 2011-00162 to permit LG&E to construct a new wet flue gas desulfurization system ("WFGD") to serve Unit 3 at the Mill Creek Generating Station instead of rehabilitating the existing WFGD at Unit 4.

LG&E consulted with all of the interveners in Case No. 2011-00162 concerning this proposal. The Attorney General, the Kentucky Industrial Utility Customers, Inc., The Kroger Company, Department of Defense and Other Federal Executive Agencies, and the Metropolitan Housing Coalition have authorized LG&E to state that they do not object to the proposal in this Application.

In support of this Application, LG&E states as follows:

1. <u>Address</u>: The applicant's full name and post office address is: Louisville Gas and Electric Company, 220 West Main Street, Post Office Box 32010, Louisville, Kentucky 40202.

2. <u>Articles of Incorporation</u>: A certified copy of LG&E's Articles of Incorporation are on file with the Commission in Case No. 2010-00204, *In the Matter of: Joint Application of*

*PPL Corporation, E.ON AG, E.ON U.S. Investments Corp., E.ON U.S. LLC, Louisville Gas and Electric Company, and Kentucky Utilities Company for Approval of an Acquisition of Ownership and Control of Utilities*, filed on May 28, 2010, and is incorporated by reference herein pursuant to 807 KAR 5:001, Section 8(3).

3. LG&E is a public utility, as defined in KRS 278.010(3)(a), engaged in the electric and gas business. LG&E generates and purchases electricity, and distributes and sells electricity at retail in Jefferson County and portions of Bullitt, Hardin, Henry, Meade, Oldham, Shelby, Spencer, and Trimble Counties. LG&E also purchases, stores, and transports natural gas and distributes and sells natural gas at retail in Jefferson County and portions of Barren, Bullitt, Green, Hardin, Hart, Henry, Larue, Marion, Meade, Metcalfe, Nelson, Oldham, Shelby, Spencer, Trimble, and Washington Counties.

**<u>Background of the Certificates of Public Convenience and Necessity Awarded in Case No. 2011-00162 for the Mill Creek Units</u>**

4. In Case No. 2011-00162, *In the Matter of: Application of Louisville Gas and Electric Company for Certificates of Public Convenience and Necessity and Approval of Its 2011 Compliance Plan for Recovery by Environmental Surcharge*, LG&E sought the Commission's approval of certain Certificates of Public Convenience and Necessity ("Certificates"), which included Certificates for projects related to its Mill Creek generating station.

5. In its Final Order in Case No. 2011-00162, the Commission granted Certificates for LG&E to: build two WFGD units (one to serve both Mill Creek Units 1 and 2, another to serve Mill Creek Unit 4); to tie Mill Creek 3 into the existing (but rehabilitated) Mill Creek Unit 4 WFGD, and then to remove the existing WFGDs on Mill Creek Units 1, 2, and 3. These new and rehabilitated facilities continue to be needed to comply with the one-hour $SO_2$ National

Ambient Air Quality Standard ("NAAQS") and the Mercury and Toxic Air Standards ("MATS") Rule (formerly known as the Hazardous Air Pollutants ("HAPs") Rule).[1]

**Request to Modify the Existing Certificate of Public Convenience and Necessity for the Existing Unit 4 WFGD**

6. The 2010 Black & Veatch Study, which LG&E utilized to develop its 2011 Environmental Compliance Plan, recommended new WFGDs for all units at Mill Creek, including Unit 3. At the time LG&E filed its application in Case No. 2011-00162, based on preliminary information it believed a viable compliance option and a more cost effective solution would be to rehabilitate the existing WFGD at Unit 4, and therefore did not include a new Unit 3 WFGD as part of its Plan. Instead, LG&E sought and obtained approval to rehabilitate the existing WFGD at Unit 4, then tie Unit 3 into the rehabilitated facility.

7. Statement of Need (807 KAR 5:001 § 9(2)(a)): The reasons supporting LG&E's need to provide rehabilitated or new WFGD facilities for Mill Creek Unit 3 remain unchanged from LG&E's application in Case No. 2011-00162, as LG&E must comply with all applicable environmental rules and regulations. In particular, LG&E requires rehabilitated or new WFGD facilities for Mill Creek Unit 3 to comply with the impacts of the tightened National Ambient Air Quality Standards ("NAAQS") 1-hour SO2 requirement that will establish a lower stack emission rate from all Mill Creek units by 2017 as a part of the State Implementation Plan ("SIP") for the non-attainment status of Jefferson County, Kentucky. This requirement is independent of the Cross-State Air Pollution Rule ("CSAPR"), which the U.S. Court of Appeals for the D.C. Circuit vacated on August 21, 2012.[2] In this application, LG&E seeks only an

[1] With the issuance of the final standards on December 16, 2011, the US EPA began using the phrase Mercury and Toxic Air Standards ("MATS") Rule instead of HAPs. *See* 77 FR 9304, Feb. 16, 2012 (available at http://www.epa.gov/mats/actions.html).

[2] Order available at http://www.scribd.com/doc/103461023/EME-Homer-City-Generation-v-EPA-No-11-1302-Striking-Down-EPA-Transport-Rule. The predecessor rule to CSAPR, the Clean Air Interstate Rule ("CAIR"),

amendment to its Certificate authority in order to utilize a more cost effective manner of compliance.

There are no utilities, corporations, or persons with whom the proposed new construction is likely to compete.

8. Permits or Franchises (807 KAR 5:001 § 9(2)(b)): LG&E submitted to the Louisville Metro Air Pollution Control District ("LMAPCD") requests to construct the proposed Mill Creek WFGD in June 2011. The LMAPCD issued a draft construction permit in May 2012, and issued a final air permit on June 18, 2012, with an effective date of June 15, 2012, allowing construction to commence. LG&E will also seek any additional applicable construction permits and an updated Title V operating permit.

9. Description of Proposed Construction (807 KAR 5:001 § 9(2)(c)): Since the Commission issued the Certificates in Case No. 2011-00162, LG&E, in accordance with prudent practices and competitive bid policies, has proceeded with further engineering assessment beyond the conceptual stages, updated, monitored, and re-evaluated the costs associated with the WFGDs. As part of this ongoing evaluation, LG&E has determined that the total current estimated costs associated with rehabilitating the existing WFGD at Mill Creek Unit 4 for an additional twenty-plus-year life, which, through a tie-in, would serve Mill Creek Unit 3, exceed the costs of constructing a new WFGD to serve Mill Creek Unit 3. To complete the environmental compliance projects in the most cost effective manner, LG&E is requesting the Commission modify its Certificate with regard to rehabilitating the existing WFGD at Mill Creek Unit 4 and instead permit LG&E to construct a new WFGD to serve Unit 3. LG&E is also proposing to demolish the existing WFGD at Unit 4 to provide space for the new WFGD.

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remains in effect. *Id.* at 60 ("EPA must continue administering CAIR pending the promulgation of a valid replacement.").

10. When LG&E proposed rehabilitating the existing WFGD at Unit 4, it had preliminary information from Babcock Power Environmental Inc. ("Babcock") regarding the costs to increase the WFGD $SO_2$-removal efficiency via rehabilitation and replacement of equipment and components of the existing WFGD based upon an engineering study completed in February 2011. Those costs were combined with structural steel estimates provided by Black and Veatch in their Phase II report and thought to be the most cost-effective approach at the time. While Case No. 2011-00162 was proceeding, LG&E began receiving bids for the projects it had proposed. As part of that process, on December 2, 2011, Babcock presented to LG&E the Mill Creek Unit 4 WFGD Upgrade Study developed after a detailed internal component inspection during an outage of Unit 4 and its WFGD, a copy of which is attached to the testimony of John N. Voyles as Exhibit JNV-1. That report identified more significant levels of repair were necessary beyond the components of the WFGD that affected sulfur dioxide removal performance that the initial conceptual study contemplated. After this later report, a comprehensive inspection and estimate were developed to identify all existing components of the existing Unit 4 WFGD that would need refurbished or replaced to provide a twenty-plus year life as that of a new WFGD. The rehabilitation cost estimates were revised to reflect these process improvement and infrastructure modification determinations. Based upon further engineering assessments and revised rehabilitation costs, which are approximately $161 million, LG&E began evaluating the cost of building a new WFGD instead of rehabilitating the existing Unit 4 WFGD. LG&E contacted Zachry Holdings, Inc. ("Zachry") in July 2012 to obtain an estimate of the total expected construction costs to construct a new WFGD for Unit 3 similar to what was contracted to them to construct for Units 4 and the combined WFGD for Units 1 and 2, as well as the cost to demolish the existing WFGD at Unit 4. Zachry is performing the majority of the

other environmental compliance projects at Mill Creek. As set forth in Exhibit JNV-2, on September 11, 2012, Zachry provided its estimated cost to complete these projects, which is approximately $132 million, roughly $29 million less than the updated cost from Babcock to rehabilitate the existing WFGD at Mill Creek Unit 4. This estimate is consistent with the cost for the other two WFGDs which Zachry is contracted for at Mill Creek, both of which are significantly lower than the estimated cost in the 2011 filing. The refurbished and new WFGD option values represent the installed cost with a Level I engineering accuracy.

11. Area Maps (807 KAR 5:001 § 9(2)(d)): The required area maps showing the location of the proposed construction for the new WFGD is attached as Application Exhibit 1.

12. Financing Plans (807 KAR 5:001 § 9(2)(e)): LG&E proposes to finance the proposed new WFGD for Mill Creek Unit 3 in the manner described in the testimony of Lonnie E. Bellar. LG&E does not propose any changes to the method of financing the construction from that presented in Case No. 2011-00162.

13. Estimated Cost of Operation (807 KAR 5:001 § 9(2)(f)): LG&E closely examined, by line item, the estimates Babcock and Zachry provided, in order to assess its overall confidence in the expected accuracy of the costs. An updated analysis of the retire/retrofit decision made in the 2011 Environmental Compliance Plan utilizing these costs was performed and a copy of the document LG&E prepared that illustrates this analysis is included in Exhibit JNV-3. After completing this review, LG&E determined that constructing a new WFGD for Unit 3 and demolishing the existing WFGD at Unit 4 was a more cost-effective method of compliance if an amendment to its Certificate could be obtained expeditiously from the Commission. The estimated annual cost of operating the new WFGD is also set forth in Exhibit JNV-3.

14. Although the total estimated capital cost for all of the compliance projects on Mill Creek Unit 3 has increased from the 2011 Environmental Compliance Plan estimate by approximately $21 million, the anticipated fixed and variable operating expenses have decreased largely because of the lower-than-expected cost of operating the baghouse, including the lower cost of sorbent injection for mercury and sulfuric acid. When the 2011 Environmental Compliance Plan was developed, LG&E based its projected baghouse operating costs on the Black &Veatch studies for high-sulfur coal applications and its limited experience with operating a similar facility at Trimble County Unit 2. As its experience has developed, LG&E has further revised the projected costs, resulting in a reduction in operating expenses. As such, the decision to construct a new WFGD, even at a higher capital cost than contained in the 2011 Environmental Compliance Plan, does not affect the fiscal prudency of LG&E's decision to retrofit, instead of retire, Mill Creek Unit 3.

15. In fact, the Net Present Value of Revenue Requirements ("NPVRR") savings associated with retrofitting Mill Creek Unit 3, which were initially projected to be $756 million, can be maximized even if LG&E rehabilitates the existing WFGD at Mill Creek Unit 4. To maximize the NPVRR savings to customers, however, approval to modify the Certificate to permit LG&E to construct a new WFGD must be obtained by January 18, 2013. This should allow LG&E to complete the new WFGD by April 2016, which is the date it must be in compliance with the MATS Rule (with a one year extension being granted). Under this scenario, the NPVRR savings to retrofit Mill Creek Unit 3 are $820 million, which is a $64 million increase (eight percent) over the projected savings in the 2011 Environmental Compliance Plan. Under this scenario, Commission approval as requested should ensure construction can be commenced and be completed in a timely manner. If Commission approval to modify LG&E's

Certificate is not obtained as requested, constructing a new WFGD will not meet the compliance deadline and will no longer maximize NPVRR savings; instead based on this analysis, rehabilitating the existing WFGD at Unit 4 as planned would be more cost effective to customers, as the NPVRR savings for rehabilitating the WFGD results in $794 million in savings.

16. If LG&E constructs a new WFGD, but is unable to complete construction prior to the April 2016 compliance date or obtain a second year extension of the MATS Rule compliance date, the savings steadily decline because LG&E will no longer be able to operate Mill Creek Unit 3 and thus will have to purchase power from a third party to replace its capacity.[3] For example, if the new WFGD is not completed until October 2016, a six-month delay, the NPVRR savings decline to $782 million, based on estimated costs to purchase power from a third party. These analyses demonstrate there is a short window of opportunity for LG&E to maximize NPVRR savings under the new construction option.

17. LG&E supports its request for a Certificate modification with the verified testimony and exhibits of the following persons:

- Lonnie E. Bellar, Vice President – State Regulation and Rates
- John N. Voyles, Vice President – Transmission and Generation Services

18. Prior to filing this Application, LG&E discussed its plan to seek a modification of the Certificate in the manner herein described with the intervenors to Case No. 2011-00162. The Office of the Attorney General, Utility Rate Intervention Division; Kentucky Industrial Utility Customers, Inc.; The Kroger Co.; Metropolitan Housing Coalition; and the United States Department of Defense and Other Federal Executive Agencies have authorized counsel for

[3] It is not clear that LG&E will be able to obtain a second year extension.

LG&E to represent in this Application that they have no objection to LG&E's Application or the relief requested herein.

**WHEREFORE,** Louisville Gas and Electric Company respectfully asks the Commission to enter an order by January 18, 2013 modifying the Certificate awarded in Case No. 2011-00162 to permit it to construct a new WFGD to serve Mill Creek Unit 3.

Dated: October 25, 2012

Respectfully submitted,

______________________________________


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W. Duncan Crosby III
Monica H. Braun
Stoll Keenon Ogden PLLC
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220 West Main Street
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*Counsel for Louisville Gas and Electric Company*

**CERTIFICATE OF COMPLIANCE**

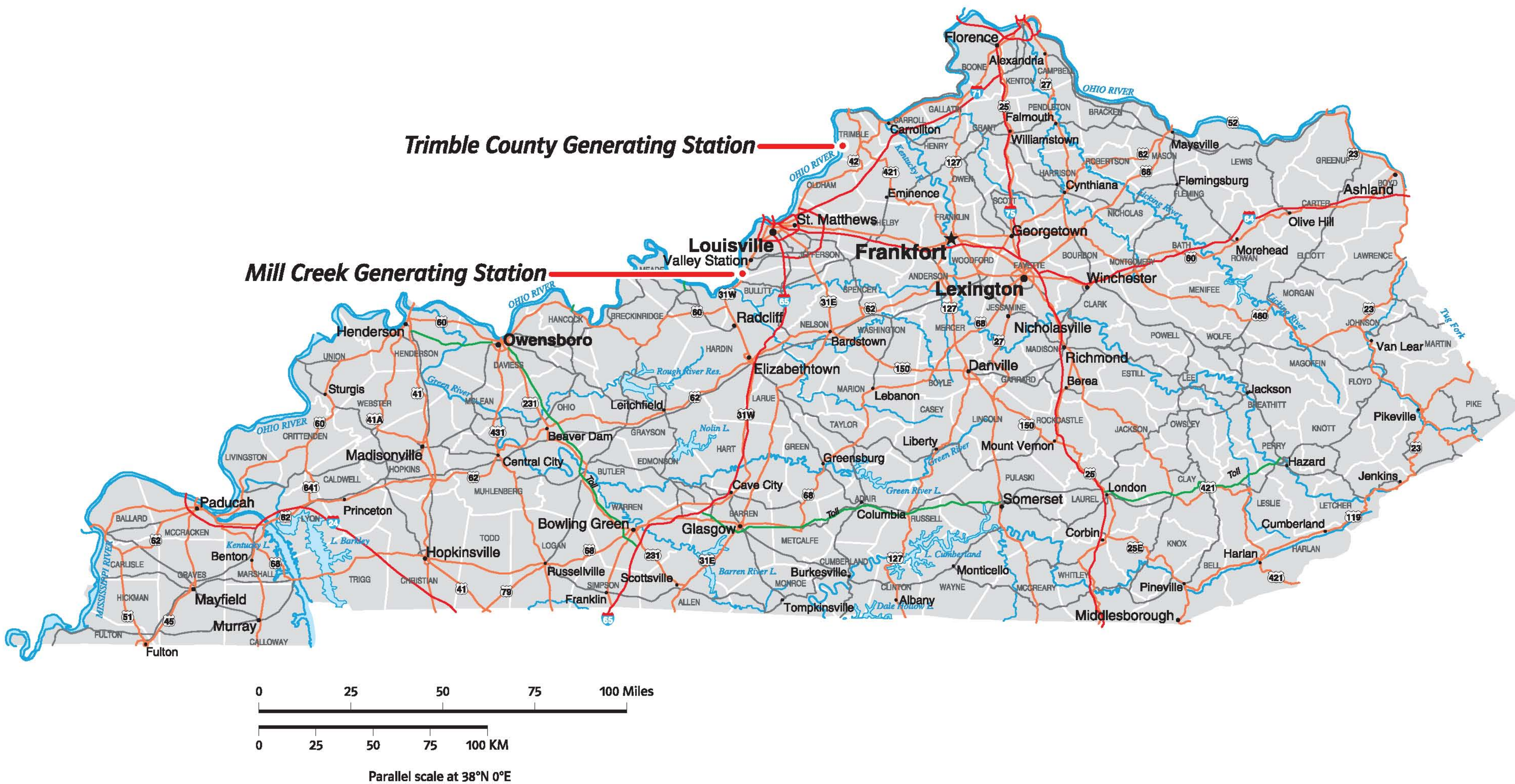
In accordance with Ordering Paragraph No. 10 of the Commission's October 25, 2012 Order, this is to certify that Louisville Gas and Electric Company's October 25, 2012 electronic filing is a true and accurate copy of the documents being filed in paper medium; that the electronic filing has been transmitted to the Commission on October 25, 2012; that there are currently no parties that the Commission has excused from participation by electronic means in this proceeding; and that an original and one copy of the filing will be hand-delivered to the Commission on October 26, 2012. There are currently no other parties to this proceeding.

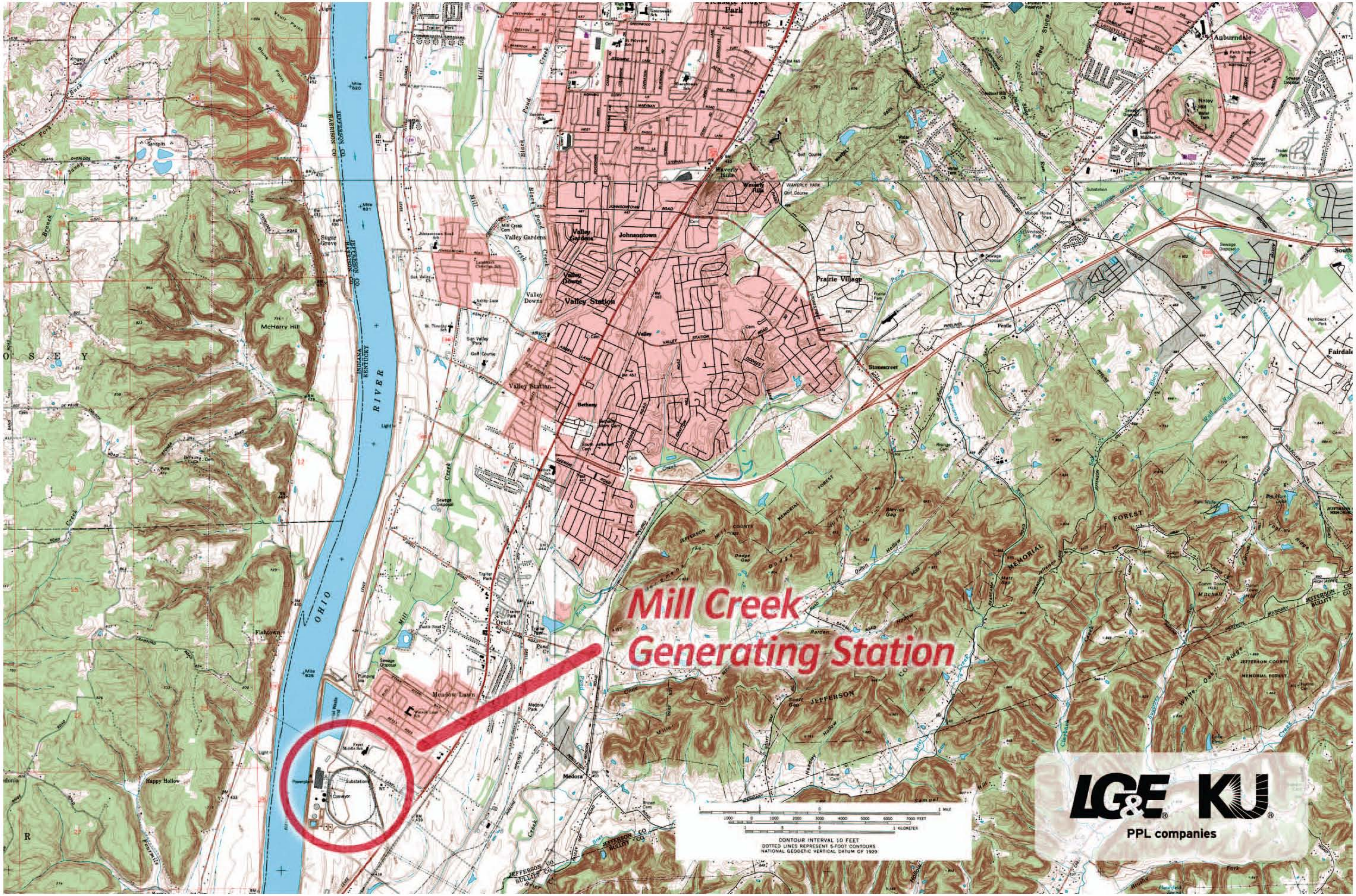
*Counsel for Louisville Gas and Electric Company*

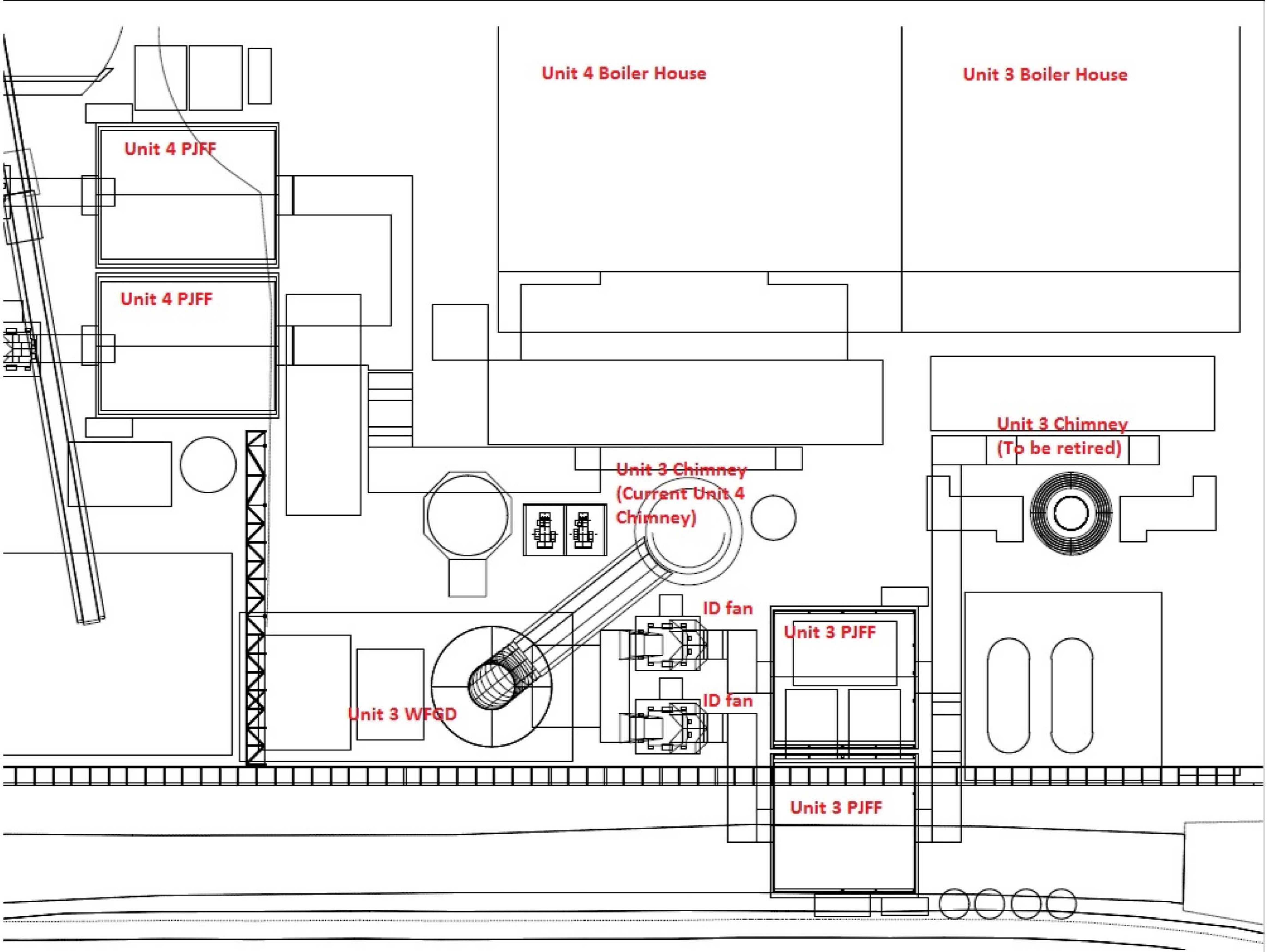
# Application Exhibit 1

# Mill Creek Maps

PPL companies




Mill Creek
Generating Station
OHIO RIVER
Valley Station
Johnsontown
Prairie Village
Fairdale
Auburndale
McHarry Hill
Meadow Lawn
Fishtown
Happy Hollow
Medora
Bethany
CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
LG&E KU
PPL companies



Unit 4 Boiler House
Unit 3 Boiler House
Unit 4 PJFF
Unit 4 PJFF
Unit 3 Chimney
(To be retired)
Unit 3 Chimney
(Current Unit 4
Chimney)
ID fan
ID fan
Unit 3 PJFF
Unit 3 WFGD
Unit 3 PJFF

**COMMONWEALTH OF KENTUCKY**

**BEFORE THE PUBLIC SERVICE COMMISSION**

**In the Matter of:**

| | | |
|---|---|---|
| **THE APPLICATION OF LOUISVILLE GAS AND ELECTRIC COMPANY TO MODIFY ITS CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY AS TO THE MILL CREEK UNIT 3 FLUE-GAS DESULFURIZATION UNIT** | ) ) ) ) ) | **CASE NO. 2012-00469** |

**TESTIMONY OF**
**LONNIE E. BELLAR**
**VICE PRESIDENT, STATE REGULATION AND RATES**
**LOUISVILLE GAS AND ELECTRIC COMPANY**

**Filed: October 25, 2012**

**Q. Please state your name, position and business address.**

A. My name is Lonnie E. Bellar. I am the Vice President, State Regulation and Rates for Kentucky Utilities Company ("KU") and Louisville Gas and Electric Company ("LG&E"). I am employed by LG&E and KU Services Company, which provides services to KU and LG&E (collectively "the Companies"). My business address is 220 West Main Street, Louisville, Kentucky 40202. A complete statement of my education and work experience is attached to this testimony as Appendix A.

**Q. Have you previously testified before the Kentucky Public Service Commission?**

A. Yes. I have testified before the Commission numerous times, including the Companies' most recent base rate cases.[1] Also, I testified in the Companies' 2011 Environmental Compliance Plan cases.[2]

**Q. What is the purpose of your testimony?**

A. The purpose of my testimony is to describe the savings customers will experience if the Commission modifies the Certificate of Public Convenience and Necessity ("Certificate") the Commission issued in LG&E's 2011 Environmental Compliance Plan case. Specifically, LG&E asks the Commission to modify the Certificate related to Mill Creek Unit 3 to permit LG&E to build a new wet flue-gas-desulfurization system ("WFGD") for Mill Creek Unit 3 rather than rehabilitating the existing Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3.

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[1]*In the Matter of: Application of Kentucky Utilities Company for an Adjustment of Its Base Rates*, Case No. 2012-00221; *In the Matter of: Application of Louisville Gas and Electric Company for an Adjustment of Its Electric and Gas Base Rates, a Certificate of Public Convenience and Necessity, Approval of Ownership of Gas Service Lines and Risers, and a Gas Line Surcharge*, Case No. 2012-00222.

[2]Case Nos. 2011-00161 (KU 2011 Environmental Compliance Plan), 2011-00162 (LG&E 2011 Environmental Compliance Plan).

I will also describe the views of those interveners from LG&E's 2011 Environmental Compliance Plan case who have authorized LG&E to report their position to the Commission.

**Q. How will building a new WFGD for Mill Creek Unit 3 be more economical than refurbishing the existing Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3?**

A. As John N. Voyles explains in greater detail in his testimony, since the Commission issued its final order in LG&E's 2011 Environmental Compliance Plan case, LG&E has obtained further engineering studies and cost estimates showing that rehabilitating the existing Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3 will be significantly more expensive than initially estimated: $161 million in estimated capital cost rather than $74 million. Building a new WFGD for Mill Creek Unit 3 will have an estimated capital cost of $132 million.

**Q. If the WFGD-related estimated capital costs for Mill Creek Unit 3 are higher than LG&E expected, is it still true that building environmental-compliance equipment for the unit is more economical than retiring and replacing it?**

A. Yes. As Mr. Voyles explains more fully in his testimony, other reduced estimated capital costs and lower anticipated operating costs have more than offset the effect of the higher estimated WFGD capital cost. In fact, the Net Present Value of Revenue Requirement ("NPVRR") savings associated with retrofitting Mill Creek Unit 3 rather than retiring it, which were initially projected to be $756 million, can be maximized even if LG&E rehabilitates the existing WFGD at Mill Creek Unit 4. But to maximize the NPVRR savings to customers as shown in the table below, LG&E must receive approval to modify the Mill Creek Unit 3 Certificate by January 18, 2013:

**Table 1: NPVRR Savings of WFGD Options for Mill Creek Unit 3**

| | 2011 ECR Plan | Updated Rehab | New FGD | New FGD with Delay |
|---|---|---|---|---|
| *Retrofit Savings (NPVRR, 2011 $M)* | *756* | *794* | *820* | *782* |

Timely approval should allow LG&E to complete the new WFGD by April 2016, which is the date it must be in compliance with the Mercury and Air Toxics Rule ("MATS Rule") (with a one year extension being granted). If Commission approval to modify LG&E's Certificate is not obtained as requested, constructing a new WFGD will not meet the compliance deadline and will no longer maximize NPVRR savings; instead, based on this analysis rehabilitating the existing WFGD at Unit 4 as planned would be more cost effective to customers, as the NPVRR savings for rehabilitating the WFGD results in $794 million in savings.

**Q. How does LG&E plan to finance construction of the new Mill Creek Unit 3 WFGD?**

A. LG&E expects to finance the costs of the new facility with a combination of new debt and equity. The mix of debt and equity used to finance the project will be determined so as to allow LG&E to maintain its strong investment-grade credit rating. To the extent that tax-exempt financing may be available for these projects, the Companies anticipate using such opportunities to the extent that they are reasonably cost-effective. This is the same financing approach LG&E proposed to finance rehabilitating the Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3 in LG&E's 2011 Environmental Compliance Plan case.

**Q. Has LG&E communicated with the interveners in LG&E's 2011 Environmental Compliance Plan case concerning this proposal?**

A. Yes. LG&E reached out to all of the interveners in LG&E's 2011 Environmental Compliance Plan case concerning this proposal, inviting them to attend an informal conference at the Commission's offices on October 10, 2012. LG&E subsequently followed up with the interveners to ask about their position on LG&E's proposal to build a new WFGD for Mill Creek Unit 3. The Attorney General, the Kentucky Industrial Utility Customers, Inc., The Kroger Company, the Department of Defense and Other Federal Agencies, and the Metropolitan Housing Coalition informed LG&E that they do not object to the proposal and authorized LG&E to make the Commission aware of the same.

**Q. What is your recommendation to the Commission?**

A. I recommend that the Commission issue an order by January 18, 2013 modifying the Certificate the Commission issued in LG&E's 2011 Environmental Compliance Plan case related to Mill Creek Unit 3 to permit LG&E to build a new WFGD to serve the unit and to demolish rather than rehabilitate the existing Mill Creek Unit 4 WFGD. This will result in lower costs for customers, less $SO_2$ emissions (as Mr. Voyles describes in his testimony), and is not opposed by most of the interveners to LG&E's 2011 Environmental Compliance Plan case.

**Q. Does this conclude your testimony?**

A. Yes, it does.

**VERIFICATION**

**COMMONWEALTH OF KENTUCKY )**
**) SS:**
**COUNTY OF JEFFERSON )**

The undersigned, **Lonnie E. Bellar**, being duly sworn, deposes and says that he is Vice President, State Regulation and Rates for Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the foregoing testimony, and that the answers contained therein are true and correct to the best of his information, knowledge and belief.

Lonnie E. Bellar

**Lonnie E. Bellar**

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 24th day of October 2012.

Sheri L. Gardner (SEAL)
Notary Public

My Commission Expires:

SHERI L. GARDNER
Notary Public, State at Large, KY
My commission expires Dec. 24, 2013

## APPENDIX A

**Lonnie E. Bellar**
LG&E and KU Energy LLC
220 West Main Street
Louisville, Kentucky 40202

**Education**

Bachelors in Electrical Engineering;
University of Kentucky, May 1987
Bachelors in Engineering Arts;
Georgetown College, May 1987
E.ON Academy, Intercultural Effectiveness Program: 2002-2003
E.ON Finance, Harvard Business School: 2003
E.ON Executive Pool: 2003-2007
E.ON Executive Program, Harvard Business School: 2006
E.ON Academy, Personal Awareness and Impact: 2006

**Professional Experience**

**E.ON U.S. LLC**

| | |
|---|---|
| Vice President, State Regulation and Rates | Aug. 2007 – Present |
| Director, Transmission | Sept. 2006 – Aug. 2007 |
| Director, Financial Planning and Controlling | April 2005 – Sept. 2006 |
| General Manager, Cane Run, Ohio Falls and Combustion Turbines | Feb. 2003 – April 2005 |
| Director, Generation Services | Feb. 2000 – Feb. 2003 |
| Manager, Generation Systems Planning | Sept. 1998 – Feb. 2000 |
| Group Leader, Generation Planning and Sales Support | May 1998 – Sept. 1998 |

**Kentucky Utilities Company**

| | |
|---|---|
| Manager, Generation Planning | Sept. 1995 – May 1998 |
| Supervisor, Generation Planning | Jan. 1993 – Sept. 1995 |
| Technical Engineer I, II and Senior, Generation System Planning | May 1987 – Jan. 1993 |

**Professional Memberships**

IEEE

**Civic Activities**

E.ON U.S. Power of One Co-Chair – 2007
Louisville Science Center – Board of Directors – 2008 – Present
Chairman of Louisville Science Center Board beginning June 2012
Metro United Way Campaign – 2008
UK College of Engineering Advisory Board – 2009 – Present

**COMMONWEALTH OF KENTUCKY**

**BEFORE THE PUBLIC SERVICE COMMISSION**

**In the Matter of:**

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|---|---|---|
| **THE APPLICATION OF LOUISVILLE GAS** | ) | |
| **AND ELECTRIC COMPANY TO MODIFY ITS** | ) | |
| **CERTIFICATE OF PUBLIC CONVENIENCE** | ) | **CASE NO. 2012-00469** |
| **AND NECESSITY AS TO THE MILL CREEK** | ) | |
| **UNIT 3 FLUE-GAS DESULFURIZATION UNIT** | ) | |

**TESTIMONY OF**
**JOHN N. VOYLES, JR.**
**VICE PRESIDENT, TRANSMISSION AND GENERATION SERVICES**
**LOUISVILLE GAS AND ELECTRIC COMPANY**

**Filed: October 25, 2012**

**Q. Please state your name, position and business address.**

A. My name is John N. Voyles, Jr. I am the Vice President of Transmission and Generation Services for Kentucky Utilities Company ("KU") and Louisville Gas and Electric Company ("LG&E"), and I am an employee of LG&E and KU Services Company, which provides services to LG&E and KU (collectively "the Companies"). My business address is 220 West Main Street, Louisville, Kentucky 40202. A complete statement of my education and work experience is attached to this testimony as Appendix A.

**Q. Have you previously testified before this Commission?**

A. Yes. I testified in the Companies' 2011 and 2009 environmental compliance plan cases,[1] and I testified in a number of earlier proceedings, including LG&E's original application for recovery of its 1995 Environmental Compliance Plan.[2]

**Q. Are you sponsoring any exhibits?**

A. Yes. I am sponsoring the following exhibits:

Exhibit JNV-1: Babcock Power Environmental Inc. Mill Creek Unit 4 Upgrade Study

Exhibit JNV-2: Zachry New WFGD Estimate for Mill Creek Unit 3

Exhibit JNV-3: Update to Mill Creek 3 Retire/Retrofit Decision, October 2012

**Q. What is the purpose of your testimony?**

A. The purpose of my testimony is to describe the analysis LG&E recently undertook concerning its Commission-approved plan to rehabilitate the existing wet flue-gas-

[1] Case Nos. 2011-00161 (KU 2011 Environmental Compliance Plan), 2011-00162 (LG&E 2011 Environmental Compliance Plan), 2009-00197 (KU 2009 Environmental Compliance Plan), and 2009-00198 (LG&E 2009 Environmental Compliance Plan).

[2] *In the Matter of: The Application of Louisville Gas and Electric Company for Approval of Compliance Plan and to Assess a Surcharge Pursuant to KRS 278.183 to Recover Costs of Compliance With Environmental Requirements For Coal Combustion Wastes and By-Products*, Case No. 93-332.

desulfurization system ("WFGD") for Mill Creek Unit 4 for Mill Creek Unit 3's future use. The analysis shows (1) retrofitting Mill Creek Unit 3 with environmental controls remains a lower-cost alternative than retiring the unit, (2) building a new WFGD to serve Mill Creek Unit 3 will be lower-cost than rehabilitating the existing Mill Creek Unit 4 WFGD, and (3) delaying the construction of a new WFGD for Mill Creek Unit 3 by even six months could cause that option to become higher-cost than rehabilitating the existing Mill Creek Unit 4 WFGD. In other words, the cost-saving opportunity of building a new WFGD for Mill Creek Unit 3 is the reason LG&E requests expedited action by the Commission to approve the modification to the existing Certificate of Public Convenience and Necessity ("Certificate") the Commission issued in LG&E's 2011 Environmental Compliance Plan case. LG&E therefore asks the Commission to issue an order by January 18, 2013, granting a Certificate modification authorizing LG&E to build a new WFGD for Mill Creek Unit 3.

**Q. Why did LG&E seek a CPCN for an upgraded WFGD for Mill Creek Unit 3 in its 2011 Environmental Compliance Plan case?**

A. As I explained in my testimony in that proceeding:

> LG&E proposes to build two new FGDs (one to serve both Mill Creek Units 1 and 2, another to serve Mill Creek Unit 4), to tie Mill Creek Unit 3 into the existing (but upgraded) Mill Creek Unit 4 FGD, and then to remove the current FGDs on Mill Creek Units 1, 2, and 3. These new and upgraded facilities are necessary to comply with the 1-hour $SO_2$ NAAQS [National Ambient Air Quality Standards], under which Jefferson County is expected to be declared a non-attainment area and would require $SO_2$ emission reductions

> at Mill Creek. These projects also support compliance with the proposed reductions on the emission of $SO_2$ from the [Cross-State Air Pollution Rule ("CSAPR")].[3]

LG&E witness Gary H. Revlett further explained in his testimony the $SO_2$ NAAQS and its impact on Mill Creek:

> [T]he EPA finalized a new 1-hour $SO_2$ NAAQS in June 2010, which required state and local air pollution control agencies to develop implementation plans for any non-attainment area. Jefferson County has already begun recording $SO_2$ levels in excess of the new 1-hour NAAQS. According to the CAAA for NAAQS, the LMAPCD [Louisville Metro Air Pollution Control District] must declare the county to be in "non-attainment" of the standard, which the EPA must confirm within 1 year. After that, the LMAPCD must file, and the EPA must approve, a plan to bring the county back into attainment. Emission sources must then take actions to reduce $SO_2$ emissions consistent with the approved plan. As the largest $SO_2$ emitter in Jefferson County, the Mill Creek Station will need to reduce its $SO_2$ emissions, which has been true of all the previous $SO_2$ non-attainment plans developed by the LMAPCD.[4]

**Q. Please briefly explain the role and purpose of LMAPCD.**

A. For over sixty years, LMAPCD or its predecessors have studied and worked to improve the air quality in Jefferson County, Kentucky. In 1952, the Kentucky legislature passed KRS Chapter 77 authorizing the formation of county air pollution

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[3] *In the Matter of: Application of Louisville Gas and Electric Company for Certificates of Public Convenience and Necessity and Approval of Its 2011 Compliance Plan for Recovery by Environmental Surcharge*, Case No. 2011-00162, Testimony of John N. Voyles at 6-7 (June 1, 2011).

[4] *In the Matter of: Application of Louisville Gas and Electric Company for Certificates of Public Convenience and Necessity and Approval of Its 2011 Compliance Plan for Recovery by Environmental Surcharge*, Case No. 2011-00162, Testimony of Gary H. Revlett at 3-4 (June 1, 2011).

control districts. The same year, the Air Pollution Control District of Jefferson County was created and staffed with air quality professionals to study and improve air quality in Louisville. LMAPCD is governed by the Air Pollution Control Board, which includes seven members appointed by the Mayor of Louisville and approved by the Louisville Metro Council.

Among other things, LMAPCD, as the only local air pollution control agency in Kentucky, is responsible for developing the Jefferson County portion of the State Implementation Plan ("SIP"). In addition, LMAPCD monitors and measures throughout Jefferson County the concentration of pollutants under the NAAQS, including ozone ($O_3$), carbon monoxide (CO), sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$) and nitric oxide (NO), inhalable particulates (PM10), fine particulates (PM2.5) and lead (Pb). Most of LMAPCD's monitoring is currently conducted at seven air monitoring sites. To insure national consistency in air monitoring data, EPA requires that all sites meet certain criteria and that monitors are operated using approved procedures. LMAPCD develops and submits its network plans to EPA for review and approval.

**Q. Have portions of Jefferson County been designated by LMAPCD as non-attainment areas under the 1-hour SO2 NAAQS?**

A. Yes. In a letter dated June 2, 2011, Kentucky recommended to U.S. EPA Region 4 that all counties, except Jefferson County, be classified as attainment and Jefferson County be designated as nonattainment. Following further discussions with staff at U.S. EPA Region 4, LMAPCD performed further analysis to more precisely define the area of Jefferson County to be designated nonattainment. On December 20, 2011, Kentucky provided the results of U.S. EPA Region 4 analysis to EPA Region 4, expressed its concurrence LMAPCD's review, and requested a specific boundary for $SO_2$ nonattainment be established which includes the Mill Creek Generation Station.

**Q. What is the status of CSAPR?**

A. The U.S. Court of Appeals for the D.C. Circuit vacated CSAPR on August 21, 2012.[5] The predecessor rule to CSAPR, the Clean Air Interstate Rule ("CAIR"), remains in effect.[6]

**Q. Does a rehabilitated or new WFGD for Mill Creek Unit 3 continue to be necessary even though CSAPR has been vacated?**

A. Yes. LG&E requires rehabilitated or new WFGD facilities for Mill Creek Unit 3 to comply with the impacts of the tightened NAAQS 1-hour $SO_2$ requirement that will establish a lower stack emission rate from all Mill Creek units by 2017 as a part of the State Implementation Plan ("SIP") for the non-attainment status of Jefferson County, Kentucky. This requirement is independent of CSAPR.

**Q. Why is LG&E asking the Commission to modify the Certificate it granted LG&E concerning the WFGD to serve Mill Creek Unit 3?**

A. In LG&E's most recent Environmental Compliance Plan case, LG&E sought, and the Commission granted, Certificates related to a number of 2011 Environmental Compliance Plan projects.[7] Among the Certificates the Commission granted was one authorizing LG&E to rehabilitate the existing Mill Creek Unit 4 WFGD and to tie Mill Creek Unit 3 into it. Upgraded scrubbing ability is necessary for Mill Creek Unit 3 to comply with the impacts of the 1-hour $SO_2$ National Ambient Air Quality

[5] Order available at http://www.scribd.com/doc/103461023/EME-Homer-City-Generation-v-EPA-No-11-1302-Striking-Down-EPA-Transport-Rule.
[6] *Id.* at 60 ("EPA must continue administering CAIR pending the promulgation of a valid replacement.").
[7] *In the Matter of: Application of Louisville Gas and Electric Company for Certificates of Public Convenience and Necessity and Approval of Its 2011 Compliance Plan for Recovery by Environmental Surcharge*, Case No. 2011-00162, Order (Dec. 15, 2011).

Standard ("NAAQS"). At the time of LG&E's application and the Commission's approval, LG&E's conceptual engineering information indicated that an option of rehabilitating the existing Mill Creek Unit 4 WFGD for Mill Creek Unit 3's use would be the lowest-reasonable-cost means to achieve additional $SO_2$ reductions from Mill Creek Unit 3's flue gas.[8]

Since the Commission issued the Certificate related to Mill Creek Unit 3 in Case No. 2011-00162, LG&E, in accordance with prudent practices and competitive bid policies, has proceeded with further engineering assessment beyond the conceptual stages, updated, monitored, and re-evaluated the costs associated with the WFGDs. As part of this ongoing evaluation, LG&E has determined that the total current estimated costs associated with rehabilitating the existing WFGD at Mill Creek Unit 4 for an additional twenty-plus-year life, which, through a tie-in, would serve Mill Creek Unit 3, exceed the costs of constructing a new WFGD to serve Mill Creek Unit 3. To complete the environmental compliance projects in the most cost-effective manner, LG&E asks the Commission to modify its Certificate with regard to rehabilitating the existing WFGD at Mill Creek Unit 4 and instead permit LG&E to construct a new WFGD to serve Unit 3. LG&E is also proposing to demolish the existing WFGD at Unit 4 to provide space for the new WFGD.

**Q. Please describe in greater detail how LG&E has reached the conclusion that building a new WFGD for Mill Creek Unit 3 will be more economical than rehabilitating the existing Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3.**

A. When LG&E proposed rehabilitating the existing WFGD at Unit 4, it had preliminary information from Babcock Power Environmental Inc. ("Babcock") regarding the

[8] This compared favorably to the 2010 Black & Veatch report for constructing a new WFGD for Mill Creek Unit 3. *See* Case No. 2011-00162, Testimony of John N. Voyles Exh. JNV-2 Appx. A (June 1, 2011).

costs to increase the WFGD $SO_2$-removal efficiency via rehabilitation and replacement of equipment and components of the existing WFGD based upon an engineering study completed in February 2011. Those costs were combined with structural steel estimates provided by Black and Veatch in their Phase II report and thought to be the most cost-effective approach at the time. While Case No. 2011-00162 was proceeding, LG&E began receiving bids for the projects it had proposed. As part of that process, on December 2, 2011, Babcock presented to LG&E the Mill Creek Unit 4 WFGD Upgrade Study developed after performing detailed internal component inspection during an outage of Unit 4 and its WFGD after the filing in June 2011, a copy of which is attached as Exhibit JNV-1. That report identified more significant levels of repair were necessary beyond the components of the WFGD that affected sulfur dioxide removal performance than the initial conceptual study contemplated. After this later report, a comprehensive inspection and estimate were developed to identify all existing components of the existing Unit 4 WFGD that would need refurbished or replaced to provide a twenty-plus year life as that of a new WFGD. The rehabilitation cost estimates were revised to reflect these process improvement and infrastructure modification determinations. Based upon further engineering assessments and revised rehabilitation costs, which are approximately $161 million, LG&E began evaluating the cost of building a new WFGD instead of rehabilitating the existing Unit 4 WFGD. LG&E contacted Zachry Holdings, Inc. ("Zachry") in July 2012 to obtain an estimate of the total expected construction costs to construct a new WFGD for Unit 3 similar to what was contracted to them to construct for Units 4 and the combined WFGD for Units 1 and 2, as well as the cost to demolish the existing WFGD at Unit 4. Zachry is performing the majority of the other environmental compliance projects at Mill Creek. As set forth in Exhibit JNV-2, on September 11, 2012, Zachry provided its estimated cost to complete these projects, which is approximately $132 million, roughly $29 million less than the updated cost from Babcock to rehabilitate the existing WFGD at Mill Creek Unit 4. This estimate is consistent with the cost for the other two WFGDs which Zachry is contracted for at Mill Creek, both of which are significantly lower than the estimated cost in the 2011 filing. The refurbished and new WFGD option values represent the installed cost with a Level I engineering accuracy.

LG&E closely examined, by line item, the estimates Babcock and Zachry provided, to assess its overall confidence in the expected accuracy of the costs. An updated analysis of the retire/retrofit decision made in the 2011 Environmental Compliance Plan utilizing these costs was performed and a copy of the document LG&E prepared that illustrates this analysis is attached as Exhibit JNV-3. After completing this review, LG&E determined that constructing a new WFGD for Unit 3 and demolishing the existing WFGD at Unit 4 was a more cost-effective method of compliance if an amendment to its Certificate could be obtained expeditiously from the Commission. The estimated annual cost of operating the new WFGD is also set forth in the attached Exhibit JNV-3.

**Q. If the WFGD-related capital costs for Mill Creek Unit 3 are higher than LG&E expected, is it still true that building environmental-compliance equipment for the unit is more economical than retiring and replacing it?**

A. Yes. Although the total estimated capital cost for all of the compliance projects for Mill Creek Unit 3 has increased from the 2011 Environmental Compliance Plan estimate by approximately $21 million, the anticipated fixed and variable operating expenses have decreased largely because of the lower-than-expected cost of operating the baghouse, including the lower cost of sorbent injection for mercury and sulfuric acid. When the 2011 Environmental Compliance Plan was developed, LG&E based its projected baghouse operating costs on the Black &Veatch studies for high sulfur coal applications and its limited experience with operating a similar facility at Trimble County Unit 2. As its experience has developed, LG&E has further revised the projected costs, resulting in a reduction in operating expenses. As such, the decision to construct a new WFGD, even at a higher capital cost than contained in the 2011 Environmental Compliance Plan, does not affect the prudency of LG&E's decision to retrofit, instead of retire, Mill Creek Unit 3.

In fact, the Net Present Value of Revenue Requirement ("NPVRR") savings associated with retrofitting Mill Creek Unit 3 rather than retiring it, which were initially projected to be $756 million, can be maximized even if LG&E rehabilitates the existing WFGD at Mill Creek Unit 4. But to maximize the NPVRR savings to customers as shown in the table below, LG&E must receive approval to modify the Mill Creek Unit 3 Certificate by January 18, 2013:

**Table 1: NPVRR Savings of WFGD Options for Mill Creek Unit 3**

| | **2011 ECR Plan** | **Updated Rehab** | **New FGD** | **New FGD with Delay** |
|---|---|---|---|---|
| *Retrofit Savings (NPVRR, 2011 $M)* | *756* | *794* | *820* | *782* |

Timely approval should allow LG&E to complete the new WFGD by April 2016, which is the date it must be in compliance with the Mercury and Air Toxics Rule ("MATS Rule") (with a one year extension being granted). Under this scenario, the NPVRR savings to retrofit Mill Creek Unit 3 are $820 million, which is a $64 million increase (eight percent) over the projected savings in the 2011 Environmental Compliance Plan. Under this scenario, Commission approval as requested should ensure construction can be commenced and be completed in a timely manner. If Commission approval to modify LG&E's Certificate is not obtained as requested, constructing a new WFGD will not meet the compliance deadline and will no longer maximize NPVRR savings; instead, based on this analysis rehabilitating the existing WFGD at Unit 4 as planned would be more cost effective to customers, as the NPVRR savings for rehabilitating the WFGD results in $794 million in savings.

**Q. Why is it important for the Commission to approve expeditiously LG&E's proposal?**

A. If LG&E constructs a new WFGD but is unable to complete construction prior to the April 2016 compliance date or obtain a second year extension of the MATS Rule compliance date, the savings steadily decline because LG&E will no longer be able to operate Mill Creek Unit 3 and thus will have to purchase power from a third party to replace its capacity.[9] For example, if the new WFGD is not completed until October 2016, a six-month delay, the NPVRR savings decline to $782 million, based on estimated costs to purchase power from a third party. These analyses demonstrate there is a short window of opportunity for LG&E to maximize NPVRR savings under the new construction option.

**Q. For the sake of clarity, please state what would be the cost of delaying an approval of LG&E's proposal and how LG&E will proceed if it does not receive a timely approval.**

[9] It is not clear that LG&E will be able to obtain a second year extension.

A. The cost to LG&E's customers of not receiving an order by January 18, 2013, approving the requested Certificate modification would be $26 million in NPVRR terms. Table 1 above shows that the value to customers of pursuing a new WFGD for Mill Creek Unit 3 rather than rehabilitating Mill Creek Unit 4's WFGD disappears after that time due to the need to purchase replacement capacity (most likely in the form of a power-purchase agreement). Therefore, this analysis suggests LG&E should proceed within its current Certificate authority to rehabilitate the Mill Creek Unit 4 WFGD if the Commission does not approve the requested Certificate modification as requested.

**Q. Do the NPVRR savings of building a new Mill Creek Unit 3 WFGD remain under different fuel-price projections less favorable to retrofitting existing coal units?**

A. Yes, these savings hold true even under fuel-cost projections generally less favorable to coal units, such as those from the Cambridge Energy Research Associates ("CERA") the Companies included in their analyses from the 2011 Environmental Compliance Plan cases, as shown in Table 2 below:

**Table 2: NPVRR Savings of WFGD Options for Mill Creek Unit 3**

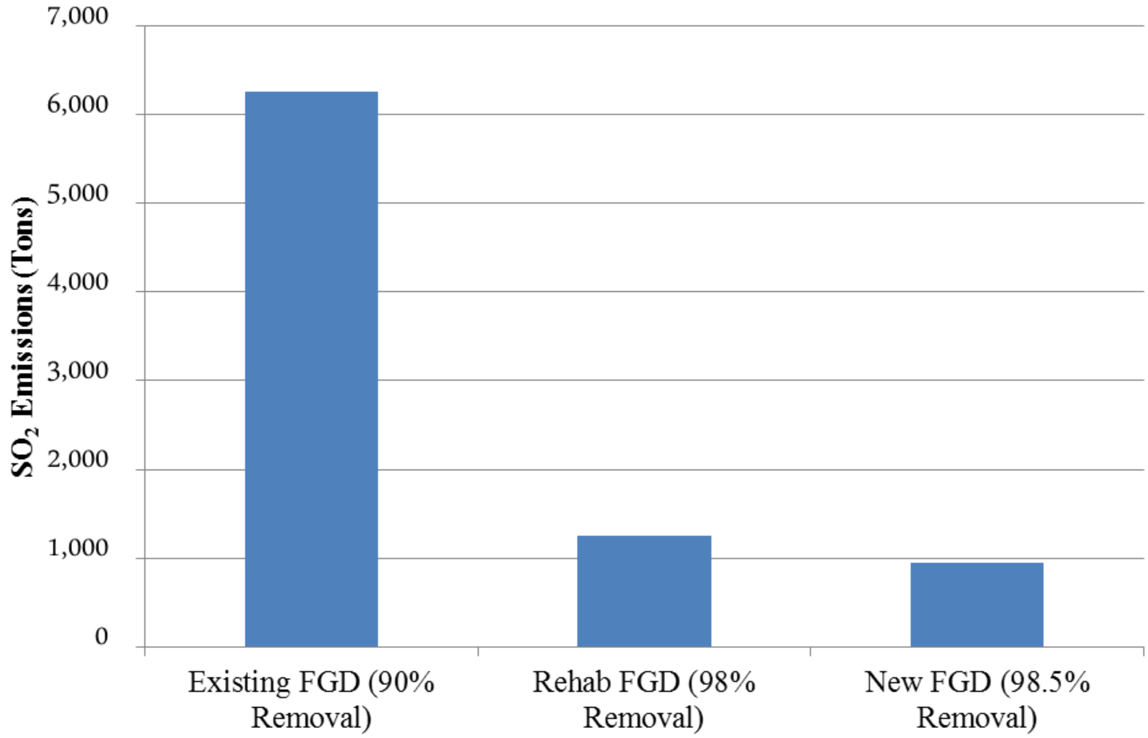
| | 2011 ECR Plan | Updated Rehab | New FGD | New FGD with Delay |
|---|---|---|---|---|
| *Retrofit Savings (NPVRR, 2011 $M)* | *338* | *376* | *402* | *370* |

Current base fuel-price projections remain within the ranges the Companies studied in their 2011 Environmental Compliance Plan cases, so these results remain valid and continue to support retrofitting Mill Creek Unit 3 generally, as well as specifically supporting building a new WFGD for the unit.

**Q. In addition to the savings associated with LG&E's proposal, what would be the environmental benefits of building a new WFGD for Mill Creek Unit 3 rather than rehabilitating the existing Mill Creek Unit 4 WFGD to serve Mill Creek Unit 3?**

A. Both WFGD solutions will significantly improve the control of Mill Creek Unit 3's $SO_2$ emissions, but one of the significant benefits of building a new WFGD for Mill Creek Unit 3 is that it would remove at least 25% more of the likely $SO_2$ emissions from a rehabilitated Mill Creek Unit 4 WFGD. The Babcock study indicated the rehabilitated WFGD could remove up to 98% of the $SO_2$, increasing from the current levels of up to 90% removal. A new WFGD would have a guaranteed removal rate of 98.5% with expected removal rates of 99% or higher, which would remove over three hundred more tons of $SO_2$ emissions at Mill Creek Unit 3's forecasted 60% capacity factor than would a rehabilitated WFGD, as shown in Figure 1 below:

**Figure 1: Mill Creek 3 $SO_2$ Emissions at Forecasted 60% Capacity Factor**




The company's experience with the same WFGD technology recently installed and operating at the KU Ghent and E.W. Brown stations have shown performance can exceed the guaranteed value of 98.5%. Thus, a new WFGD would deliver greater environmental benefits while reducing customers' energy costs. To deliver this win-win solution LG&E requests the Commission to approve the Certificate modification on an expedited basis.

**Q. Is there a contracting advantage to committing soon to put in place a new WFGD?**

A. Yes. LG&E is currently contracting for the other WFGD work at Mill Creek, making it important to act soon to increase the possibility of obtaining pricing similar to the excellent pricing that has been obtained for the Unit 4 and combined Unit 1 and 2 WFGDs, as well as making it possible to lock in the pricing discussed herein.

**Q. Does this conclude your testimony?**

A. Yes, it does.

**VERIFICATION**

**COMMONWEALTH OF KENTUCKY )**
**) SS:**
**COUNTY OF JEFFERSON )**

The undersigned, **John N. Voyles, Jr.**, being duly sworn, deposes and says that he is Vice President, Transmission and Generation Services for Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the foregoing testimony, and that the answers contained therein are true and correct to the best of his information, knowledge and belief.

John N. Voyles, Jr.

**John N. Voyles, Jr.**

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 24th day of October 2012.

Sheri L. Gardner (SEAL)
Notary Public

My Commission Expires:
SHERI L. GARDNER
Notary Public, State at Large, KY
My commission expires Dec. 24, 2013

**APPENDIX A**

**John N. Voyles, Jr.**

Vice President, Transmission and Generation Services
Louisville Gas and Electric Company and Kentucky Utilities Company
220 West Main Street
Louisville, Kentucky 40202
(502) 627-4762

**Education**

Rose-Hulman Institute of Technology, B.S. in Mechanical Engineering - 1976

**Previous Positions**

**E.ON U.S. LLC**

June 2008 - Present -Vice President, Transmission and Generation Services
2003 - 2008 -Vice President, Regulated Generation

**LG&E Energy Corp.**

February - May 2003 -- Director, Generation Services

**Louisville Gas and Electric Company**

1998 - 2003 -- General Manager, Cane Run, Ohio Falls and Combustion Turbines
1996 -1998 -- General Manager, Jefferson County Operations
1991 - 1995 -- Director, Environmental Excellence
1989 - 1991 -- Division Manager, Power Production, Mill Creek
1984 - 1989 -- Assistant Plant Manager, Mill Creek
1982 - 1984 -- Technical and Administrative Manager, Mill Creek
1976 - 1982 -- Mechanical Engineer

**Professional Development**

Emory Business School -- Management Development Program
Center for Creative Leadership (La Jolla, CA)
University of Louisville -The Effective Executive
Harvard Business School - Finance for the Non-Financial Manager
MIT - Leading Innovation & Growth: Managing the International Energy Co.

**Board/Committee Memberships**

Fund for the Arts - Board Member
Ohio Valley Electric Co. (OVEC) - Board member and Executive Committee member
Electric Energy, Inc. - Board member
Edison Electric Institute (EEI) - Committee member Energy Supply Executive Advisory Committee and the Environment Executive Advisory Committee
Electric Power Research Institute (EPRI) - Chairman, Research Advisory Committee

Exhibit JNV-1

# Babcock Power Environmental Inc.

# Mill Creek Unit 4 Upgrade Study

# LG&E and KU Services Company
# Mill Creek Station
# WFGD Performance Upgrade Study

## Feasibility Assessment
## Mill Creek Unit 3 Gas Being Diverted to Unit 4
## WFGD System Upgrades

**December 2, 2011**

BabcockPower ENVIRONMENTAL

# LG&E and KU Services Company

# Mill Creek Station Unit 4 Upgrade Analysis

# WFGD System Upgrade

**December 2, 2011**

December 2, 2011

Mr. Larry Van Gansbeke
LG&E and KU Services Company
Project Engineering
820 West Broadway
Louisville, KY 40202

RE: Mill Creek Station FGD System Upgrade Analysis

Mill Creek Station, 14660 Dixie Highway, Louisville, KY 40272

Dear Mr. Van Gansbeke:

Babcock Power Environmental Inc. (BPEI) has conducted an in-depth condition survey and evaluation of the existing Unit 4 Wet Flue Gas Desulfurization (WFGD) System at Louisville Gas and Electric and KU Services Company's (LG&E and KU's) Mill Creek Generating Station. The purpose of the evaluation was to perform an Upgrade Analysis of Unit 4 WFGD System to service boiler Unit 3 while maintaining high (+98%) $SO_2$ removal at both 12,500 ppm[1] and 50,000 ppm chlorides.

BPEI's current evaluation of the existing Unit 4 WFGD is built on the Feasibility Assessment completed on March 16, 2011. By working with LG&E Engineering and the Mill Creek plant, BPEI has conducted a comprehensive assessment of existing conditions and has defined the upgrades required to meet the Basis of Design specification and Project goals. The Basis of Design and goals are as follows:

- Fuel: 6.3lb SO2/mmBtu
- Operating Chloride limit: 12,500 ppm & 50,000 ppm
- SO2 Removal Efficiency: +98.0%

BPEI and LG&E/KU have a long and very successful history of contracting and delivering multiple AQC Systems for your generating stations. We are confident this Upgrade Analysis will prove to further enhance our relationship as well as save LG&E/KU substantial capital compared to the cost of completely replacing the existing Mill Creek 4 Scrubber. Should you have any questions regarding our report please do not hesitate to contact me at (508) 854-3964, or via email: doleary@babcockpower.com

Very truly yours,

Daniel O'Leary
Project Manager

[1] Chloride content of 12,500 ppm and 15,000 ppm has been used interchangeably in this report. They represent the same upgrade solution.

Cc: Eileen Saunders, LG&E and KU – Project Engineering
Harry Culberson – BPEI
Mike Kelly - BPEI

# LG&E and KU Services Company
# Contract No. 843037
# Mill Creek Unit 4 WFGD System Upgrade Analysis to Service Boiler Unit #3

## Table of Contents

**Attachments**

General Arrangement Drawings

Material Balances

- Second Design Basis – no filtrate return
- First Design Basis – filtrate return via Clearwell Pond

Design Basis

Water Flow Schematic

Budget Engineering and Procurement Estimate

Work Scope

Schedule (high level)

# 1. EXECUTIVE SUMMARY

Babcock Power Environmental Inc. (BPEI) conducted an in-depth condition survey and evaluation of the existing Unit 4 Wet Flue Gas Desulfurization (WFGD) System at Louisville Gas and Electric and KU Services Company's (LG&E and KU's) Mill Creek Generating Station. The purpose of the evaluation was to perform an Upgrade Analysis of Unit 4 WFGD System to service boiler Unit 3, while maintaining high (+98%) $SO_2$ removal and high system reliability at both 12,500 ppm[1] and 50,000 ppm chlorides while burning a 6.3 lb $SO_2$/MMBtu coal.

## Inspection

An inspection of Unit 4 WFGD absorbers was conducted by BPEI on September 27-28, 2011 during a short unit outage. The purpose of the inspection was to better understand the conditions and capability of the existing Unit 4 absorbers in order to develop a comprehensive scope of work to retrofit this unit to treat Unit 3 flue gas and reliably achieve high $SO_2$ removals.

The inspection revealed a number of issues that need to be corrected to achieve the high $SO_2$ removal efficiency specified while processing Unit 3 flue gas at design coal conditions. These findings include:

- Significant evidence of corrosion on the unit and support steel.
- Absorber flue gas inlet is shorter, and has a larger surface area, than typical new absorber designs.
- Quench water is run daily to prevent solids build up at the inlet. The use of quench water in this manner is not typical of a well configured system.
- In a high efficiency scrubber, the distance between spray levels and the distance between the tray and spray levels are ≥5 ft. In Unit 4 this spacing is only 3 ft.
- First spray header is only 3.25 ft above the top of the absorber inlet, as compared to a minimum of 6.5 ft in a new scrubber.
- Current spray nozzles provide little spray coverage along the absorber wall and between the absorber nozzles.
- Spray zone in Unit 4 is 11'7'' as compared to high efficiency open spray towers which would typically have a spray zone of 20'.
- Use of reclaim water for ME washing often leads to scaling on the ME elements rather than washing off the solids. Scaling was evident on the chevron style Mist Eliminator (ME) in Unit 4. A clean water source should be used for this service
- Bleed pump performance is not optimal in terms of either pump wear and tear or power consumption without an orifice on the bleed return to the reaction tank.
- The hydrocyclone assembly is of an older design.

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[1] Chloride content of 12,500 ppm and 15,000 ppm has been used interchangeably in this report. The materials required to maintain a 12,500 ppm chlorides level is also suitable to allow the system to operate at 15,000 ppm chlorides.

**Design Basis**
The design basis coal has a sulfur content of 6.3 lb $SO_2$/MMBtu. Material balances were created for Unit 4 allowing the scrubber slurry to cycle up to 8,000 ppm chlorides (current operation) and to levels of 15,000 ppm and 50,000 ppm chlorides assuming material upgrades in the absorbers.

**Process Upgrades**
A number of process upgrades are recommended for the existing Unit 4 WFGD system to be able to treat Unit 3 flue gas maintaining high (+98%) $SO_2$ removal and chloride concentrations of 15,000 ppm and 50,000 ppm:

- Replace existing WFGD Absorber modules with new high grade alloy materials and upgraded design.
- Replace and extend the absorber inlet and replace the absorber inlet awning
- Replace recycle spray headers and space 5’ apart above the tray.
- Stagger spray nozzles layout and increase spray nozzle density
- Replace nozzles with dual-flow nozzles and add wall rings to spray levels 2 and 3.
- Replace recycle pumps with pumps suitable for high chloride service.
- Install five (5) new agitators and oxidation air lances on each reactor tank
- Install new DV210 Mist Eliminators.
- Provide a source of clean water for the ME wash system.
- Optimize process operating ranges and control logic.
- Redirect reaction tank vent into the absorber and add a seal pot to the overflow.
- Replace bleed pumps and primary dewatering hydrocyclones.
- Complete physical model to evaluate new ductwork layout and inlet duct design.

**Project Plan**
Babcock Power Environmental, Inc. has developed a preliminary Project Plan that capitalizes on its engineering, product fabrication, installation, and startup expertise to provide LG&E-KU Services Company with an efficient retrofit design that provides a low project cost and a short outage schedules.

The fully upgraded Unit 4 absorbers will be finished and available for service on November 17, 2014 at the completion of an 8-week outage on Unit 4. Flue gas from Unit 3 can be processed in the upgraded Unit 4 absorber once the blank off plate is removed during a one-week outage on Unit 3 scheduled in the Fall of 2014.

There are six outages, of various lengths, scheduled on Units 3 and 4 starting with a four (4) week outage on Unit 4 beginning April 16, 2012. Babcock Power needs to receive full notice to proceed by 1/1/2012 in order to place orders with vendors, perform detailed engineering and materials fabrication for this outage. BPEI plans to replace the absorber reaction tank tile lining as required, replace the reaction tank roof, replace the floor and install agitator mounting boxes and nozzles during this first outage. Scope of work assigned to the other outages was scheduled based on the lead time to engineer, procure and deliver vendor supplied equipment.

General work that can take place while the unit is operating has been scheduled throughout the period of 2012 to 2014. The general work includes replacement of the recycle pumps and oxidation air piping.

Part of the general work includes structural steel improvements and an interconnecting duct between Unit 3 and 4. These activities are critical for the upgrade of Unit 4, but are in LG&E-KU's scope of work. BPEI has included them in the project schedule to ensure the project can be completed in the available time.

Materials of construction were identified for two chloride levels: 12,500 ppm and 50,000 ppm. These two cases require the selection of different materials to address the condition in the absorber. The schedule for installing this equipment is not however affected by the required material.

**Estimated Pricing**

The estimated Engineering and Procurement cost of the retrofit improvements for the Mill Creek Unit 4 WFGD upgrade are shown below. This cost is based on current 2011 dollars without escalation. The accuracy is +25% to -10%. The pricing is for engineering and procurement only. No allowances have been made for BOP work, construction or maintenance upgrades to the WFGD structure. Additional details of this estimate are available in the attachments.

**Budget Engineering and Procurement Estimate**

| Description | Engineering Labor | Materials | Total |
|---|---|---|---|
| Case 1:Alloy 27–7MO Unit 4 (12,500 ppm chlorides) | $7,800,000 | $24,700,000 | $32,500,000 |
| Case 2: Alloy C-276 Unit 4 (50,000 ppm chlorides) | $7,800,000 | $27,400,000 | $35,200,000 |

**Conclusion**

Flue gas from Unit 3 can be processed in an upgraded Unit 4 while maintaining high (+98%) $SO_2$ removal and high reliability at both 12,500 ppm and 50,000 ppm chlorides. These removal efficiencies can be achieved with quality, well proven, reliable and cost effective technology that has been successfully applied at multiple installations throughout the United States.

The Unit 4 upgrade can be completed and the Unit 3 flue gas stream tied-in by November, 2014 through the effective use of six outages, of various lengths, scheduled for Units 3 and 4.

EPC cost to upgrade Unit 4 WFGD System is extremely cost competitive to the cost of new construction. To fully evaluate cost, the cost of existing infrastructure and BOP upgrades should be added to the estimated cost provided in this report.

## 2. INSPECTION AND EVALUATION OF EXISTING WFGD SYSTEM

A walk down and inspection of Unit 4 absorbers was completed in September on the 27th and 28th during a short unit outage. The reaction tanks were not drained during this outage and, therefore, were not available for inspection. The purpose of the inspection was to better understand the capability of the Unit 4 absorbers in order to develop a comprehensive scope of work to retrofit this unit to treat Unit 3 flue gas and achieve high $SO_2$ removals. A previous evaluation of the Mill Creek system was completed earlier this year and the results were summarized in a report issued to LG&E-KU in March of 2011.

### 2.1 Absorbers

Unit 4 Boiler System is currently configured with two 50% ID Fans. Flue gas from ID Fan A is directed to two absorber towers where recycle slurry is supplied from a common reaction tank. Flue gas from ID Fan B is directed to two additional absorber towers where recycle slurry is supplied from a common reaction tank servicing these two absorber towers. Both reaction tanks are Stebbins tile lined. These reaction tanks are relatively small for a forced oxidation WFGD system. The reaction tanks and absorber overflows vent to atmosphere. Figure 1 shows photos of the existing reaction tank vent and overflow line.

**Figure 1. Absorber Reaction Tank Vent and Overflow**

Each absorber tower has a single tray level and four recycle spray levels. Each reaction tank has four recycle pumps each providing slurry to two recycle spray levels, one on the ‘A’ and one on the ‘B’ towers, for a total of 8 recycle pumps feeding 16 recycle spray levels. Oxidation air is introduced thru a sparger type system. The sparger is arranged as a single header located above the floor introducing air evenly throughout the absorber.

Flue gas flows vertically through the four spray levels, interacting with the slurry sprayed from the recycle spray headers. Above the first spray header, LG&E has installed a perforated plate or tray for the purpose of providing even flue gas distribution. Flue gas exits the absorbers through the mist eliminators to the stack. Figures 2 and 3 show the general arrangements of the existing Unit 4 absorbers.

**Figure 2. General Arrangement – South Elevation**

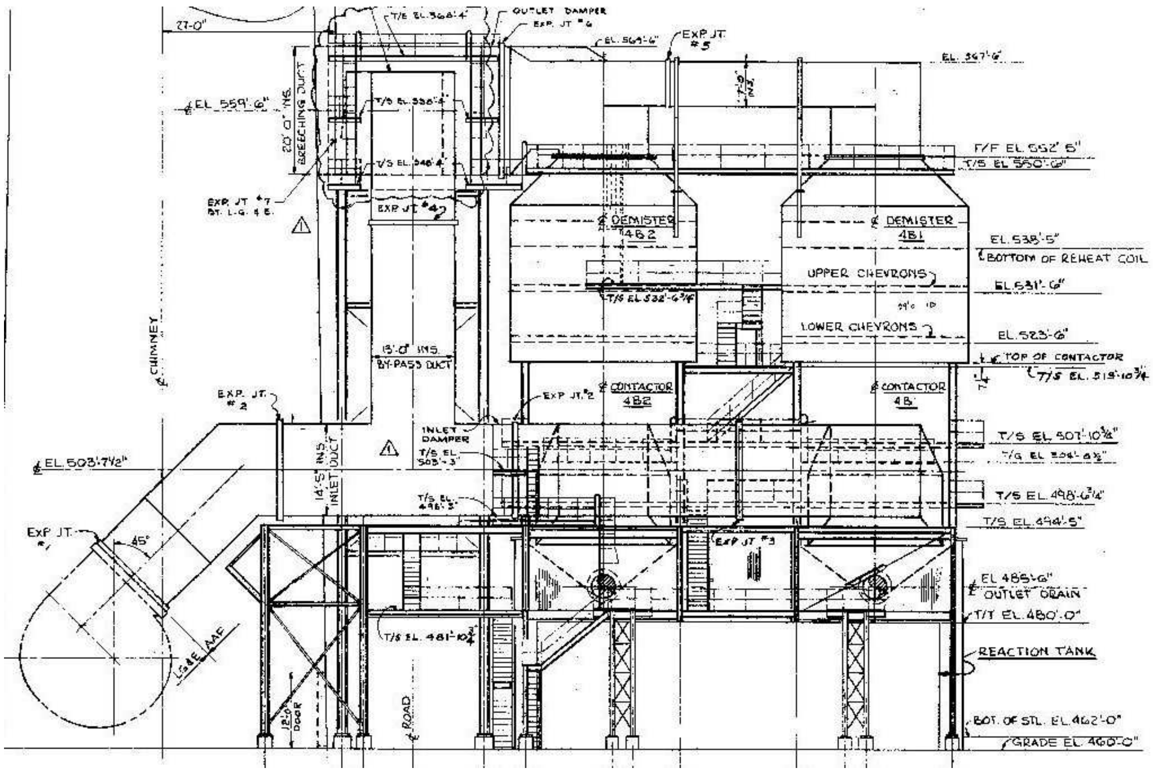
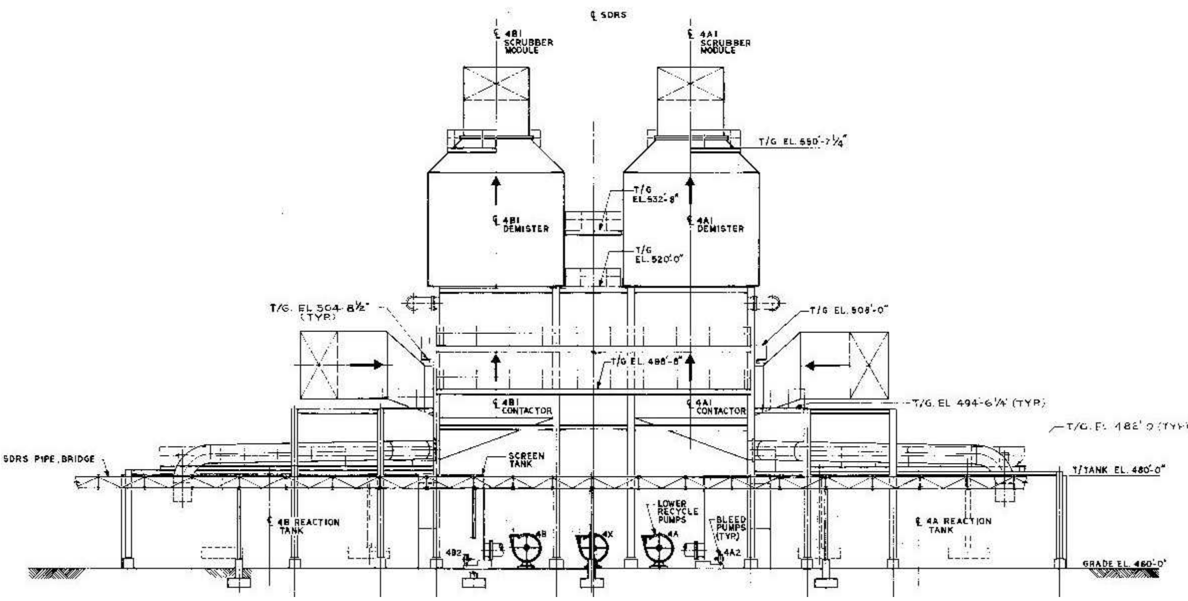


**Figure 3. General Arrangement – East Elevation**




All scrubber internals are some degree of stainless steel. Hastelloy or 317LMN wallpaper has been applied at various locations in the scrubber and outlet duct. Reheaters, originally installed in the outlet duct of the scrubber towers, have been removed. There was significant evidence of corrosion on the unit and support steel. Main contributors to the corrosion are believed to be flue gas leakage from the ductwork and pinhole leaks in the absorber shell. Figure 4 shows a few of the areas of corrosion.

**Figure 4. Areas of Corrosion on Unit 4**


## 2.2 Inlet Duct

The absorber flue gas inlet is shorter and has a larger surface area than is typical for new absorber designs. The length, shape, and angle of a typical absorber inlet are designed to minimize splash back of absorber slurry into the carbon steel ductwork. Flue gas velocity in the absorber is controlled with the size of the absorber inlet to evenly distribute flue gas prior to the first spray level, to eliminate any reverse flow in the duct, and to maintain the wet/dry interface in the absorber area. Otherwise, a large, shallow absorber inlet may result in corrosion of the ductwork upstream of the absorber. Flow modeling can determine if the installed tray offsets the negative impact of the current absorber inlet design or if modifications are required to the absorber inlet and/or the size of the awning (rain hood) installed to prevent slurry from entering the absorber inlet duct.

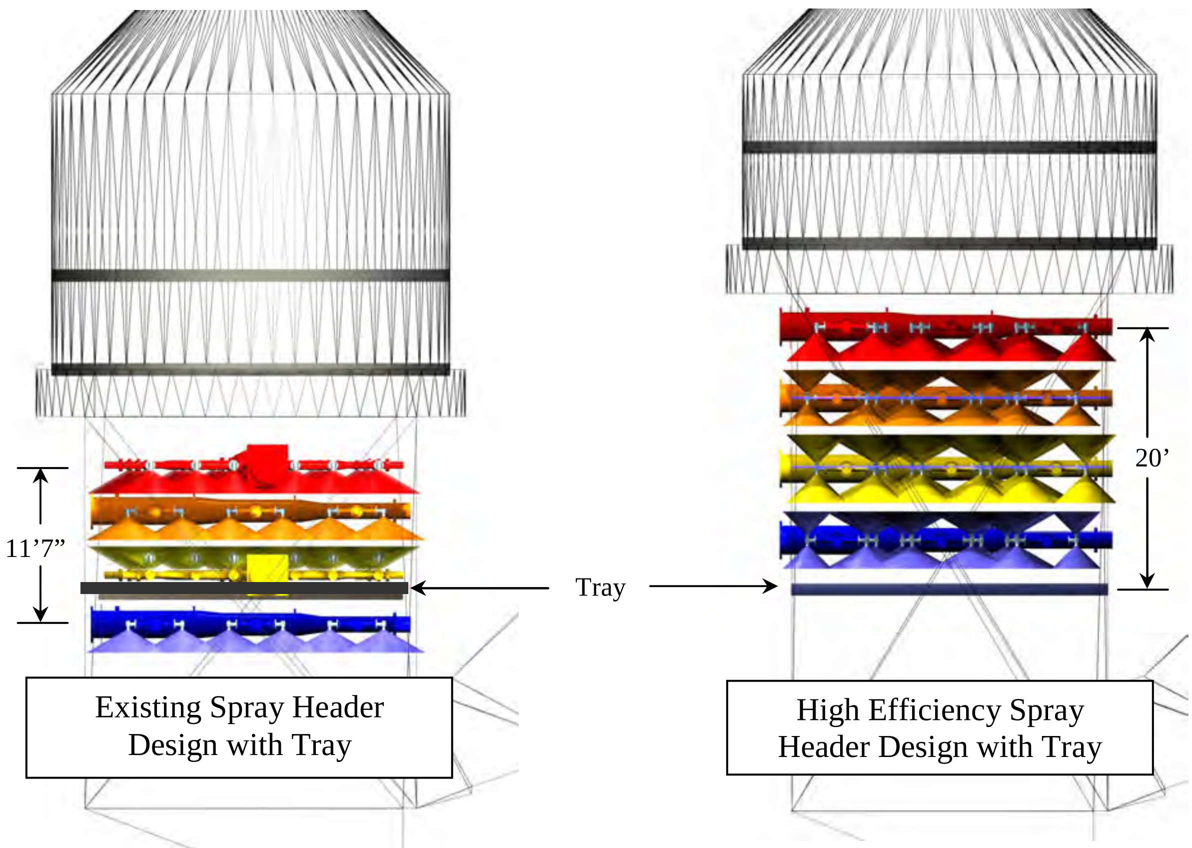
There is an emergency quench water system installed at the absorber inlet that is operated daily to reduce the solids buildup at the absorber inlet. The use of quench water in this manner is not typical of a well configured system and is an indication of issues with the existing inlet design and spray header layout.

### 2.3 Recycle Spray Header

The spray levels and tray are closely spaced together (approximately 3 ft apart) compared to high efficiency scrubber designs (≥5 ft apart). When the tray was added to the absorbers between spray levels 1 and 2, the spray nozzles installed on spray level 2 were directed to spray up to prevent erosion issues on the tray.

Dual-spray nozzles are designed to produce a finer mist without sacrificing pressure drop. However, dual-spray nozzles on the first spray level would have to remain downward-only spray because of the tray installed directly above the spray header. Likewise, the dual-spray nozzles on the second spray level would have to remain upward-only spray. As a result, if there are no modifications completed to the existing spray header arrangement, dual-spray, bi-directional spray nozzles could only be installed on the third spray header. The total spray zone is also very small, only 11’7”. High efficiency open spray towers of this size would normally have a spray zone that is closer to 20’ in length, almost twice the height of the existing spray header arrangement. Figure 5 shows the existing spray zone on the Unit 4 absorber compared to a high-efficiency designed absorber.

**Figure 5. Absorber Spray Zone Height**



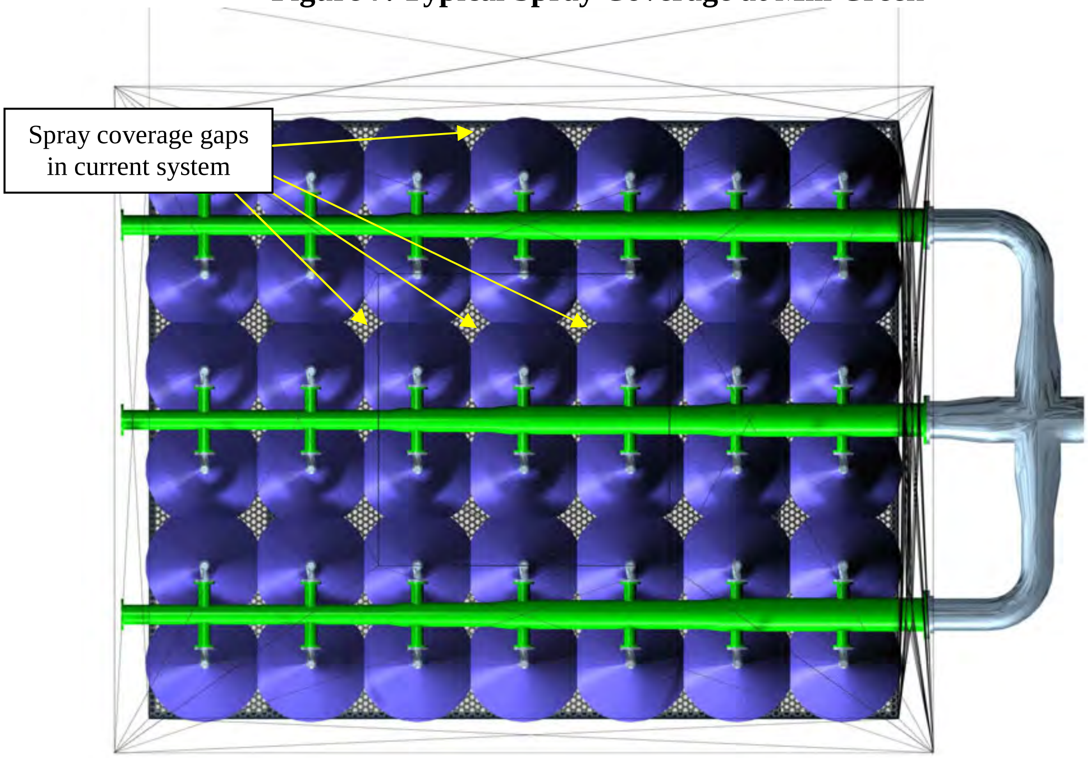

Internal inspection determined that only the second and third recycle spray level piping is 316L stainless steel where it was previously thought all 4 spray-levels were stainless steel. The piping in the first and fourth recycle spray levels is FRP and is showing signs of stress and fatigue. The location of the first spray level is much closer to the absorber inlet than recommended in new scrubber designs. The spray header is only 3.25' above the top of the absorber inlet. There might be additional issues of splash back into the carbon steel section of the ductwork upstream of the absorber inlet as a result. New scrubber designs utilize at least 6.5' between the top of the absorber inlet and the first spray header. Figure 6 shows photos of the existing spray headers.

**Figure 6. Existing Absorber Spray Headers**




The high-flow, hollow-cone spray nozzles currently installed in the Mill Creek absorber are designed to produce small droplets with a spray pressure of 10 psig at a spray angle of $120^o$. Figure 7 shows the spray coverage with this spray header and nozzle configuration and clearly shows there is very little spray coverage along the absorber wall and between the absorber nozzles. The four spray headers are identical in layout such that some channeling of the flue gas through the absorber likely occurs. Installing wall rings at spray levels 2 and 3 could help prevent flue gas sneakage in the corners and along the walls of the absorber.

**Figure 7. Typical Spray Coverage at Mill Creek**




LG&E-KU requested that BPEI estimate the $SO_2$ removal efficiency from the currently configured absorber with upgrades similar to the Trimble County and also asked what fuel sulfur level would be needed to achieve 98% removal with these same modifications. The scrubbing efficiency of the currently configured absorber could be improved with the addition of wall rings and dual flow spray nozzles[2], similar to Trimble County. However, an upgrade limited to these modifications is not recommended as these upgrades will not address all of Mill Creek's concerns, namely: meeting high $SO_2$ removal efficiencies, eliminating corrosion issues, increasing reliability, and allowing operation at 12,500 or 50,000 ppm chlorides. A very short spray zone and the inability to install dual-orifice, bi-directional spray nozzles on all lower spray headers are the prime factors that limit $SO_2$ removal from the current Unit 4. The performance capability of the currently configured Unit 4 absorber with the addition of wall rings and dual-flow spray nozzles is limited as follows:

- An $SO_2$ removal efficiency of 95% and as high as potentially 96% can be maintained at the design coal conditions
- An $SO_2$ removal efficiency of 98% if the sulfur content of the coal is reduced by 50%, or to approximately 3.2 lb $SO_2$/MMBtu

[2] As mentioned previously, only spray level 3 would have up/down dual flow nozzles installed. The other three spray levels would have single direction dual flow nozzles installed in the absorber as currently configured.

## 2.4 Recycle Spray Pumps

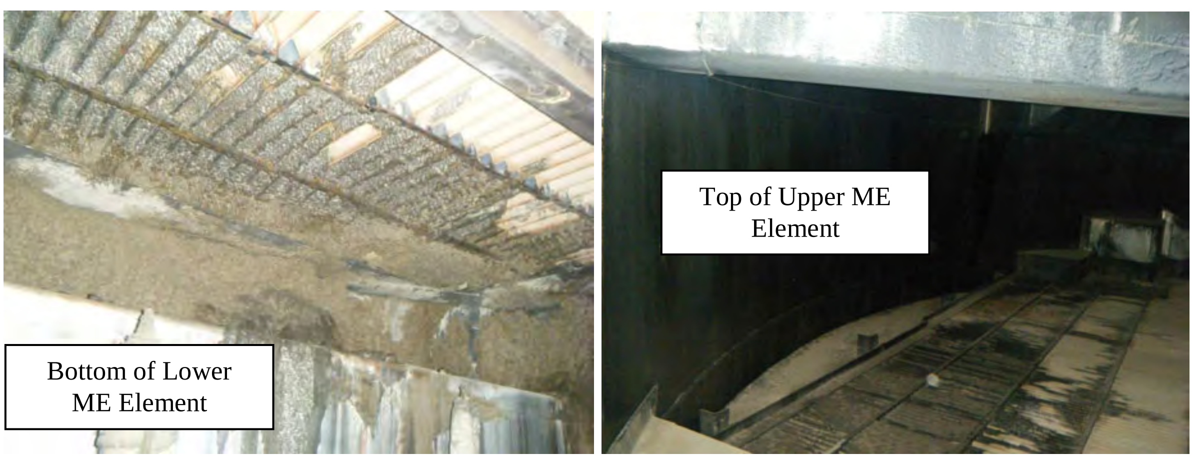
Unit 4 recycle pumps were replaced in the mid 1990s and appear to be adequately sized to provide a high L/G ratio of 162 gal/macf when treating Unit 3 flue gas. However, $SO_2$ removal will be limited because of the poor spray coverage and the limited spray zone height.

## 2.5 Mist Eliminator

The lower mist eliminator (ME) wash water header piping is FRP while the middle wash water header piping is alloy. The mist eliminator section contains baffles that are used to direct the air flow. It is not clear why the baffles are necessary or the exact geometry of the ME section.

The chevron style MEs showed scaling/buildup in some areas as well as some plugged wash nozzles. The plant reported that the Clearwell Pond is the source of wash water for the ME wash system and that this pond receives filtrate return from dewatering. Reclaim water is not recommended for ME wash. The high calcium, magnesium, and sulfate concentrations and any fines in the water result in hard water scaling in piping, wash nozzle pluggage, and erosion of wash valves. These components can also introduce a source of alkalinity at the ME section in the absorber. This alkalinity will remove a fraction of the remaining $SO_2$ exiting in the flue gas resulting in precipitation of solids in the ME section. Reclaim water often ends up causing scaling on the ME elements instead of washing solids off the ME elements. Figure 8 are photos showing scaling evident during the inspection.

**Figure 8. Photos of Existing Unit 4 Mist Eliminator Elements**




## 2.6 Oxidation Air System

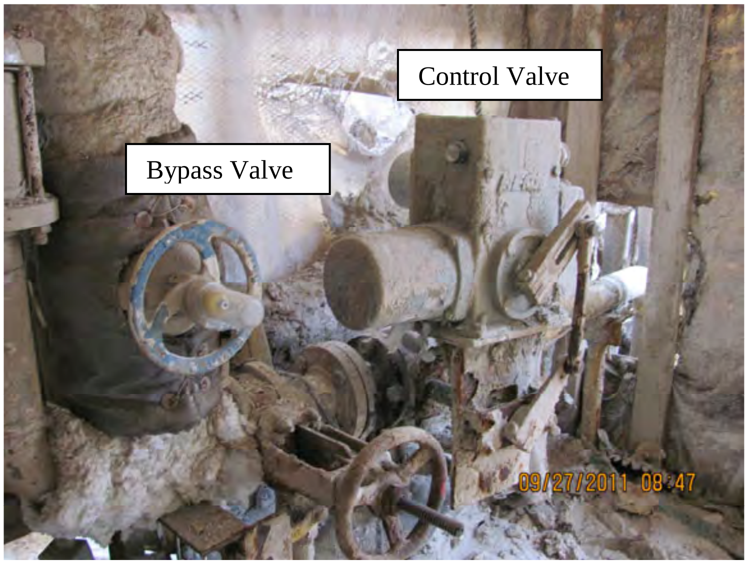
There are no agitators installed on the reaction tanks. Mixing and absorber chemistry is maintained with oxidation air. Oxidation air is injected by a sparge system in a ring installed several feet off the absorber reaction tank floor. A fraction of the oxidation air is also used to maintain agitation in the area sump. There is a quench system on the oxidation header at each reaction tank. There are two quench nozzles installed at each location spraying approximately 100 gpm of quench water. Adequate quench can be maintained with less than 10 gpm at each location. The air sparger ring is also a source of high unreliability in the absorber system causing forced unit outages whenever the oxidation air system is out of service longer than 30 minutes due to sparger ring pluggage.

Oxidation is supplied by 2 of 3 air compressors. The control logic is such that there is a lead blower that is base loaded and the second blower in service follows to maintain oxidation air supply pressure set point. The standby compressor will automatically start if one of the compressors in service trips.

## 2.7 Limestone Slurry Feed

Limestone slurry feed is based on maintaining absorber slurry pH between 4.7 and 5.8. The pH set point is adjusted by the control room operator based on unit load and $SO_2$ removal. Gypsum purity is maintained above 90% in the absorber and is measured by the on site lab. Figure 9 is a photo of the limestone slurry control valve on top of the reaction tank.

**Figure 9. Limestone Slurry Control Valve and Bypass**




## 2.8 Absorber Bleed System

Absorber density is maintained between 10-12% solids. A pair of bleed pumps (1 operating + 1 spare) on each reaction tank maintains absorber density. Bleed from each pair of pumps is directed to a dedicated hydrocyclone assembly. There are no orifices installed on the bleed return to the reaction to balance the pressure losses between bleeding to the hydrocyclone assembly and bleeding back to the reaction tank. The existing bleed pumps are not variable speed. Without orifices, the pumps must operate on different parts of the pump curve when bleeding to dewatering at high solids versus returning bleed to the reaction tank at low solids. This is not optimal for pump performance in terms of either pump wear and tear or power consumption. There is no flush on the bleed piping, slurry gravity drains back to reaction tank.

## 2.9 Primary Dewatering and Chloride Purge

At the high absorber slurry density set point, bleed is directed to primary dewatering hydrocyclones. Underflow from the hydrocyclones gravity drains to an underflow storage tank and is pumped to gypsum slurry storage at a common dewatering area. Overflow from the hydrocyclones is gravity fed back to the absorber. A fraction of the overflow can be directed to an area sump and purged from the absorber system to maintain chloride concentration and remove fines from the process to maintain gypsum quality and dewatering operation.

The hydrocyclone assembly is an older design with several cyclones (28 total cyclones for Unit 4 as compared to 10, plus 2 spare, cyclones proposed for the new Unit 4 WFGD system). There is no supply pressure indication to monitor hydrocyclone performance online. Monitoring hydrocylone supply pressure can help determine if there are pluggage issues that need to be addressed. The lab monitors overflow and underflow solids concentration to ensure the hydrocyclone assembly does not have any buildup, pluggage, or wear issues. Photos of the existing hydrocyclone assemblies at Mill Creek and Brown are in Figure 10.

**Figure 10. Photos of Hydrocyclone Assemblies at Mill Creek and Brown**

Mill Creek Hydrocyclone treating 263 MW bleed slurry

Brown Hydrocyclone treating 750 MW bleed slurry (9'9"ϕx11')

# 3. MATERIAL BALANCE – CHLORIDE PURGE EVALUATION

## 3.1 Design Basis

The original design basis submitted for the new absorbers systems on Units 1/2 and 4 was used to re-model the material balance for Unit 3 operation through Unit 4 absorbers. This design utilizes coal with a sulfur content of 6.0 lb $SO_2$/MMBtu and a reclaim stream from the Clearwell Pond that contains filtrate from dewatering. Table 1 is a summary of the coal used to develop the flue gas properties for this evaluation. The previous evaluation, in the March 2011 report, was completed using slightly higher coal sulfur content, 6.3 vs. 6.0 lb $SO_2$/MMBtu.

**Table 1. Design Coal Conditions**

| Coal Analysis | Design |
|---|---|
| Carbon | 61.20% |
| Hydrogen | 4.28% |
| Sulfur | 3.36% |
| Nitrogen | 1.27% |
| Chlorine | 0.16% |
| Oxygen | 6.89% |
| Ash | 12.00% |
| Moisture | 11.00% |
| Higher Heating Value | 11,200 Btu/lb |
| Filtrate Return | Yes |

A new design basis was submitted (4-Nov-11) for the new absorber systems on Units 1/2 and 4. This new design basis utilizes a coal with the higher sulfur content of 6.3 lb$SO_2$/MMBtu and a higher chlorine content of 0.35%. Also LG&E-KU reported that no filtrate will be returned through the Clearwell Pond. Table 2 is a summary of the revised coal. Material balances were completed for all cases as it is unclear which case is the appropriate design basis for Mill Creek current and future operation. The conflicting design conditions impact calculated purge rates, but do not impact the proposed absorber upgrades identified in this report.

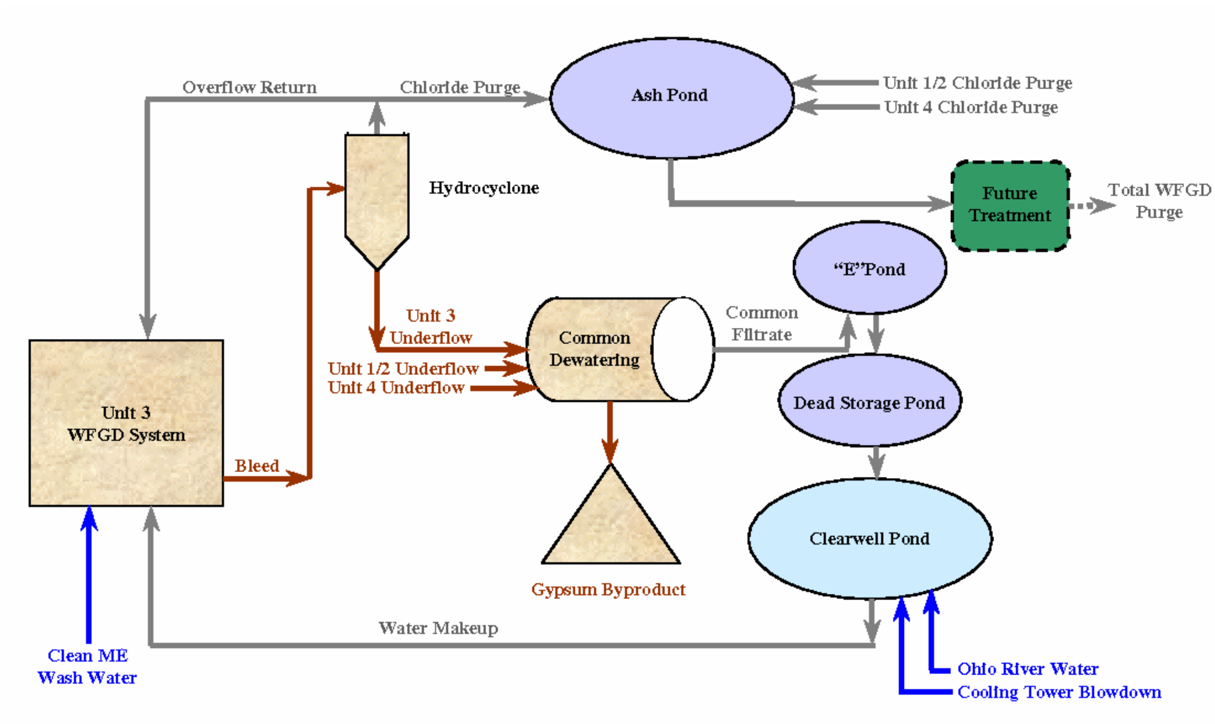
**Table 2. Revised Design Coal Conditions**

| Coal Analysis | Design |
|---|---|
| Carbon | 60.00% |
| Hydrogen | 4.00% |
| Sulfur | 3.45% |
| Nitrogen | 1.30% |
| Chlorine | 0.35% |
| Oxygen | 5.90% |
| Ash | 14.00% |
| Moisture | 11.00% |
| Higher Heating Value | 10,900 Btu/lb |
| Filtrate Return | No |

### 3.2 Original Design Basis with Filtrate Return

Chloride concentration is maintained by purging a fraction of the hydrocyclone overflow from the WFGD process. This purge rate was evaluated, for the original design basis (Table 1), assuming that the Unit 3[3] WFGD system was designed for 8,000 ppm, 15,000 ppm and 50,000 ppm chlorides. These evaluations assumed that the filtrate containing chloride is returned to the WFGD systems via Clearwell Pond. Figure 11 is a schematic of the water streams leaving and returning to Unit 3 WFGD system. Section 3.3 describes a scenario when this filtrate is not returned to the system.

**Figure 11. Schematic of Water Flow – Filtrate Returns to WFGD System**




#### 3.2.1 Maintaining 8,000 ppm Chloride in Unit 3 WFGD System

The system currently consists of materials of construction that allow the scrubber slurry to cycle up to 8,000 ppm chloride concentration. Chloride concentration is maintained by purging a fraction of the hydrocyclone overflow from the WFGD process. Based on the design coal and

[3] Please note: reference to Unit 3 in this section refers to the flue gas from Unit 3 treated in the existing (or upgraded) Unit 4.

full load conditions, the average purge rate required to maintain a chloride concentration of 8,000 ppm when directing Unit 3 flue gas to the existing Unit 4 WFGD system is 136 gpm.

New WFGD systems are being proposed for Units 1/2 and 4. Units 1 and 2 flue gas streams will be combined to one absorber island and Unit 4 will have a dedicated absorber island. The materials of construction proposed for these new WFGD systems are designed to operate at chloride concentrations up to 50,000 ppm. The slurry from all the absorber systems is directed to a common dewatering system. It was reported by the plant that filtrate from dewatering eventually ends up in the Clearwell Pond and reclaimed as makeup to all the absorber systems. This reclaim will contain higher chlorides once the new WFGD systems start up. As a result, higher purge rates will be required to maintain Unit 3 operation at 8,000 ppm. Multiple material balances were completed to determine the purge rate required to maintain the existing materials of construction on the old Unit 4 absorbers when treating Unit 3 flue gas. These results are summarized in Table 3.

**Table 3. Preliminary Purge Rates for Existing Materials of Construction**

| Water Balance | | Preliminary Purge Rates, gpm | | | |
|---|---|---|---|---|---|
| **U1/U2 & U4** | **U3** | **U1/U2** | **U4** | **U3** | **Total** |
| 8,000 ppm | 8,000 ppm | 211 | 168 | 136 | 515 |
| 15,000 ppm | 8,000 ppm | 99 | 79 | 227 | 405 |
| 50,000 ppm | 8,000 ppm | 12 | 10 | 680* | 702 |
| **Direct Unit 3 Purge to Units 1/2 & 4** | | | | | |
| 15,000 ppm | 8,000 ppm | 166 | 133 | ** | 299 |
| 50,000 ppm | 8,000 ppm | 73 | 58 | ** | 131 |

* Require additional 14 gpm additional fresh water makeup

** Purge redirected to Units 1, 2, and 4

The new WFGD design calls for two specific design conditions, 15,000 ppm[4] Cl and 50,000 ppm Cl. If Units 1/2 and Unit 4 WFGD systems operate at 15,000 ppm chloride, the purge rate for Unit 3 increases from 136 gpm to 227 gpm. If Mill Creek decides to operate the new WFGD systems at the design chloride concentration of 50,000 ppm to minimize purge from those WFGD processes, the purge from Unit 3 increases substantially, up to 680 gpm. To maintain this high of a purge rate, 100% of the overflow from the primary dewatering hydrocyclones will be directed to purge. Plus, reclaim makeup would have to be restricted by a small volume and additional (14 gpm) low-chloride service water makeup would be required to maintain 8,000 ppm chloride in the Unit 3 absorbers. At 50,000 ppm chlorides, the overall purge rate increases from the current design of 515 gpm at 8,000 ppm to 702 gpm because of the high purge rates required for Unit 3 operation.

Additional cases were completed to consider directing purge from Unit 3 to Units 1/2 and Unit 4 WFGD systems to decrease the overall purge from the WFGD system by cycling up the

[4] The material balances were prepared at chloride levels of 15,000 ppm and 50,000 ppm which are equivalent to the design values for the new Units 1/2 and 4. The material required to maintain 12,500 ppm chlorides is also suitable to allow the system to operate at 15,000 ppm.

chlorides leaving with the purge from Unit 3 in Unit 1/2 and 4 absorbers. Under this scenario, the chloride purge is directed toward Unit 1/2 and 4 rather than going to the Ash Pond. If 15,000 ppm is maintained on Units 1/2 and Unit 4, the overall purge rate can be reduced from 405 gpm to 299 gpm by directing Unit 3 purge to the other two absorber systems. If 50,000 ppm is maintained on Units 1/2 and 4, the overall purge rate can be reduced from 702 gpm to 131 gpm by directing Unit 3 purge to the other two absorber systems.

### 3.2.2 Maintaining 15,000 ppm or 50,000 ppm Chloride in Unit 3 WFGD system

Additional material balances were completed to determine Unit 3 purge rates if the materials of construction were upgraded to higher grades of alloy. These cases are summarized in Table 4. If the materials of construction are upgraded to handle 15,000 ppm Cl[5], Unit 3 purge rate can be reduced from 136 gpm to 64 gpm. However, if the new WFGD systems operation at a chloride concentration of 50,000 ppm, the purge from Unit 3 increases up to 335 gpm. If 50,000 ppm is maintained on Units 1/2 and 4, the overall purge rate can be reduced from 357 gpm to 76 gpm by directing Unit 3 purge to the other two absorber systems. If the materials of construction on Unit 3 are upgraded to handle 50,000 ppm Cl, Unit 3 purge rate can be reduced to 8 gpm.

**Table 4. Preliminary Purge Rates for Upgrade Materials of Construction**

| Water Balance | | Preliminary Purge Rates, gpm | | | |
|---|---|---|---|---|---|
| **U1-U2 & U4** | **U3** | **U1&2** | **U4** | **U3** | **Total** |
| 8,000 ppm | 8,000 ppm | 211 | 168 | 136 | 515 |
| 15,000 ppm | 15,000 ppm | 99 | 79 | 64 | 242 |
| 50,000 ppm | 15,000 ppm | 12 | 10 | 335 | 357 |
| 50,000 ppm | 50,000 ppm | 12 | 10 | 8 | 30 |
| **Direct Unit 3 Purge to Units 1, 2, & 4** | | | | | |
| 50,000 ppm | 15,000 ppm | 42 | 34 | ** | 76 |

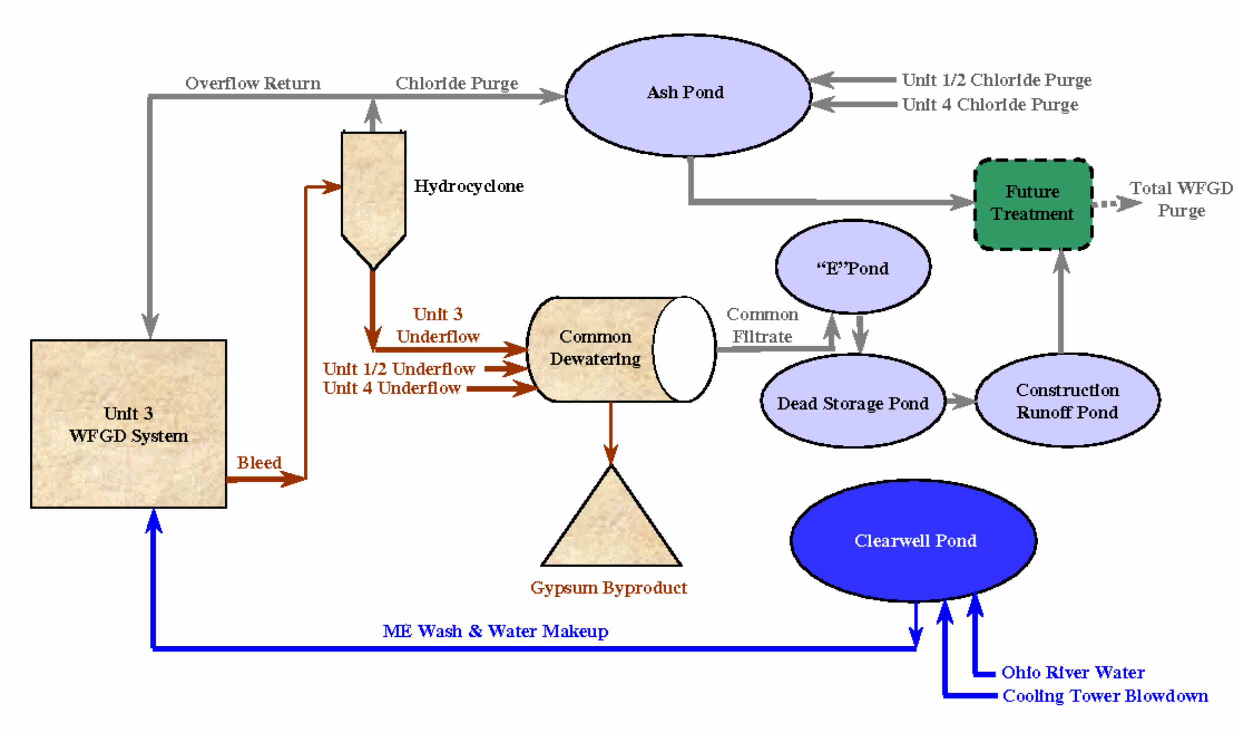
** Purge redirected to Units 1, 2, and 4

## 3.3 Revised Design Basis without Filtrate Return

The purge rates were evaluated with the revised design basis (Table 2) assuming that Unit 3 WFGD system had a chloride concentration of 8,000 ppm, 15,000 ppm, and 50,000 ppm. These evaluations assume that the filtrate containing chloride is not returned to the WFGD system as shown in the schematic in Figure 12. When filtrate containing chloride is not returned to the WFGD systems, the purge rates from the absorber systems decrease under constant fuel conditions. However it should be noted, the overall purge from the plant also includes filtrate if it is not reclaimed through the absorbers.

[5] Identical materials required to maintain 12,500 ppm Cl

**Figure 12. Schematic of Water Flow – Filtrate Does Not Return to WFGD System**




### 3.3.1 Maintaining 8,000 ppm Chloride in Unit 3 WFGD System

Based on the revised design coal with a higher chlorine content and full load conditions, the average purge rate required to maintain a chloride concentration of 8,000 ppm is 185 gpm when directing Unit 3 flue gas to the existing Unit 4 WFGD system.

Since no filtrate is returned from the common dewatering system, Unit 3 water balance is not impacted by water balances maintained on Units 1/2 and 4. The overall absorber purge rate decreases when higher chlorides are maintained in the new WFGD absorber systems. These results are summarized in Table 5. This table provides the total water purged from the system which is a combination of the chloride purge entering the Ash Pond and common filtrate entering "E" Pond.

**Table 5. Preliminary Purge Rates for Existing Materials of Construction**

| Water Balance | | Preliminary Purge Rates, gpm | | | | Filtrate Loss, gpm | Total Water Purge, gpm |
|---|---|---|---|---|---|---|---|
| U1-U2 & U4 | U3 | U1&2 | U4 | U3 | Total | | |
| 8,000 ppm | 8,000 ppm | 293 | 229 | 185 | 707 | 1,074 | 1,781 |
| 15,000 ppm | 8,000 ppm | 40 | 30 | 185 | 255 | 1,104 | 1,359 |
| 50,000 ppm | 8,000 ppm | 0 | 0 | 185 | 185 | 1,109 | 1,294 |
| **Direct Unit 3 Purge to Units 1, 2, & 4** | | | | | | | |
| 15,000 ppm | 8,000 ppm | 95 | 74 | ** | 169 | 1,104 | 1,273 |
| 50,000 ppm | 8,000 ppm | 0 | 0 | ** | | 1,109 | 1,109 |

** Purge redirected to Units 1, 2, and 4

While no purge is required for chlorides at the 50,000 ppm operating condition for Units 1/2 and 4, some purge may be required to remove fines from the process to maintain dewatering operation.

Additional cases were completed to consider directing purge from Unit 3 to Units 1-2 and Unit 4 WFGD systems to decrease the overall purge from the WFGD system. If 15,000 ppm is maintained on Units 1/2 and Unit 4, the overall purge rate can be reduced from 255 gpm to 169 gpm by directing Unit 3 purge to the other two absorber systems. If 50,000 ppm is maintained on Units 1-2 and 4, the overall purge rate can be reduced from 185 gpm to 0 gpm by directing Unit 3 purge to the other two absorber systems. Again, there may be purge requirements to remove fines for dewatering operation.

### 3.3.2 Maintaining 15,000 ppm or 50,000 ppm Chloride in Unit 3 WFGD system

Additional material balances were completed to determine Unit 3 purge rates if the materials of construction were upgraded to higher grades of alloy. These cases are summarized in Table 6. If the materials of construction are upgraded to handle 15,000 ppm Cl, Unit 3 purge rate can be reduced from 185 gpm to 25 gpm. If 50,000 ppm is maintained on Units 1-2 and 4, the overall purge rate can be reduced from 25 gpm to 0 gpm by directing Unit 3 purge to the other two absorber systems. If the materials of construction on Unit 3 are upgraded to handle 50,000 ppm Cl, Unit 3 purge rate can be reduced to 0 gpm.

**Table 6. Preliminary Purge Rates for Upgrade Materials of Construction**

| Water Balance | | Preliminary Purge Rates, gpm | | | | Filtrate Loss, gpm | Total Water Purge, gpm |
|---|---|---|---|---|---|---|---|
| U1-U2 & U4 | U3 | U1&2 | U4 | U3 | Total | | |
| 8,000 ppm | 8,000 ppm | 293 | 229 | 185 | 707 | 1,074 | 1,781 |
| 15,000 ppm | 15,000 ppm | 40 | 30 | 25 | 95 | 1,115 | 1,210 |
| 50,000 ppm | 15,000 ppm | 0 | 0 | 25 | 25 | 1,119 | 1,144 |
| 50,000 ppm | 50,000 ppm | 0 | 0 | 0 | 0 | 1,122 | 1,122 |
| **Direct Unit 3 Purge to Units 1, 2, & 4** | | | | | | | |
| 50,000 ppm | 15,000 ppm | 0 | 0 | ** | 0 | 1,119 | 1,119 |

** Purge redirected to Units 1, 2, and 4

### 3.4 Existing Dewatering System

BPEI recommends an evaluation of the balance of plant regarding operation at higher chloride concentrations. Specifically the dewatering and reclaim water system materials of construction, valves, and instrumentation should be reviewed

## 4. PROCESS UPGRADES FOR EXISTING UNIT 4 WFGD SYSTEM

The following upgrades are recommended for the existing Unit 4 WFGD system to be able to treat Unit 3 flue gas maintaining high (+98%) $SO_2$ removal and higher chloride concentrations.

- Replace existing WFGD Absorber modules with new upgraded design
- Replace absorber inlet
- Replace awning over absorber inlet
- Replace recycle spray headers and space 5' apart above the tray
- Stagger spray header layout
- Increase spray density by increasing the number of nozzles per spray level from 36 to 52
- Change spray level 1,2 & 3 nozzles to dual-flow, up-down nozzles
- Change spray level 4 nozzles to dual-flow, double-down nozzles
- Add wall rings to spray levels 2 and 3
- Replace recycle pumps with equipment suitable for high chloride service
- Install five (5) new agitators and five (5) new oxidation air lances on each reactor tank (total of 10 lances) and add external distribution ring above normal liquid level to supply air to the individual lances.
- Install new DV210 Mist Eliminators
- Provide a source of clean water for the ME wash system
- Optimize process operating ranges and control logic
- Redirect reaction tank vent to the absorber
- Add a seal pot to the reaction tank overflow
- Replace bleed pumps
- Replace primary dewatering hyrdocyclones
- Complete physical model to evaluate new ductwork layout and inlet duct design

BPEI's recommended equipment vendors and justification for these vendor selections are included in the sections below.

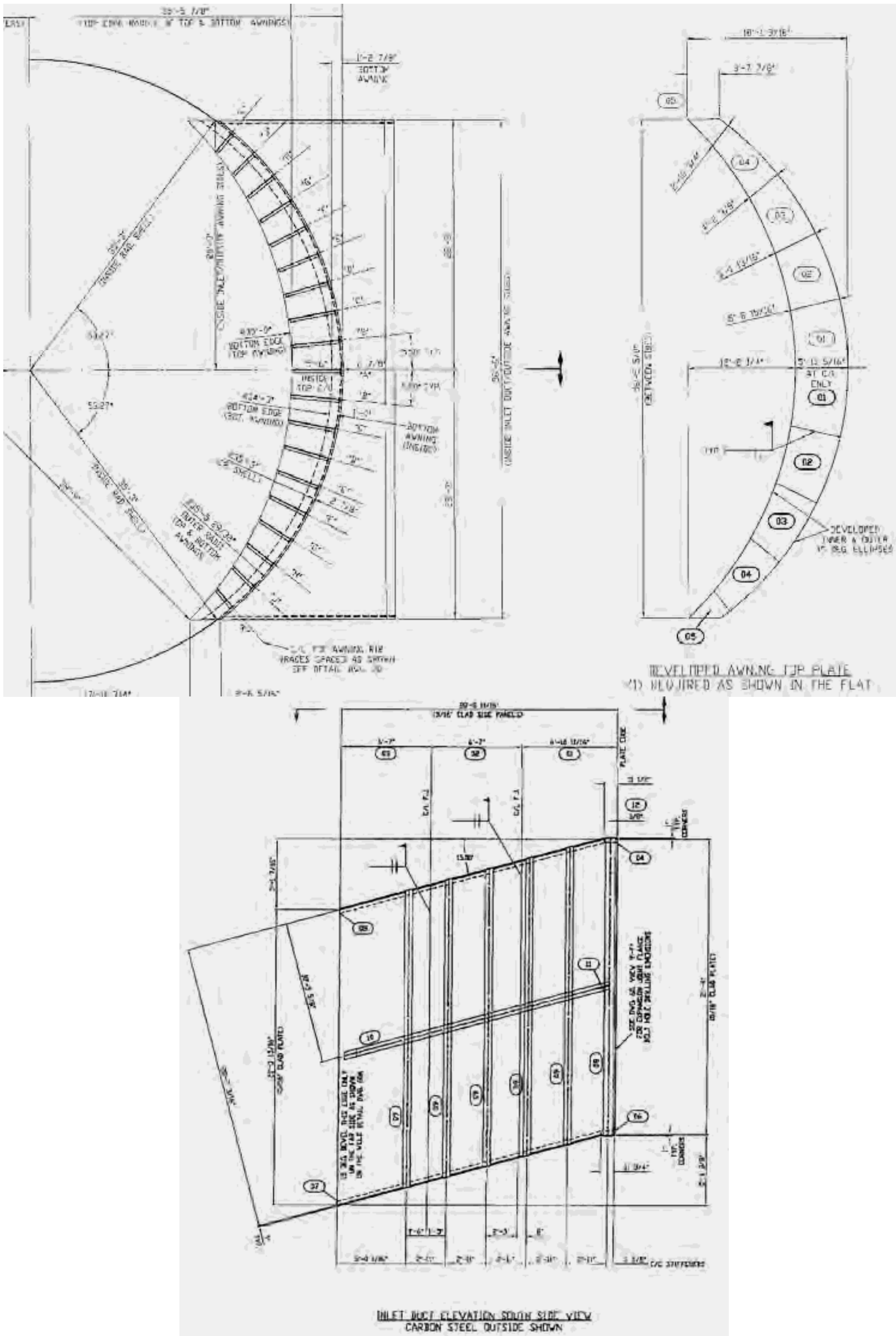
### 4.1 Existing Absorber Modules

Replace existing 317LMN alloy absorber modules with higher grade alloy materials to handle higher chloride concentrations. For the same reason, all valves and instrumentation will have to be replaced on slurry and reclaim water lines to handle the higher chloride concentrations.

### 4.2 Absorber Inlet and Awning above Absorber Inlet

Since the inlet ductwork is going to be modified to accept flue gas from Unit 3 and the absorber modules replaced to handle higher chlorides, it is recommended to replace the absorber inlet. The new absorber inlet will be longer with a surface area designed to maintain flue gas velocity between 50 and 60 ft/sec. The awning design above absorber inlet will be evaluated and re-designed to minimize the potential for carryover into the inlet ductwork. Figure 13 are typical absorber inlet duct and awning drawings.

## Figure 13. Typical Absorber Inlet Awning

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## 4.3 Recycle Spray Headers

The stainless steel headers will require new materials of construction to handle the higher chlorides, also the existing FRP headers show excessive signs of stress and deterioration and need to be replaced. BPEI proposes new FRP spray headers redesigned to produce a denser spray pattern and a staggered layout pattern. Spray nozzle location and spacing on the spray headers is an important design consideration, which must take into account relative locations of adjacent nozzles on alternate levels to take full advantage of the interaction between nozzle spray cones. Staggering nozzle layout between spray headers minimizes the potential of gas channeling or 'laning' through paths of low liquid flow. Increasing the spray density also has the potential additional benefits of increasing the removal of particulate and acid gas ($SO_3$) in the absorber. Increasing spray density will have some impact on pressure drop across the absorber.

The current arrangement of the tray and spray headers is less than optimal for maximum $SO_2$ removal. The spray headers are spaced closely together and the tray is installed between spray levels 1 and 2. The present nozzle arrangement is identical on all spray levels which results in flue gas channeling ("laning") through the absorber, reducing $SO_2$ removal potential.

Historically, trays were installed in open spray towers with a spray header installed below the tray to quench the flue gas and minimize scaling on the tray. This issue primarily affected natural oxidation systems. Research has since been completed which demonstrates that a quench spray header is not necessary for limestone, forced-oxidation systems. BPEI proposes leaving the installed tray at its existing elevation and spacing the spray headers in the newly designed absorber module so that they are all located above the tray.

The spray headers will be relocated 5 ft apart to match current design practices for high efficiency absorbers. To create the extra space required in the spray zone section, BPEI is utilizing the abandoned re-heater section and relocating the mist eliminator section in this unused area. This concept for spray header spacing allows the use of bi-directional nozzles on all but the top-level spray header. Further, this combination of spray header spacing and nozzle selection provides uniform distribution of slurry to the entire spray zone and enhanced droplet collision and retention which increases $SO_2$ removal efficiency by promoting more intimate contact between $SO_2$ molecules and slurry droplets. Figure 14 shows the staggered pattern for the spray headers to provide better spray coverage and Figure 15 shows the spray pattern with the modified spray header layout.

**Figure 14: Modified Spray Header Layout with 5' Spacing**

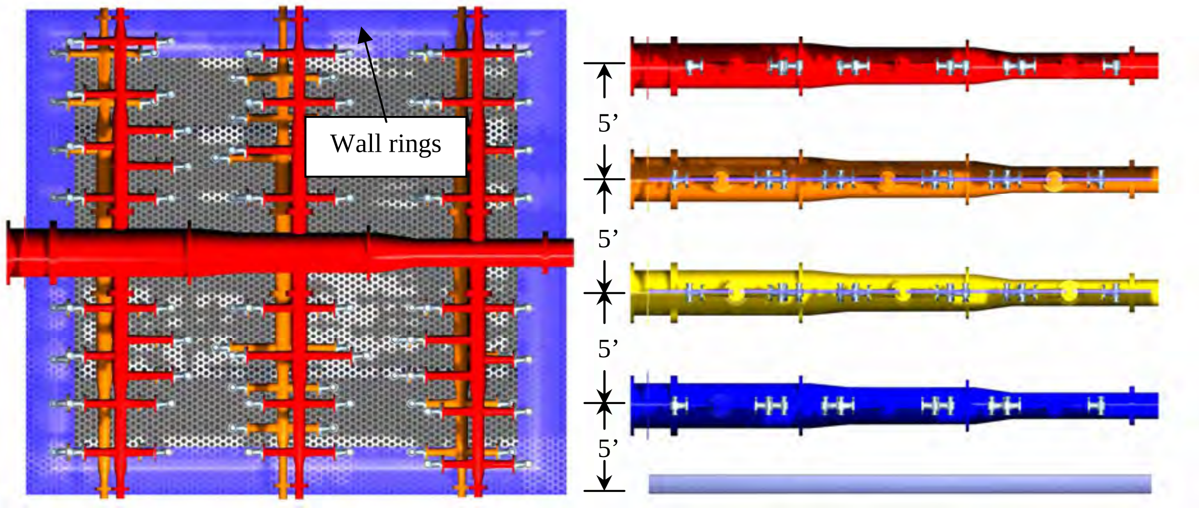
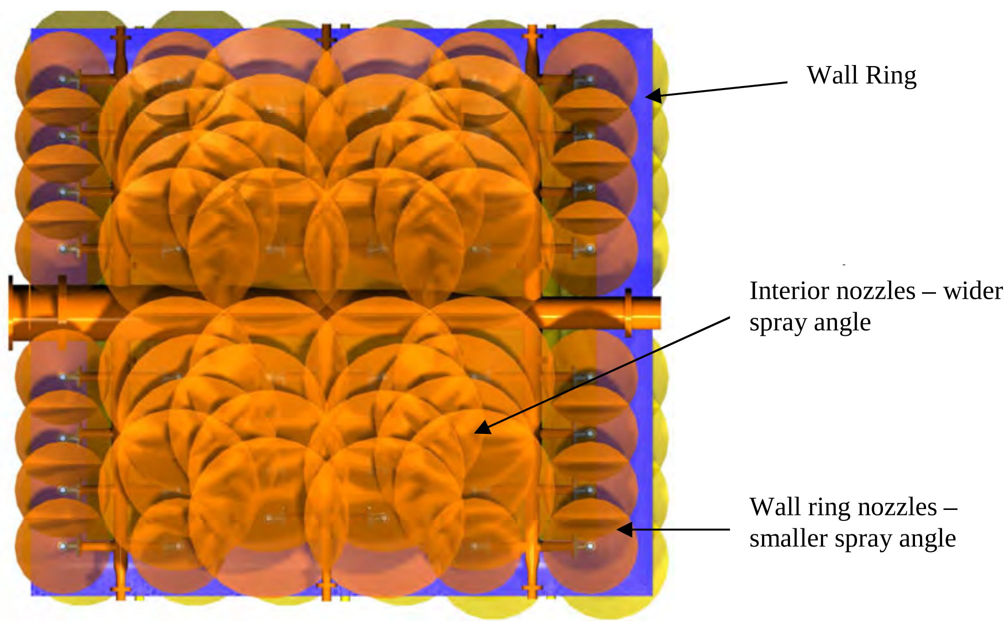



**Figure 15. Modified Nozzle Arrangement**




## 4.4 Spray Nozzles

BPEI proposes installing dual-orifice nozzles on all four spray levels. Spray level 4 will use dual-orifice 'double-down' style nozzles while spray levels 1, 2, and 3 will use dual-orifice 'up-down' style nozzles. Installing dual-orifice nozzles on all four spray levels maximizes surface area available for liquid to gas contact. Dual-orifice spray nozzles increase the number of droplets and the number of droplet collisions (when measured against single-orifice nozzles) by increasing the amount of spray area from the same total nozzle flow. Increasing the number of droplet collisions results in smaller droplets and a significant improvement in $SO_2$ removal efficiency due to increased intimate contact between flue gas and slurry droplet.

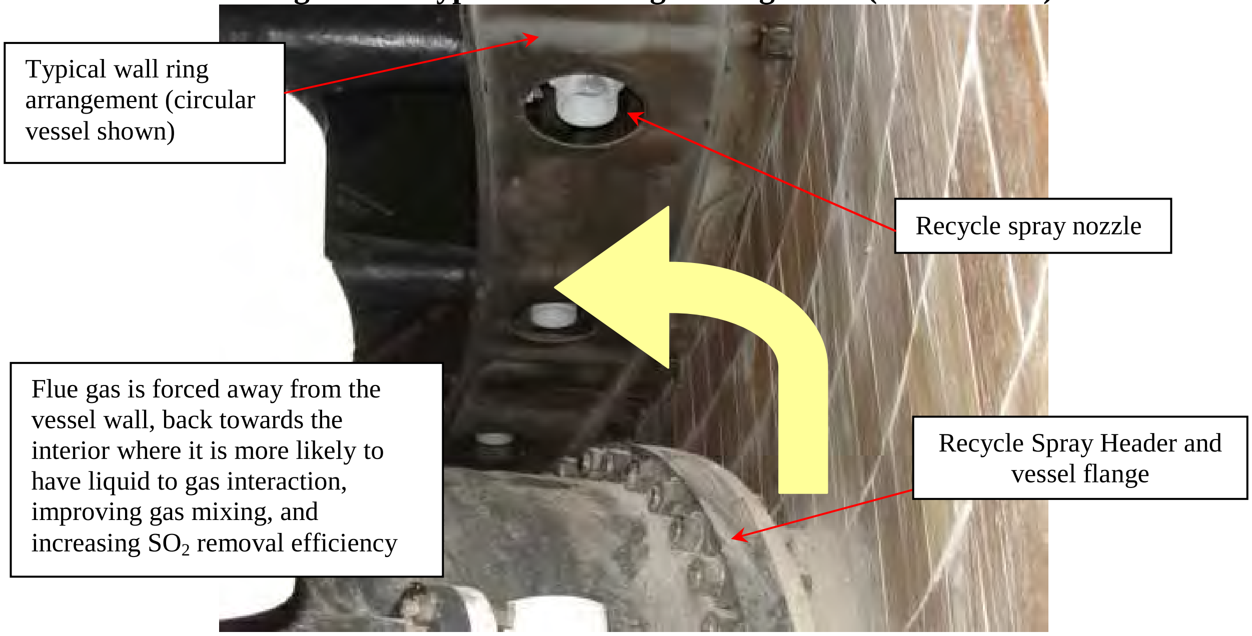
Up-down nozzles have the additional benefit of increasing the residence time of droplets in the absorber by doubling the slurry spray height. Spray level 4 utilizes double-downward nozzles to minimize carryover into the mist eliminator section. Figure 16 is an example of a bi-directional spray nozzle being tested.

**Figure 16. Bi-directional Spray Nozzle Testing**

### 4.5 Wall Rings

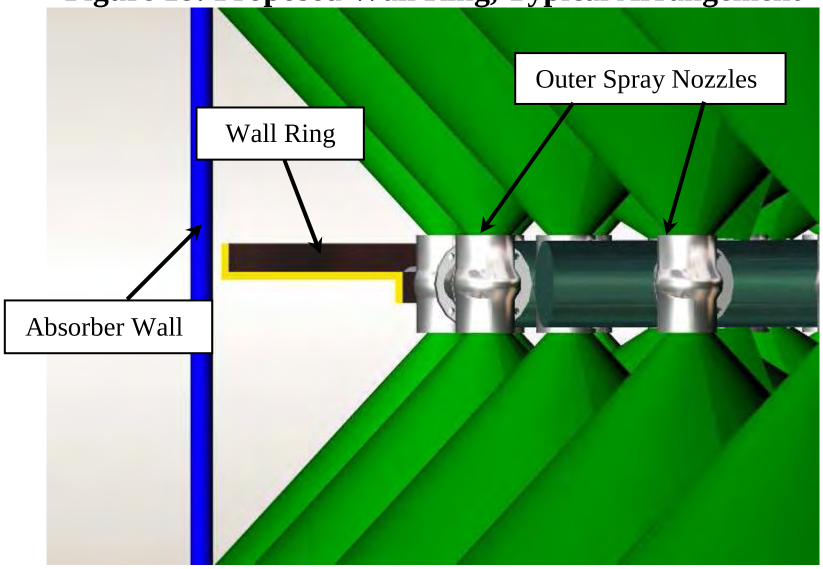
There is a physical limit to the degree of spray coverage along the wall of the absorbers especially in the corners of square reactor modules. Increased flue gas flow is expected along the wall because of the decreased resistance from this reduced coverage. BPEI will add wall rings to deflect flue gas from the absorber wall into the interior of the absorber where there is a greater chance of interaction with recycle spray droplets. This also promotes more thorough mixing of the flue gas, ensuring no areas of high $SO_2$ concentration along the walls are allowed to bypass the effective spray zones. Figure 17 shows a typical wall ring installation in a circular, tile-lined vessel.

**Figure 17: Typical Wall Ring Arrangement (Ghent Plant)**




Wall rings will be added at spray levels 2 and 3 to maximize the benefit of contacting flue gas with the slurry spray while minimizing the impact on pressure drop across the absorber. Preliminarily, the pressure drop increase is expected to be minimal. Figure 18 is a graphic representation of the wall rings proposed for Mill Creek absorbers.

**Figure 18: Proposed Wall Ring, Typical Arrangement**




## 4.6 Recycle Pumps

Two options were considered for the recycle pumps. The first is to replace the current equipment with pumps appropriate for operation up to 50,000 ppm chlorides. This alternative will require new foundations for the pumps plus new electrical and (spray header) piping. A second option is to rebuild the pumps. This second option would allow the foundations, electrical and riser pipes to be reused. However, the allowable chloride level of the rebuilt pumps will be 5,000 ppm as discussed below.

### 4.6.1 New Recycle Pumps

As discussed earlier, the L/G ratio on Unit 4 absorber treating Unit 3 flue gas is more than adequate for high removal efficiency, once modifications are completed to increase the spray zone and spray coverage. Increasing the spray header elevation raises the recycle system resistance increasing in the total dynamic head (TDH) required. The new recycle pumps will be similar to the existing direct drive recycle pumps except they will be designed to handle higher chloride concentrations and increased TDH requirements. Figure 19 contains photos of recycle pumps designed for high chloride operation on smaller units.

**Figure 19. Recycle Pumps**

The recycle pumps are important to this project because they are utilized to pump a mixture of ground limestone slurry and gypsum crystals from the reservoir of the flue gas absorbers to a series of manifolds, from which the slurry is sprayed in the top of the absorber so as to combine with flue gas for the purpose of reducing the sulfur content of the gas. The flow rate and head of the slurry, plus resistance to abrasion and corrosion by the slurry, are the primary performance characteristics of interest in the recycle pumps.

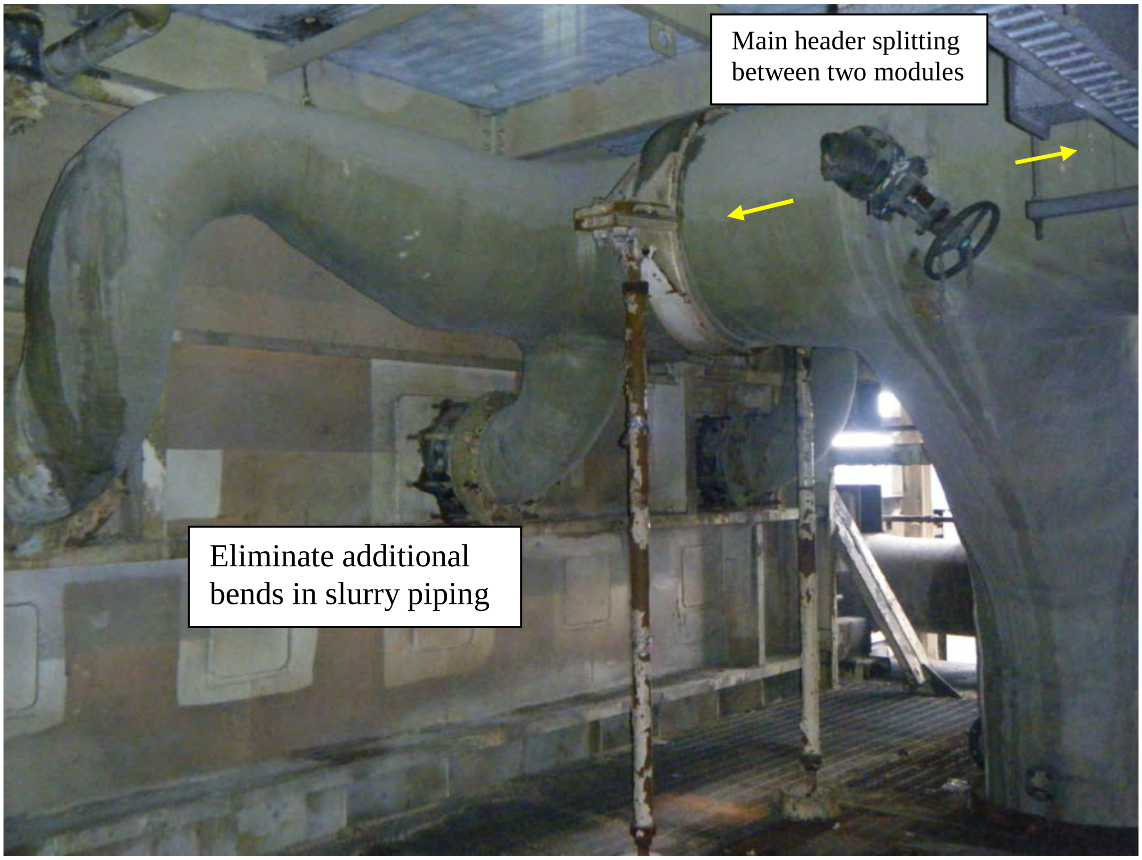
The critical performance parameters for the Mill Creek pumps are head and flow, with consideration for required Net Positive Suction Head (NPSH). Babcock Power is planning to supply Duchting recycle pumps for the LG&E-KU Mill Creek Project.

The Duchting pump has an iron shell with a cast-in-place liner and impeller made of a composite of silicon carbide grains with an epoxy binder. The Duchting cast composite liner has been reported to provide excellent service at KU Brown Station, Alcoa Warrick Station and in a number of European installations. BPEI has had 26 Duchting pumps in service for the past 3 years with very good performance. The Duchting ceramic/epoxy has the highest protection against erosion but would tend to be less resistant to corrosion and erosion should pH level drop or chloride level increase beyond the warrantee limits.

Duchting Pumpen has been building and selling gypsum slurry service pumps since 1992. They have well over a thousand pumps in service throughout Europe and Asia. There are about 135 gypsum slurry service pumps of the same size (or larger) than those required for the Mill Creek project in service around the world. The pump-wetted parts are a cast silicon carbide material in an epoxy matrix binder. Wear characteristics are claimed to be several times that of abrasion resistant metals. The Duchting pumps would be serviced in this country by Duchting Pumps North America out of Middleton, MA.

The existing recycle piping is 36" in diameter. The slurry velocity of 8.7 ft/sec is within the limits of 5 to 10 ft/sec recommended by BPEI. When the recycle piping splits between the two absorbers the slurry velocity increases to 9.8 ft/sec. The slurry piping can be replaced in kind. Effort will be made to minimize the number of bends. Figure 20 is a photo of the existing Unit 4 spray header.

**Figure 20. Spray Header**




### 4.6.2 Rebuilt Recycle Pumps

LG&E-KU requested that BPEI evaluate the existing recycle pump for use with an upgraded absorber. Unfortunately, based on discussions with the recycle pump supplier, the pump materials of construction are designed to handle 5,000 ppm chlorides and would therefore be unworkable for high chloride operation. A summary of the pump materials, as received from the supplier, is outlined on Table 7. There is no data available to indicate that these materials of construction have been changed since the original pump installation. From a capacity standpoint, BPEI's preliminary review indicated that new gear boxes and a pump rpm increase of less than 10% would provide the necessary flow rate at the higher TDH required with the upgraded absorber.

**Table 7. T2 Commercial Specification**

I. SCOPE:

ASTM A532-IIIA Abrasion resistant cast iron for use where corrosion as well as abrasion resistance is important. Use at Svedala-Thomas includes but is not limited to Pumps, Impellers, and Side Liners, A thermal treatment is used to obtain optimum wear resistant properties.

II. CHEMICAL COMPOSITION:

| | | C | Mn | Si | Cr | Mo | Ni | S | P |
|---|---|---|---|---|---|---|---|---|---|
| ASTM A532-IIIA | Min: | 2.0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 |
| | Max: | 3.3 | 2.0 | 1.5 | 30 | 3.0 | 2.5 | 0.06 | 0.10 |

III. PROPERTIES:

A. Metallurgical:

A chemistry is chosen within the above limits that is mid-range in carbon and Chromium with enough hardenability (i.e. Mn, Ni, and Mo) to produce a microstructure of approximately 30% M7C3 carbides held in place by a matrix of Martensite and Retained Austenite.

B. Mechanical:

1. Hardness: >650 BHN (i.e. > 58.6Rc or 712 VPH)
2. Tensile strength 90[6]: - 110 KSI (i.e. 600-750 MPa)
3. Fracture Toughness[6]: 23 - 30 KSI-IN^1/2 (i.e. 25 - 33 MN/m^2/3)

### 4.7 Agitators and Oxidation Air Lances

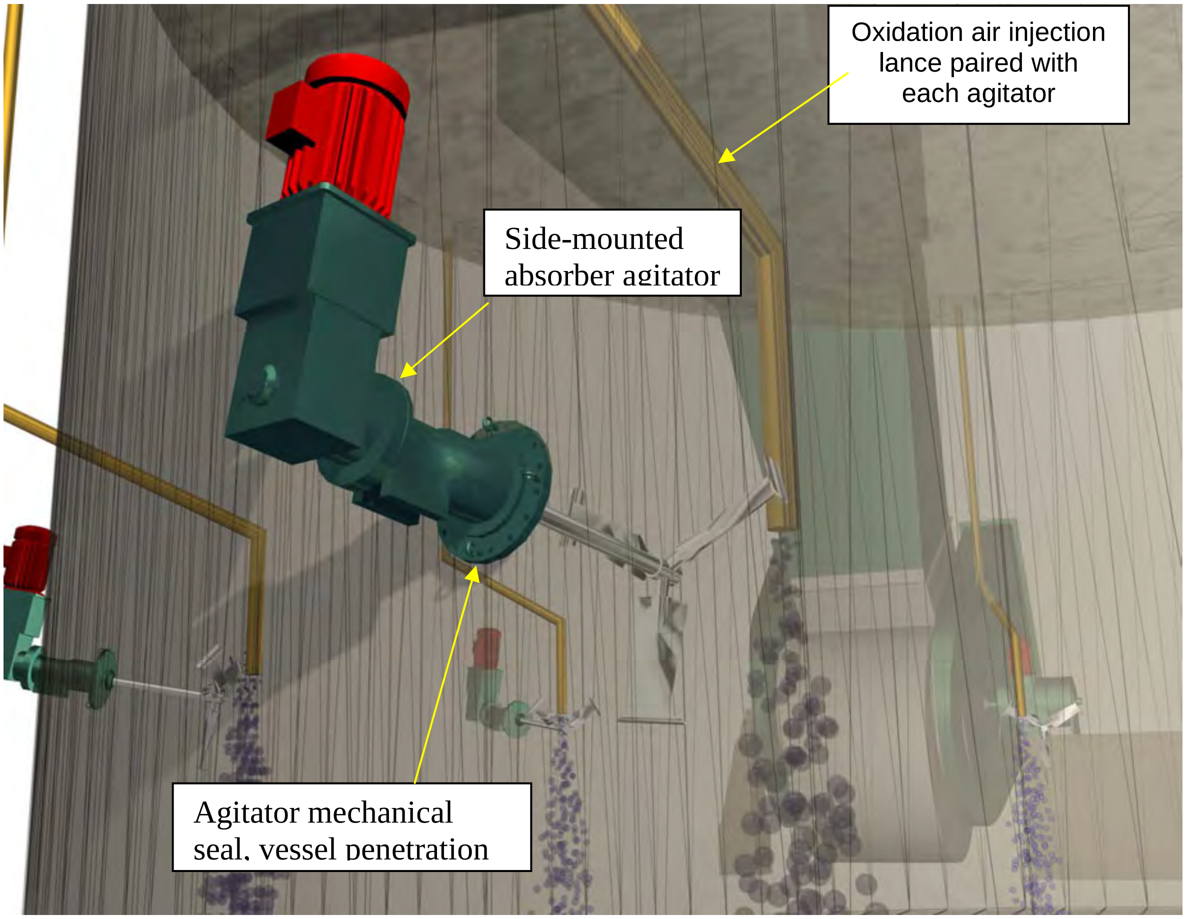
Poor mixing of injected oxidation air and absorber slurry can reduce the performance of the absorber. The oxidation air sparger ring currently installed requires higher oxygen to $SO_2$ ($O:SO_2$) ratios to provide enough excess air to complete the reaction of $SO_2$ removed by the absorber to gypsum. BPEI recommends adding agitator and air lance assemblies which will reduce the $O:SO_2$ requirements, increase agitation in the absorber allowing the absorber to be maintained at design solids concentration, improve reactivity by decreasing excess limestone in the absorber, and most importantly, improve reliability of the WFGD system. Oxidation air lances will be between 8” and 10” in diameter, which will eliminate issues with pluggage even if the oxidation air blower is out of service for several hours. Figure 21 show a photo of agitators and oxidation air lances on a Stebbins tile-line reaction tank. Figure 22 is a graphical representation of the agitator air-lance assembly. Agitators will be appropriately spaced from the recycle pumps to avoid entraining air in the recycle pump suction and causing cavitation. The

[6] The most useful properties of abrasion resistant cast iron are its hardness and carbide content. Carbide content is established by Carbon and Chromium values. Hardness is usually the only property that is determined in practice. The determination of tensile strength and toughness is very difficult, and has little bearing on the intended use of the castings other than obvious ones (i.e. absence of fracture). These facts are generally recognized in standards of abrasion resistant cast iron. Tensile strength and Toughness are not part of this specification and are given for information only.

number and size of agitators and air lances required is a function of the reaction tank diameter, absorber slurry level in the reaction tank, and volume of oxidation air required to maintain full oxidation.

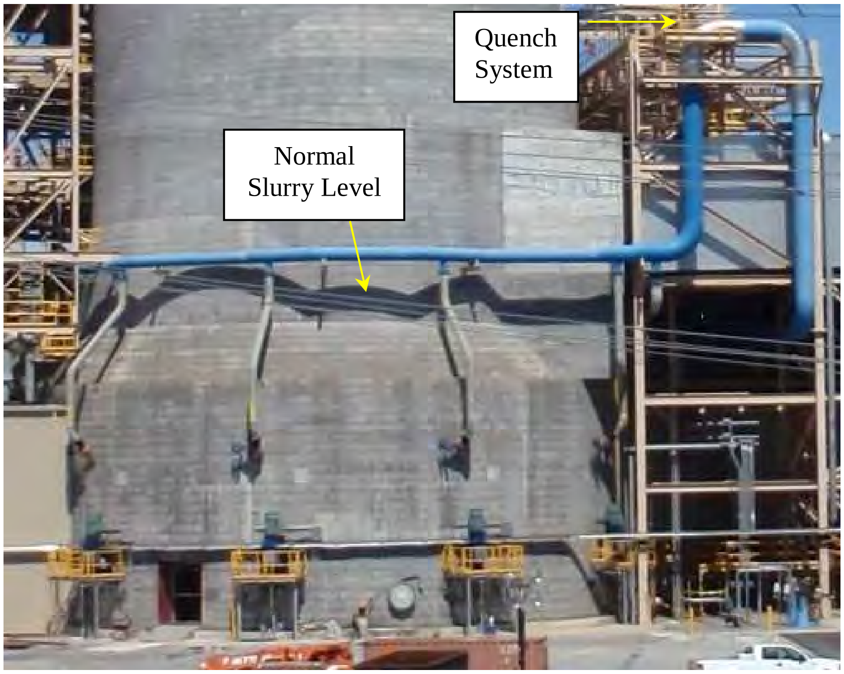
**Figure 21: Oxidation Air Lances and Agitator Impellers in Tile-Line Tank**

**Figure 22. Agitator Air Lance Assembly**




The oxidation air piping is designed that if the oxidation air blowers do trip out of service, slurry will not back up into the air sparger system because the oxidation air distribution ring is physically located above the reaction tank slurry level. Figure 23 is a photo of the oxidation air distribution ring at Brown Station.

**Figure 23: Oxidation Air Distribution Ring and Agitators**




Oxidation air rate required for the high sulfur, high $SO_2$ removal is 14,000 scfm with a supply pressure of 7.2 psig. The existing air compressors are capable of maintaining adequate airflow. The piping system will include an adjustment valve on each air lance to evenly distribute airflow. Quench requirements are much reduced compared to the quench rates currently maintained (10 gpm vs. 100 gpm). A quench system will be installed at each ring header with 1 operating and 2 spare quench nozzles.

Physical modeling is recommended to verify mixing and ensure the oxidation air can be dispersed in the reaction tanks to complete oxidation. The upgraded Unit 4 may require a higher $O:SO_2$ ratio than is typical for WFGDs because of the small reaction tanks, but preliminarily, the blower appears to have the capacity to accommodate higher air flows if necessary.

Agitator design is as much an art as it is a science. While agitators appear as relatively simple science, their operational parameters are complex and difficult to theoretically model. Further, agitators are one of the most critical components in the oxidizing WFGD absorber. If the agitators' operation is even marginal, serious operational problems will develop in areas including: gypsum quality, absorber efficiency, scaling and slurry settling. In the case of the Mill Creek WFGD program with reliability requirements being extremely important, design conservatism is requisite. Ekato is the clear leader in successful agitator experience for WFGD service that disperses oxidation air (mass transfer) to the slurry.

The WFGD oxidizing absorber agitator characteristics: mixing, erosion and corrosion resistance, mass transfer capability, resistance to flooding, torque and horsepower are the primary performance characteristics of interest. These key technical parameters were evaluated for Mill

Creek Unit 4. On all of these key performance parameters, Ekato emerges as the clear leader because:

- Mixing: Torque is key to adequate mixing. Ekato has the highest torque values as compared to the other vendors and is capable of provide the highest comparable level of mixing.
- Erosion Resistance: Erosion resistance is a function of impeller blade tip speed and impeller design. Ekato has low blade tip speeds as well as their proprietary “Wingjet” blade tip designed to minimize erosion.
- Mass Transfer Capability: A larger impeller is greatly preferred over high RPM for mass transfer. Ekato has the largest impellers as compared to the other manufacturers.
- Resistance to Flooding: Larger and lower RPM impellers have the best flooding resistance. Ekato has the largest impellers with comparative low RPM operation.
- Torque and Horsepower: These factors are related to mass transfer and mixing, the larger these figures are the better. Ekato has the highest operational torque and horsepower values.

In addition to the primary performance parameters, Ekato offers the following features that are a factor in critical operational parameters and experience issues:

- Ekato has more experience in oxidizing scrubber absorber agitator technology than any other manufacturer.
- Ekato has the most experience with mechanical seals in FGD operation.
- Ekato has a robust agitator shaft assembly
- The Ekato Impeller is a one piece monolithic cast design
- Ekato mounts their agitator about 2-2.5 impeller diameters off of the floor of the absorber, reducing risk of being locked in slurry during start-up.
- Ekato’s proprietary “WingJet” impeller is designed to provide more efficient mixing and mass transfer (oxidation air dispersion) with less erosion.

### 4.8 Mist Eliminators and Mist Eliminator Wash

Munter’s DV210 Mist Eliminators are an alternative to traditional flat mist eliminator arrangements and is the only known ME that will provide the de-misting and particulate removal performance BPEI demands. Figure 24 is a photo of a DV210 installation. The installation of a single layer benefits installation time and requires only one layer of support beams instead of two. Figure 25 is a graphic of the ME design typical in open spray tower systems.

**Figure 24: DV210 Mist Eliminators**

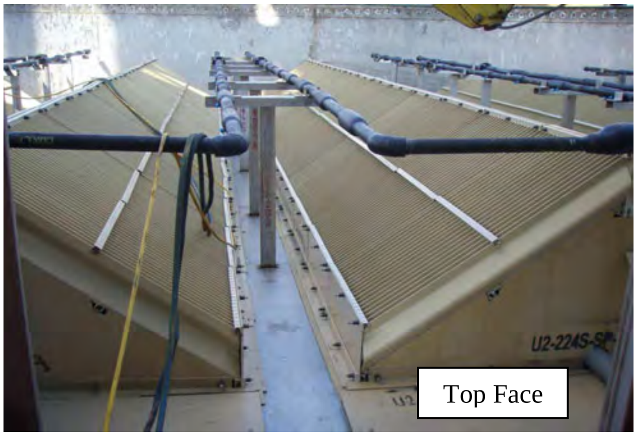
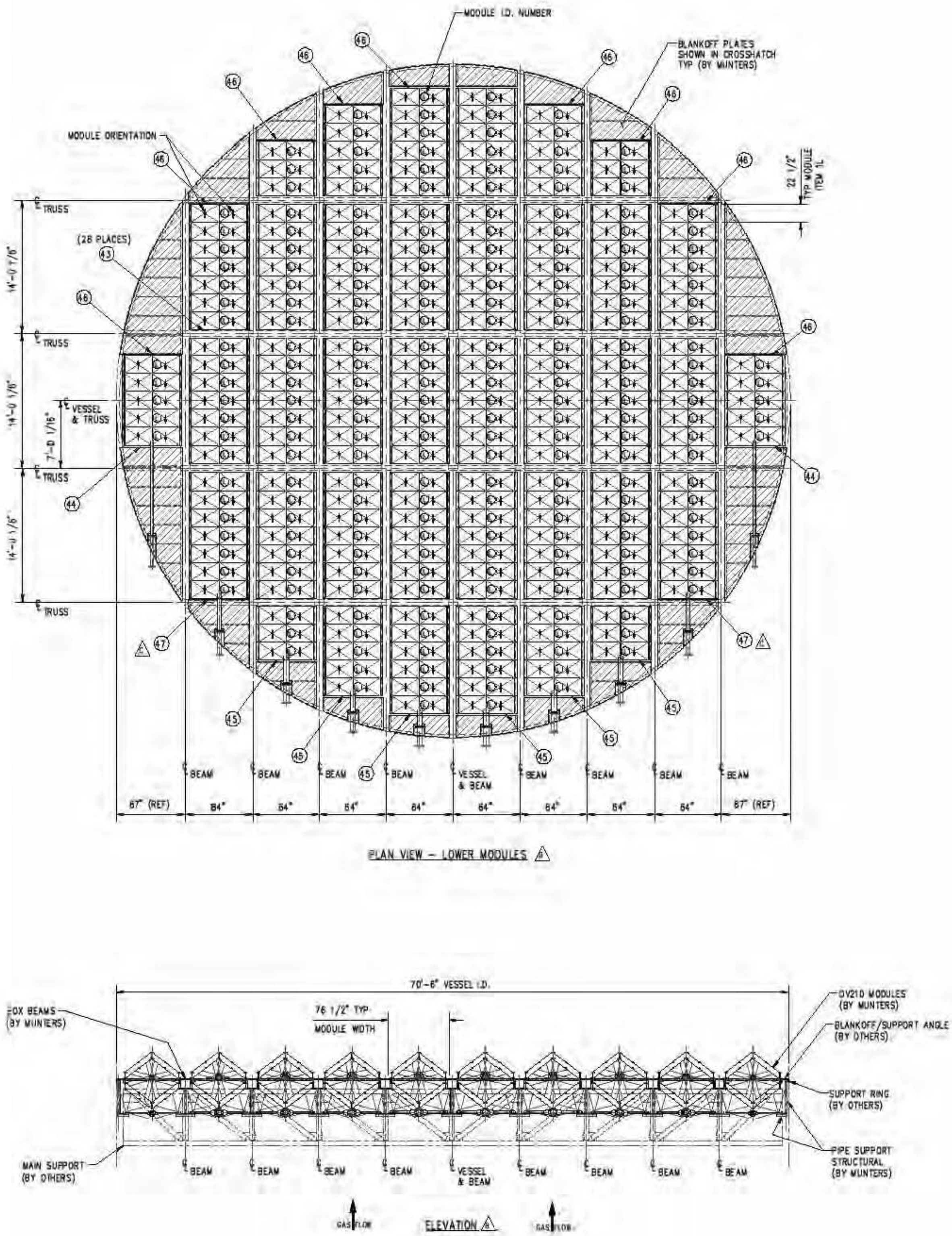



**Figure 25. Mist Eliminator Layout**



The purpose of the Mist Eliminators (ME) in a WFGD system is to remove the slurry mist entrained in the flue gas. If not removed, the mist can lead to the buildup of solids and liquid in the downstream ductwork and stack; corrosion of downstream equipment, ducts, and stack liner; and stack "rain" (emission of liquid, solids or slurry) to the area surrounding the plant. The physical and chemical environments in which the MEs operate require that the ME system (including the wash system) be carefully designed to ensure the reliability of the FGD system.

The critical performance parameters for the design and selection of the mist eliminators are: the ability to successfully remove mist from the flue gas stream (to the required droplet size), the spray wash system effectiveness, pressure drop across the ME, liquid drainage capability and re-entrainment, corrosion resistance, design (flat versus peaked) and expected life.

Munters has significant empirical data for the DV210 including third party engineering and testing analysis. Fisia, Licensor of BPEI WFGD Technology, has amassed significant data on the combined scrubber and DV210 performance for the collection of fly ash particulate.

The Munters DV210 peaked design adds an additional margin of performance not possible with traditional flat "pancake" type mist eliminator designs. Their angled design and multi-pass configuration traps wash water on their surface longer as it migrates to the lower inverted peak of the first pass stage. This makes the wash water more effective on a volumetric quantity basis and allows a longer coalescing path for the mist. The slower migration of the water down the profile of the blades is more effective at limiting re-entrainment of the water into the gas stream than other mist eliminator types. Further, these blades remain wetted longer (between wash cycles); provide an effective capture surface using the adhesive properties of water to more effectively capture particulate matter as compared to other designs. This, coupled with historical operational data, is the primary reason for specifying the Munters DV210.

The support structure for the Munters DV210 Mist Eliminator is a single level support. The "diamond" design of the DV210 extends with the lower ME section below the support structure and the upper section placed on top of the support structure. This is in contrast to the standard flat ME design where each stage requires a dedicated level of support. The DV210 (2-stage) can provide full ME capabilities in a 6' vertical section of the absorber whereas the flat 2-stage design requires 9' and is less efficient at coalescing the mist. The DV210 design provides savings over the flat ME design in two ways: first, a lesser quantity of exotic metal is used to support the ME and secondly, the vessel height can be reduced by the amount of ME depth difference between the two design types. This is an approximate 3' savings in absorber structure as well as foundation and structural steel costs.

Maintenance requirements for the Munters DV210 mist eliminator are minimal and consist of periodic inspections as long as it is operated within the specified design constraints and is spray washed in accordance with the manufacturer's recommendations. The Munters DV210, when operated in accordance with the manufacturer's guidelines, should provide an operational life of about 15 years. This expected life is in contrast to typical flat designs with life expectancies anywhere from 5 to 15 years.

As explained earlier in section 2.5, BPEI highly recommends evaluating the source of water used for ME wash. There are several papers to support the conclusion that utilizing water that has even a fraction process liquor or filtrate causes scaling issues in the ME wash piping and on ME elements. Scaling of ME elements increases pressure drop and the potential of carryover into the outlet ductwork. ME elements can also scale to the degree that they fall through supports in the reaction tank causing pluggage in recycle slurry piping and spray nozzles. Clean, filtered water should be used. BPEI recommends an automatic, self-cleaning filter to handle the relatively high solids normally associated with Ohio River water.

The ME wash logic should be reviewed to ensure adequate ME wash is maintained while minimizing fresh water makeup to the WFGD system. The control logic will adjust wash frequency based on minimum requirements from the manufacturer and unit load. Clearwell Pond water can still be used to control absorber level by directly adding water to the absorber reaction tanks. It is also recommended to use clean service water for oxidation air quenching and for the emergency quench system.

### 4.9 Process Chemistry and Controls

The control logic will be revised as necessary to maintain appropriate ME wash frequency, maintain absorber level, maintain absorber density, and maintain $SO_2$ removal. ME wash frequency will be reviewed to maintain appropriate wash cycles but minimize excessive service water usage. Absorber level and density will be optimized to maximize liquid and solids residence times to maximize limestone utilization and gypsum quality. The logic for $SO_2$ removal will include feed forward logic with feedback trims to optimize $SO_2$ removal control and limestone slurry feed.

### 4.10 Absorber Vent and Overflow

The absorber reaction tanks will be modified to accommodate side-mounted agitators coupled with oxidation air lances. The reaction tank top will be replaced to eliminate any flue gas discharge from the reaction tank. The vent from the reaction tank will be re-routed to the absorber instead of venting to atmosphere. It is recommended to vent the reaction tank to the absorber to make sure there is no liquid carryover into the outlet duct. The absorber overflow will be redesigned so that the overflow is directed to a seal pot to prevent flue gas venting out of this line.

### 4.11 Bleed Pumps

BPEI recommends improving the reliability of the absorber bleed system so that absorber slurry density can be maintained within higher controlled limits to maintain 15-18% slurry density in the absorber reaction tank. Improving the reliability of the bleed system to operate at higher solids concentration will improve limestone utilization as a result of increasing the solids residence time in the reaction tank. Besides replacing the bleed pumps and control valves to handle the higher chlorides, BPEI recommends installing orifice(s) on the bleed return line to the reaction tank. The purpose of the orifice(s) is to keep the pump running on the same part of the pump curve by evening the pressure drop between bleeding to the hydrocyclones and bleeding back to the reaction tank. When the bleed pump is designed to run on the same part of the pump curve, power consumption and pump performance is optimized. Figure 26 is a photo of bleed pumps installed at Brown Station.

**Figure 26. Bleed Pumps at Brown Station**

The Duchting pump was evaluated over other pumps and determined to be the technologically superior choice. Some of the more significant issues supporting the selection of the Duchting pump include:

- Lowest operating noise levels
- Exceptional chemical and corrosion resistance
- Erosion resistant SiCast construction
- Low operating speeds
- Best power efficiency
- Motor direct coupled to pump
- Same pump supplier as recycle pumps

The Duchting pump is a SiCast (Silicon Carbide cast in an epoxy matrix) construct that is well proven in other components for absorber slurry service. Both the pump casing and impeller are constructed of this SiCast material. This material is similar to the material used in absorber spray nozzles which experience little to no detectable wear. The proprietary SiCast product used by Duchting differs from the standard nozzle type silicon carbide type materials in that the ratio of silicon carbide to epoxy for the Duchting SiCast is considerably greater at an 80% to 20% average ratio. Typical spray nozzles have only a 50% to 60% silicon carbide concentration. This higher SiCast content product is more resistant to erosion than products with a lesser silicon carbide percentage. Even though the velocities in the Duchting pump are the lowest, it probably matters little in that the SiCast material is far more resistant to abrasion and erosion than either of the other manufacturers' materials. From this, it is reasonable to conclude that the life of the Duchting pumps in these applications may significantly exceed the life of other types of pumps.

Strainers should be added in the suction line to the bleed pumps to screen any solid scale that may be present in the absorber reaction tank. The strainers will increase the life of the bleed pump impellers and reduce the potential for pluggage in the hydrocyclone assembly.

### 4.12 Hydrocyclones and Underflow Tank and Pumps

BPEI recommends replacing the hydrocyclone assembly with an assembly that has bigger vortexes and apexes. This will reduce the amount of pluggage without a negative impact on performance or increased bleed pump TDH. The assembly will have the proper instrumentation to monitor performance remotely from the DCS and be designed to handle the higher chloride concentrations. Figure 27 is a photo of hydrocyclone assemblies for a smaller WFGD system (< 500 MW).

**Figure 27. Hydrocyclone Assemblies**

The hydrocyclone absorber overflow will still be directed to an overflow tank where a purge stream can be maintained to control chloride concentration. The remaining fraction will be directed back to the reaction tank. At the reaction tank the return line will include a section of piping that drops below the normal slurry level to prevent any off-gassing through the overflow return when they hydrocyclone assembly is not in service.

A state of the art design hydrocyclone similar to the Krebs unit installed at the KU Brown WFGD system is recommended for this absorber upgrade.

No issues were brought up regarding the underflow tank and pumps. However, they probably require replacement to accommodate the higher chloride design.

### 4.13 Physical Flow Modeling

BPEI recommends physical modeling of planned modifications. Changes to ductwork (Unit 3 into Unit 4 Scrubber) can result in unforeseen gas dynamics that could be detrimental to the process if the appropriate internal flow control devices are not installed. BPEI makes extensive use of modeling technology for retrofit modifications such as those proposed for Mill Creek Generating Station. Some of the applications of this modeling are as follows:

- Prediction of gas distribution at the absorber inlet and into the first spray level
- Prediction of gas distribution and slurry spray distribution within the absorber spray zone
- Prediction of absorber sump recirculation for agitator performance as it relates to both suspension of solids and distribution of oxidation air for maximum effectiveness

Typical physical models are scaled for geometry and operate at full gas velocity, with the mist eliminators modeled in full scale. For this type of model, BPEI is able to analyze gas flow behavior at the gas inlet, entering, within the absorber, leaving the spray zone, and entering and leaving the mist eliminators. The results of these model tests are incorporated into the actual absorber design (ductwork layout, spray header layout, nozzle spacing, etc.) to ensure controlled gas behavior, uniform gas flow, high liquid-gas contact for maximum efficiency with installed components, and uniform gas flow to the mist eliminators for consistent mist elimination from the flue gas. Figure 28 shows examples of physical models constructed to test flue gas distribution, absorber inlet design, and mist eliminator performance.

**Figure 28. Examples Physical Models Tested on other BPEI Projects**

Ductwork to Absorber

Absorber Inlet and Absorber

## 5. PROJECT PLAN

Babcock Power Environmental, Inc. has developed a preliminary Project Plan that capitalizes on its engineering, product fabrication, installation, and startup expertise to provide LG&E-KU Services Company with an efficient retrofit design that provides a low project price and a short outage schedule.

The fully upgraded Unit 4 absorbers will be finished and available for service on November 17, 2014 at the completion of an 8-week outage on Unit 4. Flue gas from Unit 3 can be processed in the upgraded Unit 4 absorber once the blank off plate is removed during a one-week outage on Unit 3 scheduled in the Fall of 2014.

### 5.1 Basis of Design

The Basis of Design for this Project Plan is to remove of 98% $SO_2$ at either 12,500 ppm or 50,000 ppm chlorides. It is this design basis that dictates the materials of selection for Babcock Power to offer LG&E-KU Services. Babcock Power's Project Plan has been set up to match the materials of construction, the vendor lead times, and the LG&E-KU outage schedule.

### 5.2 Project Schedule

The major milestones for the proposed schedule are shown on Table 8 including engineering, procurement, fabrication & delivery, construction and unit outages. A more detailed description of the activities can be found in the high level schedule in the attachments. Commissioning of the upgraded Unit 4 WFGD system should be completed by 13-Feb-15, but additional general work is scheduled to complete by mid-June. The ongoing general work does not require a unit outage.

**Table 8. Project Schedule – Major Milestones**

| Activity Name | Duration (days) | Start | Finish |
|---|---|---|---|
| Engineering | 175 | 2-Jan-12 | 31-Aug-12 |
| Procurement | 214 | 20-Jan-12 | 14-Nov-12 |
| Fabrication & Delivery | 640 | 23-Jan-12 | 04-Jul-14 |
| Unit 4 2012 Outage (4 week) | 16 | 16-Apr-12 | 07-May-12 |
| Unit 4 2013 Outage (1 week - May) | 6 | 13-May-13 | 20-May-13 |
| Unit 4 2013 Outage (1 week - Nov) | 5 | 11-Nov-13 | 15-Nov-13 |
| Unit 3 2013 Outage (6 week - approximate) | 5 | 01-Nov-13 | 07-Nov-13 |
| Unit 4 2014 Outage (8 week) | 30 | 29-Sep-14 | 07-Nov-14 |
| Unit 3 2014 Outage (1 week - approximate) | 11 | 03-Nov-14 | 17-Nov-14 |
| Construction (general work between outages) | 901 | 2-Jan-12 | 15-Jun-15 |
| Start Up & Commissioning | 75 | 03-Nov-14 | 13-Feb-15 |
| Mill Creek Unit 4 WFGD Upgrade | 901 | 2-Jan-12 | 15-Jun-15 |

Babcock Power has developed its project plan to match KU's outage schedule. Table 9 shows how the proposed work scope has been matched to the outage schedules. The first outage date occurs in April 2012 and will require that Babcock Power be released by 1/1/2012 in order to place orders with vendors and do engineering and fabrication.

**Table 9. Work Scope vs. Outage Schedule**

| Outage Schedule | Work Scope |
|---|---|
| General Work – 2012 to 2014 (ongoing) | Engineer, supply and install recycle pumps<br>Engineer, supply and install oxidation air piping |
| Unit 4 – 4 weeks 4/16/2012 to 5/7/2012 | Evaluate absorber reaction tank walls<br>Install agitator wall boxes<br>Install prefabricated roof panels<br>Install raised floor<br>Install oxidation pipes and supports in the sump |
| Unit 4 – 1 week outage 5/13/2013 and 1 week outage 11/11/2013 | Install all valves and instruments<br>Install bleed pumps<br>Install hydrocyclone<br>Install FRP piping for Bleed/hydrocyclone<br>Install agitators |
| Unit 3 – 6 weeks 2013 outage date fall (no info available) | Install Unit 3 outlet duct blank-off plate |
| Unit 4 – 8 weeks 9/29/2014 to 11/17/2014 | Replace absorber vessel and internals:<br>o Spray headers<br>o Spray nozzles<br>o Wall rings<br>o Mist Eliminator<br>Install recycle pipes<br>Install outlet ducts<br>Install inlet duct<br>Install inlet & outlet expansion joints<br>Install analyzers Sox<br>Install knife gate valves suction and discharge<br>Install emergency quench system |
| Unit 3 – 1 week 2014 outage date fall (no info available) | Remove Unit 3 blank off plate in the ductwork |

## 5.4 Work Scope and Construction Materials

This section provides further details about the Work Scope outlined above and the materials of construction required for both a 12,500 ppm and 50,000 ppm chlorides case.

### 5.4.1 General Work 2012 to 2015

General Work is the work that can be done while the Unit 4 is operating. The general work involves replacing accessible equipment that has spares and also work to prepare components for an upcoming outage. The components of the planned general work are described below. There are approximately four months of general work that is scheduled after the upgraded Unit 4 is commissioned.

**5.4.1.1** *Recycle Pumps*

Babcock Power is planning to remove one recycle pump from service and replace new, one recycle pump at a time with the unit in operation. With the recycle pump out of service, the pump will be disassembled and its foundation removed. BPEI will have a new foundation and wiring system designed and ready to be installed. The first pump will come off line on March 1, 2013 to be retrofitted. The reason the first pump does not start until 2013 is because the pump, foundation and wiring systems will need to be designed and the vendor released to fabricate as shown on Table 10.

**Table 10. Lead Time for General Work Material**

| LEAD TIMES are from date BPI issues Purchase Order to its Suppliers | | Basis: Q1 CY2011 | | |
|---|---|---|---|---|
| Commodity Description | | Material Lead Time | Fabrication Lead Time | Total Lead Time |
| Recycle Pump (SiCast Lined) | | Included | 42 Wks | 42 Wks |

The SiCast-lined recycle pump has a current lead-time, from the date of order placement to shipment, of 42 weeks. This lead-time is based on BPEI's experience with quoting and requisitioning this equipment. BPEI will be ready to begin changing the recycle pumps out March 1, 2013 after engineering has been completed and the pumps can be delivered. BPEI plans to remove and replace one pump per month starting in March of 2013 and ending in November 2013. This schedule leaves one (1) month of float to replace eight recycle pumps

As BPEI replaces the recycle pump foundations we will also set up and pour a new foundation for the bleed pumps. The bleed pumps will be discussed later in section 5.4.3.

**5.4.1.2** *Oxidation Air Piping*

The oxidation air piping will also be installed during general work. BPEI is planning to reuse the existing Mill Creek oxidation air blowers. BPEI will modify the existing oxidation air piping external to the sump to accommodate a ring header for distribution of oxidation air to all lances. The oxidation air piping will be 20" carbon steel piping for the ring header and 8" drops from the header down to the oxidation air lances external to the sump. BPEI estimates it will use 120 hangers attached to the existing tank. This work is scheduled to take place from June 2012 to June of 2013. This work does not need to be completed until the November 2013 outage.

**5.4.1.3** *Structural Steel*

BPEI has not included structural steel in this Mill Creek Unit 4 study. However, we have included the scheduling of the steel repair and or replacement. This work will take place from May 2012 to December 2014. This work is considered general work, which will take place between outages. The anticipated scope of structural steel work will include cover plating, replacement, sand blasting and painting of structural, handrail and grating.

**5.4.1.4** *Duct Between Unit 3 and Unit 4*

This study does not include the ductwork between Unit 3 and Unit 4 that will transfer the flue gas. However, the study does set up a time frame for the owner to install this ductwork. It is anticipated that the ductwork will be installed from May 2013 to August 2013. This time frame will allow the owner or BPEI to engineer, fabricate and ship to the site modules for installation. By installing the support steel and ductwork in May to August of 2013, this will support BPEI in its planning for the eight week 2014 major outage.

**5.4.1.5** *Piping*

The removal and replacement of random sections of piping and tubing is also part of general work and will support new valves and instruments that will be replaced in the two one-week outages in 2013. This random replacement of pipe and tubing will take place while the scrubber is on line and is scheduled from May 2013 to August 2013. Wherever possible, BPEI will replace valves and instruments while the unit is on line.

**5.4.1.6** *Grating*

The final general work activity identified by BPEI is the replacement of the grating around the reactors through which the recycle piping passes. This grating cannot be replaced until the new recycle-piping configuration is developed. The schedule for this work is from April 2014 to August 2014.

**5.4.2 Unit 4 – 4 weeks 4/16/2012 to 5/7/2012**

Given that this 4 week outage is so close to the Notice to Proceed date of 1/1/2012, BPEI will be unable to engineer, procure and deliver vendor equipment. BPEI is planning to use this four-week outage to work the absorber reaction tanks. A purchase order will be issued to Stebbins to evaluate the tile lining, replace the floor and install agitator mounting boxes and nozzles. The mounting boxes and nozzles will be constructed of C-276 material for either the 12,500 or 50,000-ppm chloride option. The C-276 will be purchased from Corrosion Metals due to the short lead-time.

While Stebbins is repairing the wall tiles and possibly installing a new raised floor, BPEI will be designing and procuring precast concrete ceiling tiles for the new absorber reaction tank roof. The current reaction tank roof has many leaks, which allow the slurry gas to escape and corrode the steel supports.

During this outage, BPEI is planning to install new oxidation air lances and air lance supports. BPEI will install one air lance per agitator (5 per sump for a total of 10). These air lances will be constructed of C-276 material 8” in diameter. The air lance supports will also be constructed of C-276 high alloy material.

BPEI will purchase the C-276 alloy steel plate direct from the manufacturer and/or distributor and free issue the plate material to a fabricator to make agitator mounting boxes and air lances. The purchase order will include plate thicknesses, lengths and widths as specified by BPEI’s engineering calculations and drawings.

BPEI plans to use C-276 for the Mill Creek Unit 4 absorber reaction tank internals in either the 12,500 or 50,000-ppm cases. C-276, a nickel-molybdenum-chromium-tungsten alloy, was selected due to its excellent general corrosion resistance and ease of fabrication. This alloy is appropriate for use in environments where resistance to hot contaminated mineral acids, organic and inorganic chloride-contaminated media, chlorine, formic and acetic acids, acetic, acetic anhydride, sea water and brine solutions is desired. The elemental comparison of C-276 is given on Table 11.

**Table 11. C-276 Elemental Composition DATA**

| Element | Min | Max |
|---|---|---|
| Molybdenum | 15.0 | 17.0 |
| Chromium | 14.5 | 16.5 |
| Iron | 4.00 | 7.00 |
| Tungsten | 3.00 | 4.50 |
| Cobalt | -- | 2.50 |
| Carbon | -- | 0.01 |
| Silicon | -- | 0.08 |
| Manganese | -- | 1.00 |
| Vanadium | -- | 0.35 |
| Phosphorus | -- | 0.04 |
| Sulfur | -- | 0.03 |
| Nickel | Remainder | |

C-276 has resisted the formation of grain boundary precipitates in the weld heat-affected zone, making it a candidate for most chemical and petrochemical processing applications in the as-welded condition. The alloy has resisted both general and localized corrosion, including pitting, crevice corrosion, and stress corrosion cracking. C-276 is readily fabricated by welding, using methods similar to those utilized for nickel-based alloys.

### 5.4.3 Unit 4 – 1 week outage 5/13/2013 and 1 week outage 11/11/2013

There are two one-week outages on Unit 4 during 2013: one in May and the other in November. During the May 2013 outage BPEI is planning the following work:

- Remove and Replace Valves and Instruments
- Install a new Bleed Pump
- Install new Agitators in the Absorber Reaction Tank

During the November outage BPEI is planning to do the following work:

- Remove and Replace Instruments not replaced during May
- Remove and Replace the Hydrocyclone
- Remove and Replace FRP piping for the Bleed Pump and the Hydrocyclone

The work listed above is planned for 2013 due to engineering, procurement and fabrication lead times. The commodity lead-time chart, on Table 12, clarifies why this work must be planned for 2013.

**Table 12. Lead Times for 2013 One-Week Outages**

| LEAD TIMES are from date BPI issues Purchase Order to its Suppliers | | Basis: Q1 CY2011 | | |
|---|---|---|---|---|
| Commodity Description | | Material Lead Time | Fabrication Lead Time | Total Lead Time |
| Absorber Agitators | | Included | 38 Wks | 38 Wks |
| Piping (FRP) | | Included | 16-23 Wks | 16-23 Wks |
| Bleed Pumps | | Included | 30 Wks | 30 Wks |
| Misc. Valves & Instruments | | 8-10 Wks | 10 Wks | 18-20 Wks |

#### 5.4.3.1 *Instruments and Valves*

The replacement of valves and instruments will be planned during the 2012 engineering phase. At this time, each valve and instrument will be identified based on the current P&IDs and BPEIs new design. Once the valves and instruments have been identified both BPEI and LG&E-KU will jointly review and select the vendors. BPEI will place a purchase order in 2012 so that work can begin during the general work phase between the outages. BPEI would like to replace as many valves and instruments as possible with the unit in operation. Any valves and instruments that can't be replaced with the unit in operation will be replaced in the May 2013 one-week outage. Any valves and instrument replacement not completed during the May 2013 outage will be completed during the November 2013 outage.

**5.4.3.2** *Bleed Pumps*
BPEI is planning to replace the bleed pumps that pump directly to the hydocyclones. It is BPEIs plan to have four pumps, two per reaction tank. One pump will be operating the second will be a spare. Orifice plate(s) will be installed on the bleed return line to the reactor tank to improve pump performance. The bleed pumps will be sent from the vendor to a skid fabricator for assembly then shipment to the Mill Creek site for installation on the foundation installed before the outage. BPEI has chosen Duchting pumps because they meet both the 12,500 and 50,000-ppm chlorides cases.

**5.4.3.3** *Agitators*
BPEI plans to install (5) side mounted absorber agitators per sump for a total of (10). The new sump penetrations will be installed during the first outage in 2013 as discussed in section 5.4.2. The plan is to install the agitators during the May 2012 one-week outage. BPEI is planning to design and purchase Ekato agitators for the 12,500-ppm chloride option. The agitator blades for the 50,000 ppm chloride case will be a high alloy material with a coating.

**5.4.3.4** *Hydrocyclones*
The last task in this outage is the removal and replacement of the hydrocyclone system with a new state of the art design similar to the Krebs unit installed at the KU Brown WFGD system.

**5.4.3.5** *FRP Piping*
The plan calls for installation of new FRP piping for the Hydocyclone and Bleed systems during the November 2013 outage. Further information about FRP is included in section 5.4.4.2 below.

### 5.4.4 Unit 4 – 8 weeks 9/29/2014 to 11/17/2014 Outage

Up to this point in the discussion of outage work, BPEI has been using the same equipment for either 12,500 ppm or 50,000 ppm of chloride due to the selection of Duchting pumps, which are good for either 12,500 or 50,000 ppm chlorides. BPEI is planning to rework the following items the 8-week outage between September 29, 2014 and Novermber 7, 2014:

- Replace absorber vessel and internals:
  - Spray headers
  - Spray nozzles
  - Wall rings
  - Mist Eliminator
- External Recycle Pipes
- Outlet Ducts (by owner)
- Inlet Duct
- Inlet & Outlet Expansion Joints
- Analyzers SOx
- Knife Gate Valves Suction and Discharge
- Emergency Quench System

The lead times for the materials required for this outage are shown on Table 13.

**Table 13. Lead Times for 2014 8-week Outage**

| LEAD TIMES are from date BPI issues Purchase Order to its Suppliers | | Basis: Q1 CY2011 | | |
|---|---|---|---|---|
| Commodity Description | | Material Lead Time | Fabrication Lead Time | Total Lead Time |
| Large Recycle Isolation Valves - Knife Gate | | Included | 46 Wks | 46 Wks |
| Alloy Absorber/Ductwork (Alloy) | | 8-10 Wks | 24 Wks | 32-34 Wks |
| External Recycle Piping (FRP) | | Included | 16-23 Wks | 16-23 Wks |
| Recycle Internal Spray Headers - FRP | | Included | 26 Wks | 26 Wks |
| Recycle Internal Spray Header Supports-Alloy | | 8-10 Wks | 10 Wks | 18-20 Wks |
| Mist Eliminator | | Included | 26 Wks | 26 Wks |
| Spray Nozzles | | Included | 26-30 Wks | 26-30 Wks |
| Mist Eliminator Support Steel-Alloy | | 8-10 Wks | 14 Wks | 18-20 Wks |

**5.4.4.1** *Absorber Vessel*

The plan is to replace the absorber vessels and internals during the 8-week outage. In order for BPEI to guarantee 98% SO2 removal with either 12,500 ppm or 50,000-ppm chloride, the absorber vessel needs a material upgrade. In the 12,500-ppm chloride level Babcock Power recommends using Incoloy alloy 27-7MO. The chemical composition of this material is given in Table 14.

**Table 14. Alloy 27-7MO Elemental Composition DATA**

| Element | Min | Max |
|---|---|---|
| Molybdenum | 6.5 | 8.0 |
| Chromium | 20.5 | 23.0 |
| Iron | Balance | |
| Copper | 0.5 | 1.5 |
| Nitrogen | 0.3 | 0.4 |
| Carbon | -- | 0.020 |
| Silicon | -- | 0.50 |
| Manganese | -- | 3.00 |
| Phosphorus | -- | 0.03 |
| Sulfur | -- | 0.01 |
| Nickel | 26.0 | 28.0 |

Babcock Power recommends INCOLOY nickel-chromium-molybdenum alloy 7MO (UNSS31277) due to its high strength, ease of fabrication, and outstanding corrosion resistance at an economic price.

The second material choice for the absorber is C-276, which is good for 50,000-ppm chlorides. The composition of C-276 was shown previously on Table 11.

The INCONEL alloy C-276 (UNS N10276/W.Nr 2.4819) is known for its corrosion resistance in a wide range of aggressive media. The high molybdenum content imparts resistance to localized corrosion such as pitting. The low carbon minimizes carbide precipitation during welding to maintain resistance to intergranular attack in heat-affected zones of welded joints. It is used in chemical processing, pollution control, pulp and paper production; industrial and municipal waste treatment and the recovery of "sour" natural gas. Applications in air pollution control include stack liners, ducts, dampers, scrubbers, stack-gas re-heaters, fans and fan housings.

The BPEI plan, with either the Alloy 7MO or C-276 option is to fabricate the four absorbers and ship them to the site in two pieces each. Once at the site, the contractor will set up the two-absorber pieces on the ground and install the new spray headers, nozzles and DV210 mist eliminator. The tray and wall rings will come installed in the modules being sent from the shop. The tray and wall rings will be fabricated out of the same material as the absorber modules.

**5.4.4.2** *Absorber Vessel Internals*

The FGD spray headers and recycle pipe for Unit 4 at the Mill Creek Plant will be constructed of fiberglass reinforced plastic (FRP). This material is being selected based on its compatibility with the application.

FRP is widely used in the chemical and utility industries primarily due to its excellent chemical and erosion resistance. In an Ashland application paper, it was reported that FRP made with epoxy vinyl ester resin has equal-to, or better than, corrosion resistance than alloy C-276 with another paper showing it suitable for use on 70% sulfuric acid up to 108 deg F or saturated chlorine in water up to 210 deg F. As for erosion resistance, one FRP vendor reports the erosion resistance of the FRP liner is actually better than Alloy 2205.

There are no appreciable differences between the FRP offered by the major vendors. All use epoxy vinyl ester resin with either a C-glass (glass fiber) or Nexus (synthetic) veil. There are minor differences between the additives used for the erosion liners with some vendors having proprietary additives and the others using Silicon Carbide (SiC).

Slurry nozzles must be designed to provide not only the desired slurry flow rate, spray angle, and droplet size but they must also survive the abrasive and corrosive environment within the absorber. The nozzles are subjected to erosive slurry on both their internal and external surfaces and may be exposed to high chloride concentrations. Several materials have been used to make slurry nozzles, but by far the material of choice is silicon carbide (SiC). With a Mohs hardness of 9-10, SiC has excellent thermal and abrasion resistance properties and is offered by all the major slurry nozzle vendors.

The Emergency Quench Water System is used to protect the Absorber spray nozzle piping, mist eliminators and mist eliminator wash piping when the Absorber inlet or outlet flue gas temperature is high, or when the number and placement of operating recycle spray levels is not adequate. The quench water system is located in the Absorber inlet and water is supplied via the plant fire protection system. The environment in this location consists of unscrubbed flue gas at 300-350 degrees Fahrenheit.

During a temperature excursion, where the flue gas exceeds 400 degreed Fahrenheit, the Absorber outlet temp may exceed 350 degrees F. When this occurs, the quench water system is activated to protect the equipment referenced above. The fire protection system supplies water to the quench system and quickly cools and flushes the piping. During normal operating conditions the piping is empty and flue gas can migrate through the spray nozzles, up the individual pipes. This operating condition necessitates the use of corrosion resistant materials in the construction of the quench water system. Alloy C-276 has been selected as the appropriate material for the internal ductwork piping.

The recycle pump isolation valves are used to isolate flow to the pump from entering through the suction pipe. The suction valves are located between the absorber sump and the recycle pump. There is not currently a scheduled outage long enough to remove the knife gate valves and send them to the manufacturer for refurbishment, so it is BPEI's recommendation to install new valves into the system. The plan is to make use Tyco in-line gate valves.

## 6. ESTIMATED PRICING

The rough order of magnitude (ROM) price of the retrofit improvements for the Mill Creek Unit 4 WFGD upgrade is summarized on Table 15. This is based on current 2011 dollars without escalation and has an accuracy of +25% to -10%.

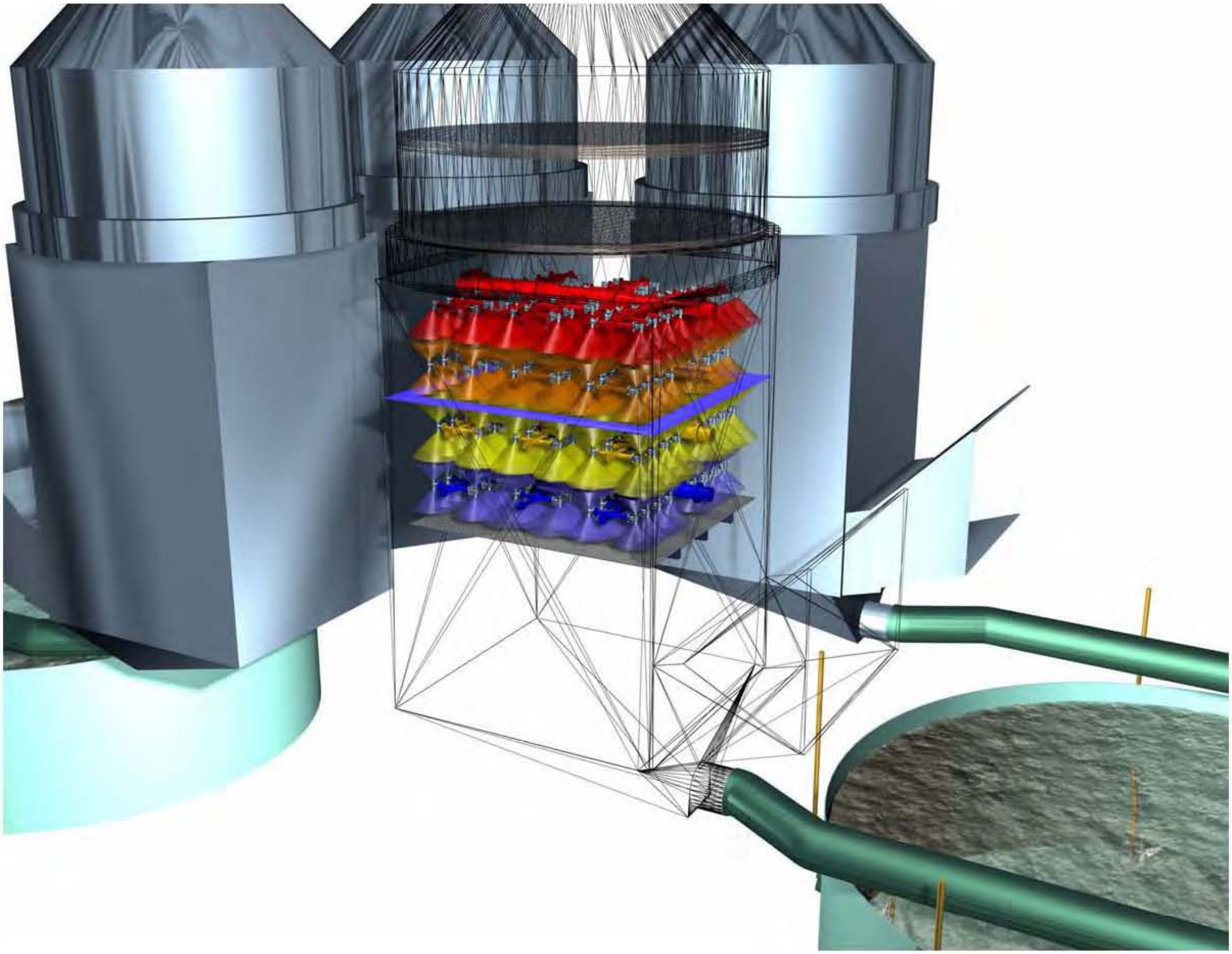
## Table 15. Budget Engineering and Procurement Estimate

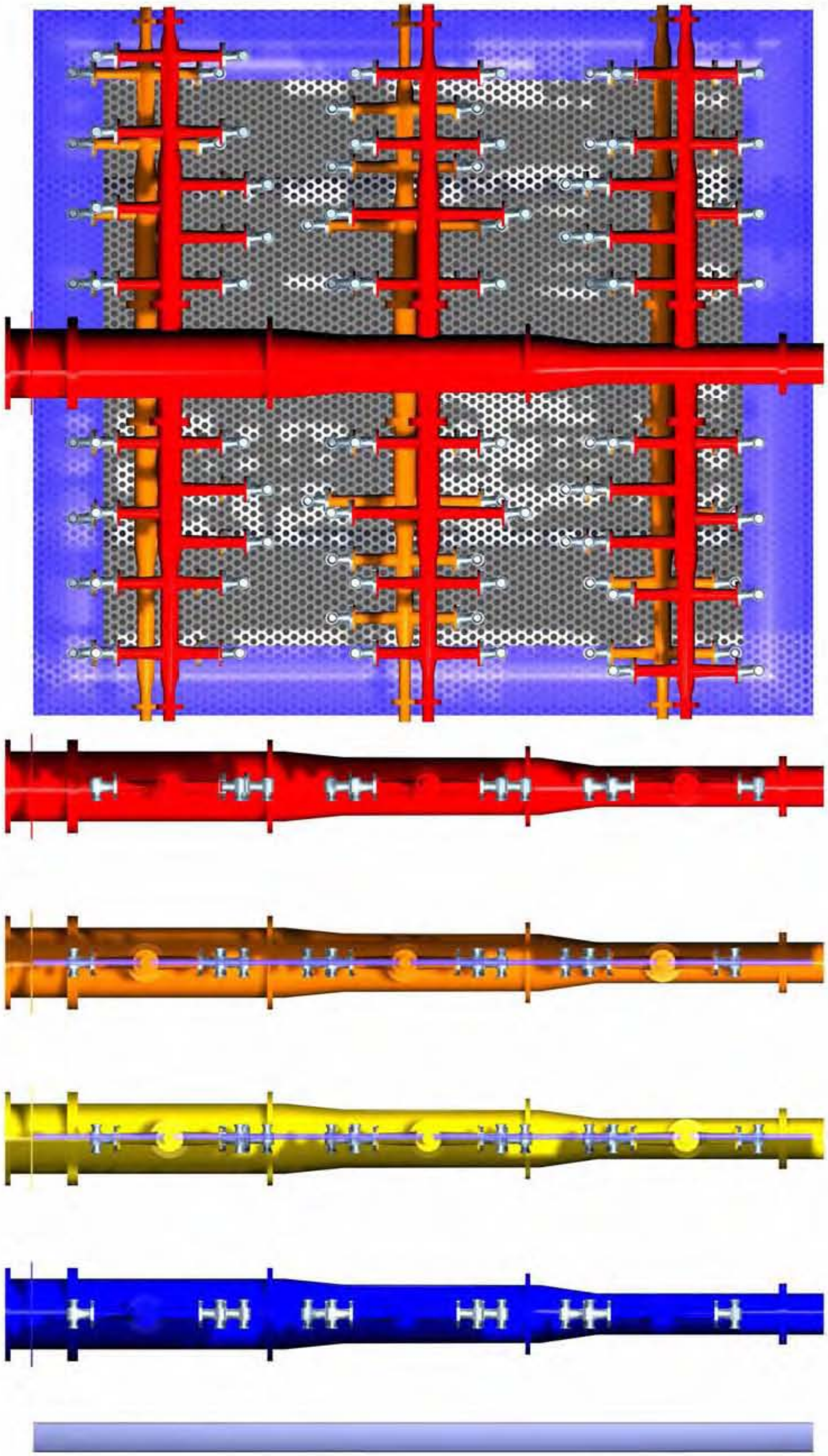
| Description | Engineering Labor | Materials | Total |
|---|---|---|---|
| Case 1:Alloy 27–7MO Unit 4 (12,500 ppm chlorides) | $7,800,000 | $24,700,000 | $32,500,000 |
| Case 2: Alloy C-276 Unit 4 (50,000 ppm chlorides) | $7,800,000 | $27,400,000 | $35,200,000 |

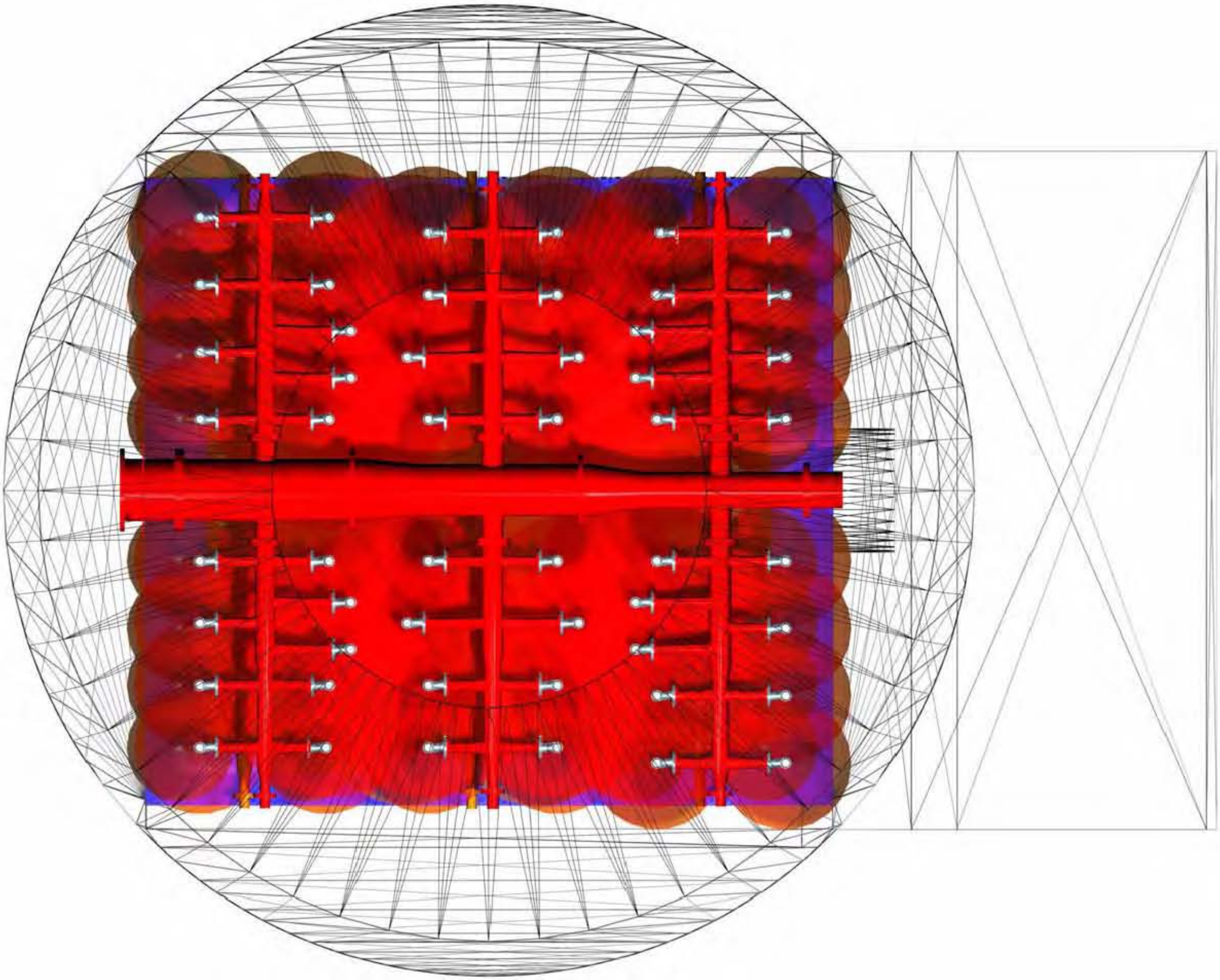
The scope of pricing is limited to the Engineering and Procurement of the retrofit improvements. There are no allowances for BOP work, construction or maintenance upgrades to the WFGD structure. Additional details of this estimate are available in the attachments.

# ATTACHMENTS

# GENERAL ARRANGEMENT DRAWINGS







# MATERIAL BALANCES

DOCUMENT NUMBER:

BabcockPower ENVIRONMENTAL

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| PROJECT NUMBER | 100585 |
| CUSTOMER NAME | Louisville Gas & Electric (LG&E) |
| PROJECT NAME | Mill Creek Unit 3 |
| LOCATION - CITY, STATE | Louisville, KY |
| DESCRIPTION | CASE: Design, 8,000 ppm Cl, no filtrate return |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water |

| | | |
|---|---|---|
| PREPARED | NAME | |
| | DATE | |
| CHECKED | NAME | |
| | DATE | |
| APPROVED | NAME | |
| | DATE | |

REVISION HISTORY

| | | PREPARED BY | APPROVED BY |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

DISTRIBUTION LIST

| | | | |
|---|---|---|---|
| 1 | | 6 | |
| 2 | | 7 | |
| 3 | | 8 | |
| 4 | | 9 | |
| 5 | | 10 | |

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,959,500 | 5,321,479 | 110,824 | 115,803 | | | |
| | lb/hr, dry | 4,726,452 | 4,774,738 | 107,080 | 107,080 | | | |
| Volume Flow | acfm, wet | 1,656,934 | 1,362,302 | 44,249 | 17,558 | | | |
| | scfm, wet | 1,082,405 | 1,206,906 | 25,305 | 12,786 | | | |
| | scfm, dry | 999,348 | 1,012,098 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.37 | 28.27 | 27.95 | 27.31 | | | |
| | lb/lb-mole, dry | 30.31 | 30.24 | 28.50 | 28.50 | | | |
| Density | $lb/ft^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^oF$ | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,529,510 | 3,578,132 | 92,378 | 92,378 | | | |
| $O_2$ | lb/hr | 342,417 | 350,433 | 14,673 | 14,673 | | | |
| $CO_2$ | lb/hr | 826,212 | 845,358 | 29 | 29 | | | |
| $SO_2$ | lb/hr | 26,222 | 393 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 553 | 277 | 0 | 0 | | | |
| HCl | lb/hr | 1,332 | 13 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 233,048 | 546,605 | 3,744 | 7,574 | | | |
| Entrained Moisture | lb/hr | 0 | 136 | 0 | 1,149 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,630 | 39 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 44 | 22 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 235 | 2 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| Stream Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | | | | | | | |
| Mass Flow | lb/hr, wet | | | | | | | |
| | lb/hr, dry | | | | | | | |
| Volume Flow | acfm, wet | | | | | | | |
| | scfm, wet | | | | | | | |
| | scfm, dry | | | | | | | |
| Molecular Weight | lb/lb-mole, wet | | | | | | | |
| | lb/lb-mole, dry | | | | | | | |
| Density | $lb/ft^3$ | | | | | | | |
| Temperature | $^oF$ | | | | | | | |
| Pressure | iwg | | | | | | | |
| | psig | | | | | | | |
| $N_2$ | lb/hr | | | | | | | |
| $O_2$ | lb/hr | | | | | | | |
| $CO_2$ | lb/hr | | | | | | | |
| $SO_2$ | lb/hr | | | | | | | |
| $SO_3$ | lb/hr | | | | | | | |
| HCl | lb/hr | | | | | | | |
| HF | lb/hr | | | | | | | |
| $H_2O$ | lb/hr | | | | | | | |
| Entrained Moisture | lb/hr | | | | | | | |
| Fly Ash | lb/hr | | | | | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | | | | | | | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 120,899,868 | 276,858 | 562,764 | 419,051 | 143,713 | | |
| Volume Flow | gpm | 220,000 | 494 | 1,024 | 820 | 204 | | |
| Specific Gravity | -- | 1.098 | 1.120 | 1.098 | 1.021 | 1.405 | | |
| Density | lb/ft3 | 68.51 | 69.94 | 68.51 | 63.73 | 87.70 | | |
| Temperature | $^oF$ | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 102,765,198 | 228,732 | 478,351 | 406,494 | 71,857 | | |
| $Cl^-$ | lb/hr | 822,122 | 12.6 | 3,827 | 3,252 | 575 | | |
| $SO_4^{--}$ | lb/hr | 435,763 | 21.4 | 2,028 | 1,724 | 306 | | |
| $SO_3^{--}$ | lb/hr | 26,725 | 0.0 | 124 | 106 | 19 | | |
| $Ca^{++}$ | lb/hr | 178,439 | 32.5 | 831 | 706 | 125 | | |
| $Mg^{++}$ | lb/hr | 283,229 | 14.8 | 1,318 | 1,120 | 199 | | |
| $Na^+$ | lb/hr | 17,393 | 13.1 | 81 | 69 | 12 | | |
| $H_2O$ | lb/hr | 101,001,528 | 228,638 | 470,141 | 399,518 | 70,621 | | |
| Mass Flow Solids | lb/hr | 18,134,670 | 48,127 | 84,413 | 12,556 | 71,850 | | |
| $CaSO_4.2H_2O$ | lb/hr | 15,953,069 | 0.0 | 74,258 | 7,426 | 66,827 | | |
| $CaCO_3$ | lb/hr | 999,220 | 43,911 | 4,651 | 1,861 | 2,788 | | |
| Inert | lb/hr | 761,656 | 1,328 | 3,545 | 2,838 | 711 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 108,808 | 0.0 | 506 | 403 | 101 | | |
| $MgCO_3$ | lb/hr | 311,916 | 2,887.6 | 1,451.9 | 28.9 | 1,422.8 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 17.4 | 15.0 | 3.0 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 8,000 | 55 | 8,000 | 8,000 | 8,000 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | CLEARWELL POND WATER TO ME WASH | CLEARWELL POND WATER TO OXIDATION | CLEARWELL POND WATER TO ABSORBER | | |
| Mass Flow | lb/hr | 94,518 | 324,532 | 77,814 | 4,980 | 173,348 | | |
| Volume Flow | gpm | 185 | 635 | 156 | 10.0 | 346 | | |
| Specific Gravity | -- | 1.021 | 1.021 | 0.995 | 0.995 | 0.998 | | |
| Density | lb/ft3 | 63.73 | 63.73 | 62.08 | 62.08 | 62.30 | | |
| Temperature | $^oF$ | 131 | 131 | 95 | 95 | 95 | | |
| Mass Flow Liquid | lb/hr | 91,686.2 | 314,808.3 | 78,098 | 4,980 | 173,061 | | |
| $Cl^-$ | lb/hr | 733.5 | 2,518.5 | 4.3 | 0.3 | 10 | | |
| $SO_4^{--}$ | lb/hr | 388.8 | 1,334.9 | 7.3 | 0.5 | 16 | | |
| $SO_3^{--}$ | lb/hr | 23.8 | 81.9 | 0.0 | 0.0 | 0 | | |
| $Ca^{++}$ | lb/hr | 159.2 | 546.6 | 11.1 | 0.7 | 24 | | |
| $Mg^{++}$ | lb/hr | 252.7 | 867.6 | 5.0 | 0.3 | 11 | | |
| $Na^+$ | lb/hr | 15.5 | 53.3 | 4.5 | 0.3 | 10 | | |
| $H_2O$ | lb/hr | 90,112.6 | 309,405.5 | 78,066 | 4,978 | 172,990 | | |
| Mass Flow Solids | lb/hr | 2,832.1 | 3,973.3 | 1.1 | 0.1 | 2.4 | | |
| $CaSO_4.2H_2O$ | lb/hr | 1,674.9 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $CaCO_3$ | lb/hr | 419.7 | 1,441.1 | 0.0 | 0.0 | 0.0 | | |
| Inert | lb/hr | 640.0 | 2,197.7 | 1.1 | 0.1 | 2.4 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 90.9 | 312.1 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 6.5 | 22.4 | 0.0 | 0.0 | 0.0 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.0 | 1.2 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 8,000 | 8,000 | 55 | 55 | 55 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

# MATERIAL BALANCE

## FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 93 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.14 |
| $CaCO_3$ | wt.%, dry | 3.88 |
| Inerts | wt.%, dry | 0.99 |
| $MgCO_3$ | wt.%, dry | 2.0 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 8,000 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:
1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

**DOCUMENT NUMBER:**

BabcockPower ENVIRONMENTAL

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| **PROJECT NUMBER** | 100585 |
| **CUSTOMER NAME** | Louisville Gas & Electric (LG&E) |
| **PROJECT NAME** | Mill Creek Unit 3 |
| **LOCATION - CITY, STATE** | Louisville, KY |
| **DESCRIPTION** | CASE: Design - 15,000 ppm Cl, no filtrate return |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water |

| | | |
|---|---|---|
| **PREPARED** | **NAME** | |
| | **DATE** | |
| **CHECKED** | **NAME** | |
| | **DATE** | |
| **APPROVED** | **NAME** | |
| | **DATE** | |

**REVISION HISTORY**

| | | PREPARED BY | APPROVED BY |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

**DISTRIBUTION LIST**

| | | | |
|---|---|---|---|
| 1 | | 6 | |
| 2 | | 7 | |
| 3 | | 8 | |
| 4 | | 9 | |
| 5 | | 10 | |

DOCUMENT NUMBER: 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,959,500 | 5,321,518 | 110,824 | 115,803 | | | |
| | lb/hr, dry | 4,726,452 | 4,774,738 | 107,080 | 107,080 | | | |
| Volume Flow | acfm, wet | 1,656,934 | 1,362,319 | 44,249 | 17,558 | | | |
| | scfm, wet | 1,082,405 | 1,206,921 | 25,305 | 12,786 | | | |
| | scfm, dry | 999,348 | 1,012,098 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.37 | 28.27 | 27.95 | 27.31 | | | |
| | lb/lb-mole, dry | 30.31 | 30.24 | 28.50 | 28.50 | | | |
| Density | $lb/ft^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^oF$ | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,529,510 | 3,578,114 | 92,378 | 92,378 | | | |
| $O_2$ | lb/hr | 342,417 | 350,438 | 14,673 | 14,673 | | | |
| $CO_2$ | lb/hr | 826,212 | 845,372 | 29 | 29 | | | |
| $SO_2$ | lb/hr | 26,222 | 393 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 553 | 277 | 0 | 0 | | | |
| HCl | lb/hr | 1,332 | 13 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 233,048 | 546,645 | 3,744 | 7,574 | | | |
| Entrained Moisture | lb/hr | 0 | 136 | 0 | 1,149 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,630 | 39 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 44 | 22 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 235 | 2 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| Stream Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | | | | | | | |
| Mass Flow | lb/hr, wet | | | | | | | |
| | lb/hr, dry | | | | | | | |
| Volume Flow | acfm, wet | | | | | | | |
| | scfm, wet | | | | | | | |
| | scfm, dry | | | | | | | |
| Molecular Weight | lb/lb-mole, wet | | | | | | | |
| | lb/lb-mole, dry | | | | | | | |
| Density | $lb/ft^3$ | | | | | | | |
| Temperature | $^oF$ | | | | | | | |
| Pressure | iwg | | | | | | | |
| | psig | | | | | | | |
| $N_2$ | lb/hr | | | | | | | |
| $O_2$ | lb/hr | | | | | | | |
| $CO_2$ | lb/hr | | | | | | | |
| $SO_2$ | lb/hr | | | | | | | |
| $SO_3$ | lb/hr | | | | | | | |
| HCl | lb/hr | | | | | | | |
| HF | lb/hr | | | | | | | |
| $H_2O$ | lb/hr | | | | | | | |
| Entrained Moisture | lb/hr | | | | | | | |
| Fly Ash | lb/hr | | | | | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | | | | | | | |

**DOCUMENT NUMBER:** 0

0

**BABCOCK POWER ENVIRONMENTAL INC.**

Mill Creek Unit 3

# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 122,210,764 | 240,920 | 600,348 | 451,121 | 149,252 | | |
| Volume Flow | gpm | 220,000 | 421 | 1,081 | 870 | 210 | | |
| Specific Gravity | -- | 1.109 | 1.142 | 1.109 | 1.035 | 1.417 | | |
| Density | lb/ft3 | 69.26 | 71.29 | 69.25 | 64.61 | 88.42 | | |
| Temperature | $^oF$ | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 103,872,211 | 192,793 | 510,271 | 435,670 | 74,626 | | |
| $Cl^-$ | lb/hr | 1,558,083 | 10.6 | 7,654 | 6,535 | 1,119 | | |
| $SO_4^{--}$ | lb/hr | 575,635 | 18.0 | 2,828 | 2,414 | 420 | | |
| $SO_3^{--}$ | lb/hr | 32,728 | 0.0 | 161 | 137 | 24 | | |
| $Ca^{++}$ | lb/hr | 234,012 | 27.4 | 1,150 | 982 | 171 | | |
| $Mg^{++}$ | lb/hr | 533,624 | 12.4 | 2,621 | 2,238 | 389 | | |
| $Na^+$ | lb/hr | 27,878 | 11.0 | 137 | 117 | 20 | | |
| $H_2O$ | lb/hr | 100,910,251 | 192,714 | 495,720 | 423,247 | 72,483 | | |
| Mass Flow Solids | lb/hr | 18,338,553 | 48,126 | 90,086 | 15,451 | 74,626 | | |
| $CaSO_4.2H_2O$ | lb/hr | 15,529,368 | 0.0 | 76,286 | 7,628 | 68,656 | | |
| $CaCO_3$ | lb/hr | 1,056,195 | 43,910 | 5,188 | 2,075 | 3,112 | | |
| Inert | lb/hr | 1,257,899 | 1,328 | 6,179 | 4,941 | 1,239 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 198,037 | 0.0 | 973 | 777 | 194 | | |
| $MgCO_3$ | lb/hr | 297,055 | 2,887.6 | 1,459.3 | 29.4 | 1,425.4 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 20.0 | 15.0 | 3.4 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 15,000 | 55 | 15,000 | 15,000 | 15,000 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | CLEARWELL POND WATER TO ME WASH | CLEARWELL POND WATER TO OXIDATION | CLEARWELL POND WATER TO ABSORBER | | |
| Mass Flow | lb/hr | 12,781 | 438,340 | 77,814 | 4,980 | 133,103 | | |
| Volume Flow | gpm | 25 | 846 | 156 | 10.0 | 266 | | |
| Specific Gravity | -- | 1.035 | 1.035 | 0.995 | 0.995 | 0.998 | | |
| Density | lb/ft3 | 64.61 | 64.61 | 62.08 | 62.08 | 62.30 | | |
| Temperature | $^oF$ | 131 | 131 | 95 | 95 | 95 | | |
| Mass Flow Liquid | lb/hr | 12,343.2 | 423,326.9 | 78,107 | 4,980 | 132,807 | | |
| $Cl^-$ | lb/hr | 185.1 | 6,349.9 | 4.3 | 0.3 | 7 | | |
| $SO_4^{--}$ | lb/hr | 68.4 | 2,346.0 | 7.3 | 0.5 | 12 | | |
| $SO_3^{--}$ | lb/hr | 3.9 | 133.4 | 0.0 | 0.0 | 0 | | |
| $Ca^{++}$ | lb/hr | 27.8 | 953.7 | 11.1 | 0.7 | 19 | | |
| $Mg^{++}$ | lb/hr | 63.4 | 2,174.8 | 5.0 | 0.3 | 8 | | |
| $Na^+$ | lb/hr | 3.3 | 113.6 | 4.5 | 0.3 | 8 | | |
| $H_2O$ | lb/hr | 11,991.3 | 411,255.6 | 78,075 | 4,978 | 132,753 | | |
| Mass Flow Solids | lb/hr | 437.8 | 7,601.3 | 1.1 | 0.1 | 1.9 | | |
| $CaSO_4.2H_2O$ | lb/hr | 216.2 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $CaCO_3$ | lb/hr | 58.8 | 2,016.3 | 0.0 | 0.0 | 0.0 | | |
| Inert | lb/hr | 140.0 | 4,801.3 | 1.1 | 0.1 | 1.9 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 22.0 | 755.2 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 0.8 | 28.5 | 0.0 | 0.0 | 0.0 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.4 | 1.7 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 15,000 | 15,000 | 55 | 55 | 55 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

# MATERIAL BALANCE

FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 92 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.26 |
| $CaCO_3$ | wt.%, dry | 4.17 |
| Inerts | wt.%, dry | 1.66 |
| $MgCO_3$ | wt.%, dry | 1.9 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 15,000 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:
1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

DOCUMENT NUMBER:

BabcockPower ENVIRONMENTAL

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| **PROJECT NUMBER** | 100585 |
| **CUSTOMER NAME** | Louisville Gas & Electric (LG&E) |
| **PROJECT NAME** | Mill Creek Unit 3 |
| **LOCATION - CITY, STATE** | Louisville, KY |
| **DESCRIPTION** | CASE: Design - 50,000 ppm Cl - no filtrate return |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water |

| | | |
|---|---|---|
| **PREPARED** | **NAME** | |
| | **DATE** | |
| **CHECKED** | **NAME** | |
| | **DATE** | |
| **APPROVED** | **NAME** | |
| | **DATE** | |

**REVISION HISTORY**

| | | PREPARED BY | APPROVED BY |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

**DISTRIBUTION LIST**

| | | | |
|---|---|---|---|
| 1 | | 6 | |
| 2 | | 7 | |
| 3 | | 8 | |
| 4 | | 9 | |
| 5 | | 10 | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,959,500 | 5,321,532 | 110,824 | 115,803 | | | |
| | lb/hr, dry | 4,726,452 | 4,774,738 | 107,080 | 107,080 | | | |
| Volume Flow | acfm, wet | 1,656,934 | 1,362,324 | 44,249 | 17,558 | | | |
| | scfm, wet | 1,082,405 | 1,206,925 | 25,305 | 12,786 | | | |
| | scfm, dry | 999,348 | 1,012,098 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.37 | 28.27 | 27.95 | 27.31 | | | |
| | lb/lb-mole, dry | 30.31 | 30.24 | 28.50 | 28.50 | | | |
| Density | $lb/ft^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^oF$ | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,529,510 | 3,578,108 | 92,378 | 92,378 | | | |
| $O_2$ | lb/hr | 342,417 | 350,440 | 14,673 | 14,673 | | | |
| $CO_2$ | lb/hr | 826,212 | 845,376 | 29 | 29 | | | |
| $SO_2$ | lb/hr | 26,222 | 393 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 553 | 277 | 0 | 0 | | | |
| HCl | lb/hr | 1,332 | 13 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 233,048 | 546,658 | 3,744 | 7,574 | | | |
| Entrained Moisture | lb/hr | 0 | 136 | 0 | 1,149 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,630 | 39 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 44 | 22 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 235 | 2 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| Stream Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | | | | | | | |
| Mass Flow | lb/hr, wet | | | | | | | |
| | lb/hr, dry | | | | | | | |
| Volume Flow | acfm, wet | | | | | | | |
| | scfm, wet | | | | | | | |
| | scfm, dry | | | | | | | |
| Molecular Weight | lb/lb-mole, wet | | | | | | | |
| | lb/lb-mole, dry | | | | | | | |
| Density | $lb/ft^3$ | | | | | | | |
| Temperature | $^oF$ | | | | | | | |
| Pressure | iwg | | | | | | | |
| | psig | | | | | | | |
| $N_2$ | lb/hr | | | | | | | |
| $O_2$ | lb/hr | | | | | | | |
| $CO_2$ | lb/hr | | | | | | | |
| $SO_2$ | lb/hr | | | | | | | |
| $SO_3$ | lb/hr | | | | | | | |
| HCl | lb/hr | | | | | | | |
| HF | lb/hr | | | | | | | |
| $H_2O$ | lb/hr | | | | | | | |
| Entrained Moisture | lb/hr | | | | | | | |
| Fly Ash | lb/hr | | | | | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | | | | | | | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 122,629,370 | 235,586 | 607,403 | 458,198 | 150,145 | | |
| Volume Flow | gpm | 220,000 | 411 | 1,090 | 881 | 211 | | |
| Specific Gravity | -- | 1.113 | 1.145 | 1.113 | 1.039 | 1.421 | | |
| Density | lb/ft3 | 69.49 | 71.50 | 69.49 | 64.87 | 88.76 | | |
| Temperature | °F | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 104,219,432 | 187,459 | 516,224 | 442,092 | 75,072 | | |
| $Cl^-$ | lb/hr | 1,797,806 | 10.3 | 8,905 | 7,626 | 1,295 | | |
| $SO_4^{--}$ | lb/hr | 617,178 | 17.5 | 3,057 | 2,618 | 453 | | |
| $SO_3^{--}$ | lb/hr | 34,701 | 0.0 | 172 | 147 | 25 | | |
| $Ca^{++}$ | lb/hr | 250,497 | 26.6 | 1,241 | 1,063 | 184 | | |
| $Mg^{++}$ | lb/hr | 615,163 | 12.1 | 3,047 | 2,609 | 451 | | |
| $Na^+$ | lb/hr | 31,294 | 10.7 | 155 | 133 | 23 | | |
| $H_2O$ | lb/hr | 100,872,793 | 187,382 | 499,648 | 427,896 | 72,641 | | |
| Mass Flow Solids | lb/hr | 18,409,937 | 48,131 | 91,187 | 16,107 | 75,072 | | |
| $CaSO_4.2H_2O$ | lb/hr | 15,457,279 | 0.0 | 76,562 | 7,657 | 68,909 | | |
| $CaCO_3$ | lb/hr | 1,063,988 | 43,915 | 5,270 | 2,107 | 3,161 | | |
| Inert | lb/hr | 1,375,085 | 1,328 | 6,811 | 5,447 | 1,359 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 219,056 | 0.0 | 1,085 | 868 | 218 | | |
| $MgCO_3$ | lb/hr | 294,530 | 2,887.6 | 1,458.9 | 29.0 | 1,426.4 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 20.4 | 15.0 | 3.5 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 17,250 | 55 | 17,250 | 17,250 | 17,250 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | CLEARWELL POND WATER TO ME WASH | CLEARWELL POND WATER TO OXIDATION | CLEARWELL POND WATER TO ABSORBER | | |
| Mass Flow | lb/hr | 1,483 | 456,715 | 77,814 | 4,980 | 127,130 | | |
| Volume Flow | gpm | 3 | 877 | 156 | 10.0 | 254 | | |
| Specific Gravity | -- | 1.039 | 1.039 | 0.995 | 0.995 | 0.998 | | |
| Density | lb/ft3 | 64.88 | 64.88 | 62.08 | 62.08 | 62.30 | | |
| Temperature | °F | 131 | 131 | 95 | 95 | 95 | | |
| Mass Flow Liquid | lb/hr | 1,430.4 | 440,661.2 | 78,096 | 4,980 | 126,846 | | |
| $Cl^-$ | lb/hr | 24.7 | 7,601.4 | 4.3 | 0.3 | 7 | | |
| $SO_4^{--}$ | lb/hr | 8.5 | 2,609.5 | 7.3 | 0.5 | 12 | | |
| $SO_3^{--}$ | lb/hr | 0.5 | 146.7 | 0.0 | 0.0 | 0 | | |
| $Ca^{++}$ | lb/hr | 3.4 | 1,059.1 | 11.1 | 0.7 | 18 | | |
| $Mg^{++}$ | lb/hr | 8.4 | 2,601.0 | 5.0 | 0.3 | 8 | | |
| $Na^+$ | lb/hr | 0.4 | 132.3 | 4.5 | 0.3 | 7 | | |
| $H_2O$ | lb/hr | 1,384.4 | 426,511.2 | 78,064 | 4,978 | 126,794 | | |
| Mass Flow Solids | lb/hr | 52.0 | 8,423.4 | 1.1 | 0.1 | 1.7 | | |
| $CaSO_4.2H_2O$ | lb/hr | 24.7 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $CaCO_3$ | lb/hr | 6.8 | 2,099.8 | 0.0 | 0.0 | 0.0 | | |
| Inert | lb/hr | 17.6 | 5,429.4 | 1.1 | 0.1 | 1.7 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 2.8 | 865.3 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 0.1 | 28.9 | 0.0 | 0.0 | 0.0 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.5 | 1.8 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 17,250 | 17,250 | 55 | 55 | 55 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

**DOCUMENT NUMBER:** 0

0

**BABCOCK POWER ENVIRONMENTAL INC.**

Mill Creek Unit 3

# MATERIAL BALANCE

FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 91.79 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.29 |
| $CaCO_3$ | wt.%, dry | 4.21 |
| Inerts | wt.%, dry | 1.81 |
| $MgCO_3$ | wt.%, dry | 1.9 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 17,250 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:

1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

DOCUMENT NUMBER:

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| **PROJECT NUMBER** | 100585 |
| **CUSTOMER NAME** | Louisville Gas & Electric (LG&E) |
| **PROJECT NAME** | Mill Creek Unit 3 |
| **LOCATION - CITY, STATE** | Louisville, KY |
| **DESCRIPTION** | CASE: Design - 8,000 ppm Cl - filtrate return via Clearwell Pond |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water + Service Water for ME Wash |

| | | |
|---|---|---|
| **PREPARED** | **NAME** | |
| | **DATE** | |
| **CHECKED** | **NAME** | |
| | **DATE** | |
| **APPROVED** | **NAME** | |
| | **DATE** | |

**REVISION HISTORY**

| | | PREPARED BY | APPROVED BY |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

**DISTRIBUTION LIST**

| | | | |
|---|---|---|---|
| 1 | | 6 | |
| 2 | | 7 | |
| 3 | | 8 | |
| 4 | | 9 | |
| 5 | | 10 | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,942,271 | 5,298,295 | 110,824 | 115,779 | | | |
| | lb/hr, dry | 4,704,921 | 4,750,980 | 105,361 | 107,276 | | | |
| Volume Flow | acfm, wet | 1,652,827 | 1,357,500 | 44,249 | 17,550 | | | |
| | scfm, wet | 1,079,723 | 1,202,285 | 25,305 | 12,781 | | | |
| | scfm, dry | 995,132 | 1,007,273 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.34 | 28.25 | 27.96 | 27.31 | | | |
| | lb/lb-mole, dry | 30.30 | 30.23 | 27.97 | 28.48 | | | |
| Density | $lb/ft^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^oF$ | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,517,078 | 3,562,873 | 93,341 | 93,341 | | | |
| $O_2$ | lb/hr | 340,973 | 348,764 | 13,907 | 13,907 | | | |
| $CO_2$ | lb/hr | 820,682 | 838,573 | 28 | 28 | | | |
| $SO_2$ | lb/hr | 24,853 | 373 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 522 | 261 | 0 | 0 | | | |
| HCl | lb/hr | 609 | 6 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 237,349 | 547,180 | 3,548 | 7,360 | | | |
| Entrained Moisture | lb/hr | 0 | 135 | 0 | 1,143 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,503 | 37 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 42 | 21 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 108 | 1 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| Stream Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | | | | | | | |
| Mass Flow | lb/hr, wet | | | | | | | |
| | lb/hr, dry | | | | | | | |
| Volume Flow | acfm, wet | | | | | | | |
| | scfm, wet | | | | | | | |
| | scfm, dry | | | | | | | |
| Molecular Weight | lb/lb-mole, wet | | | | | | | |
| | lb/lb-mole, dry | | | | | | | |
| Density | $lb/ft^3$ | | | | | | | |
| Temperature | $^oF$ | | | | | | | |
| Pressure | iwg | | | | | | | |
| | psig | | | | | | | |
| $N_2$ | lb/hr | | | | | | | |
| $O_2$ | lb/hr | | | | | | | |
| $CO_2$ | lb/hr | | | | | | | |
| $SO_2$ | lb/hr | | | | | | | |
| $SO_3$ | lb/hr | | | | | | | |
| HCl | lb/hr | | | | | | | |
| HF | lb/hr | | | | | | | |
| $H_2O$ | lb/hr | | | | | | | |
| Entrained Moisture | lb/hr | | | | | | | |
| Fly Ash | lb/hr | | | | | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | | | | | | | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 122,166,700 | 243,545 | 541,971 | 405,578 | 136,392 | | |
| Volume Flow | gpm | 220,000 | 431 | 976 | 784 | 192 | | |
| Specific Gravity | -- | 1.109 | 1.129 | 1.109 | 1.034 | 1.416 | | |
| Density | lb/ft3 | 69.23 | 70.52 | 69.22 | 64.52 | 88.38 | | |
| Temperature | $^oF$ | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 103,839,217 | 198,476 | 460,672 | 392,476 | 68,196 | | |
| $Cl^-$ | lb/hr | 830,714 | 10.9 | 3,685 | 3,140 | 546 | | |
| $SO_4^{--}$ | lb/hr | 1,346,198 | 18.6 | 5,972 | 5,088 | 897 | | |
| $SO_3^{--}$ | lb/hr | 62,661 | 0.0 | 278 | 237 | 42 | | |
| $Ca^{++}$ | lb/hr | 93,342 | 28.2 | 414 | 353 | 62 | | |
| $Mg^{++}$ | lb/hr | 572,363 | 12.8 | 2,539 | 2,163 | 381 | | |
| $Na^+$ | lb/hr | 30,742 | 11.3 | 136 | 116 | 20 | | |
| $H_2O$ | lb/hr | 100,903,197 | 198,394 | 447,647 | 381,379 | 66,248 | | |
| Mass Flow Solids | lb/hr | 18,327,484 | 45,070 | 81,307 | 13,102 | 68,203 | | |
| $CaSO_4.2H_2O$ | lb/hr | 15,807,707 | 0.0 | 70,128 | 7,012 | 63,116 | | |
| $CaCO_3$ | lb/hr | 1,006,078 | 40,739 | 4,463 | 1,785 | 2,680 | | |
| Inert | lb/hr | 1,090,376 | 1,627 | 4,837 | 3,870 | 968 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 115,452 | 0.0 | 512 | 407 | 102 | | |
| $MgCO_3$ | lb/hr | 307,871 | 2,704.2 | 1,365.8 | 27.5 | 1,336.6 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 18.5 | 15.0 | 3.2 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 8,000 | 55 | 8,000 | 8,000 | 8,000 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | SERVICE WATER WATER TO ME WASH | SERVICE WATER WATER TO OXIDATION | CLEARWELL POND RETURN TO ABSORBER | | |
| Mass Flow | lb/hr | 70,617 | 334,961 | 77,814 | 4,955 | 158,207 | | |
| Volume Flow | gpm | 136 | 647 | 156 | 10.0 | 315 | | |
| Specific Gravity | -- | 1.034 | 1.034 | 0.995 | 0.995 | 1.005 | | |
| Density | lb/ft3 | 64.53 | 64.53 | 62.08 | 62.08 | 62.72 | | |
| Temperature | $^oF$ | 131 | 131 | 95 | 95 | 131 | | |
| Mass Flow Liquid | lb/hr | 68,335.9 | 324,140.2 | 78,088 | 4,955 | 158,198 | | |
| $Cl^-$ | lb/hr | 546.7 | 2,593.1 | 4.3 | 0.3 | 490 | | |
| $SO_4^{--}$ | lb/hr | 885.9 | 4,202.2 | 7.3 | 0.5 | 795 | | |
| $SO_3^{--}$ | lb/hr | 41.2 | 195.6 | 0.0 | 0.0 | 37 | | |
| $Ca^{++}$ | lb/hr | 61.4 | 291.4 | 11.1 | 0.7 | 68 | | |
| $Mg^{++}$ | lb/hr | 376.7 | 1,786.7 | 5.0 | 0.3 | 340 | | |
| $Na^+$ | lb/hr | 20.2 | 96.0 | 4.5 | 0.3 | 24 | | |
| $H_2O$ | lb/hr | 66,403.8 | 314,975.3 | 78,055 | 4,953 | 156,444 | | |
| Mass Flow Solids | lb/hr | 2,281.3 | 10,820.9 | 1.1 | 0.1 | 8.2 | | |
| $CaSO_4.2H_2O$ | lb/hr | 1,221.0 | 5,791.4 | 0.0 | 0.0 | 6.3 | | |
| $CaCO_3$ | lb/hr | 310.7 | 1,473.8 | 0.0 | 0.0 | 0.3 | | |
| Inert | lb/hr | 673.9 | 3,196.5 | 1.1 | 0.1 | 1.4 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 70.9 | 336.5 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 4.8 | 22.7 | 0.0 | 0.0 | 0.1 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.2 | 3.2 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 8,000 | 8,000 | 55 | 55 | 3,099 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

| DOCUMENT NUMBER: | 0 | BABCOCK POWER ENVIRONMENTAL INC. |
|---|---|---|
| | 0 | Mill Creek Unit 3 |

# MATERIAL BALANCE

FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 91.79 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.29 |
| $CaCO_3$ | wt.%, dry | 4.21 |
| Inerts | wt.%, dry | 1.81 |
| $MgCO_3$ | wt.%, dry | 1.9 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 17,250 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:

1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

DOCUMENT NUMBER:

BabcockPower ENVIRONMENTAL

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| PROJECT NUMBER | 100585 |
| CUSTOMER NAME | Louisville Gas & Electric (LG&E) |
| PROJECT NAME | Mill Creek Unit 3 |
| LOCATION - CITY, STATE | Louisville, KY |
| DESCRIPTION | CASE: Design - 15,000 ppm Cl and filtrate return via Clearwell Pond |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water and Service Water for ME wash |

| | | |
|---|---|---|
| PREPARED | NAME | |
| | DATE | |
| CHECKED | NAME | |
| | DATE | |
| APPROVED | NAME | |
| | DATE | |

REVISION HISTORY

| | | PREPARED BY | APPROVED BY |
|---|---|---|---|
| 1 | | | |
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DISTRIBUTION LIST

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**DOCUMENT NUMBER:** 0

0

**BABCOCK POWER ENVIRONMENTAL INC.**

Mill Creek Unit 3

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,942,271 | 5,298,376 | 110,824 | 115,779 | | | |
| | lb/hr, dry | 4,704,921 | 4,750,981 | 105,361 | 107,276 | | | |
| Volume Flow | acfm, wet | 1,652,827 | 1,357,532 | 44,249 | 17,550 | | | |
| | scfm, wet | 1,079,723 | 1,202,313 | 25,305 | 12,781 | | | |
| | scfm, dry | 995,132 | 1,007,273 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.34 | 28.25 | 27.96 | 27.31 | | | |
| | lb/lb-mole, dry | 30.30 | 30.23 | 27.97 | 28.48 | | | |
| Density | lb/ft$^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^o$F | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,517,078 | 3,562,836 | 93,341 | 93,341 | | | |
| $O_2$ | lb/hr | 340,973 | 348,775 | 13,907 | 13,907 | | | |
| $CO_2$ | lb/hr | 820,682 | 838,599 | 28 | 28 | | | |
| $SO_2$ | lb/hr | 24,853 | 373 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 522 | 261 | 0 | 0 | | | |
| HCl | lb/hr | 609 | 6 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 237,349 | 547,260 | 3,548 | 7,360 | | | |
| Entrained Moisture | lb/hr | 0 | 135 | 0 | 1,143 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,503 | 37 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 42 | 21 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 108 | 1 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| Stream Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | | | | | | | |
| Mass Flow | lb/hr, wet | | | | | | | |
| | lb/hr, dry | | | | | | | |
| Volume Flow | acfm, wet | | | | | | | |
| | scfm, wet | | | | | | | |
| | scfm, dry | | | | | | | |
| Molecular Weight | lb/lb-mole, wet | | | | | | | |
| | lb/lb-mole, dry | | | | | | | |
| Density | lb/ft$^3$ | | | | | | | |
| Temperature | $^o$F | | | | | | | |
| Pressure | iwg | | | | | | | |
| | psig | | | | | | | |
| $N_2$ | lb/hr | | | | | | | |
| $O_2$ | lb/hr | | | | | | | |
| $CO_2$ | lb/hr | | | | | | | |
| $SO_2$ | lb/hr | | | | | | | |
| $SO_3$ | lb/hr | | | | | | | |
| HCl | lb/hr | | | | | | | |
| HF | lb/hr | | | | | | | |
| $H_2O$ | lb/hr | | | | | | | |
| Entrained Moisture | lb/hr | | | | | | | |
| Fly Ash | lb/hr | | | | | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | | | | | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | | | | | | | |

**DOCUMENT NUMBER:** 0

0



# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 124,777,477 | 225,728 | 559,851 | 420,960 | 138,891 | | |
| Volume Flow | gpm | 220,000 | 395 | 987 | 794 | 193 | | |
| Specific Gravity | -- | 1.133 | 1.141 | 1.133 | 1.058 | 1.439 | | |
| Density | lb/ft3 | 70.71 | 71.26 | 70.71 | 66.08 | 89.79 | | |
| Temperature | $^oF$ | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 106,057,295 | 180,658 | 475,849 | 406,404 | 69,445 | | |
| $Cl^-$ | lb/hr | 1,590,859 | 9.9 | 7,138 | 6,096 | 1,042 | | |
| $SO_4^{--}$ | lb/hr | 2,376,118 | 16.9 | 10,661 | 9,105 | 1,615 | | |
| $SO_3^{--}$ | lb/hr | 109,166 | 0.0 | 490 | 418 | 74 | | |
| $Ca^{++}$ | lb/hr | 95,619 | 25.6 | 429 | 366 | 65 | | |
| $Mg^{++}$ | lb/hr | 1,094,612 | 11.7 | 4,911 | 4,194 | 744 | | |
| $Na^+$ | lb/hr | 53,761 | 10.3 | 241 | 206 | 37 | | |
| $H_2O$ | lb/hr | 100,737,161 | 180,584 | 451,979 | 386,017 | 65,869 | | |
| Mass Flow Solids | lb/hr | 18,720,181 | 45,070 | 83,994 | 14,558 | 69,452 | | |
| $CaSO_4.2H_2O$ | lb/hr | 15,823,880 | 0.0 | 70,998 | 7,101 | 63,904 | | |
| $CaCO_3$ | lb/hr | 1,046,563 | 40,739 | 4,696 | 1,879 | 2,819 | | |
| Inert | lb/hr | 1,394,793 | 1,627 | 6,258 | 5,006 | 1,250 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 151,649 | 0.0 | 680 | 544 | 139 | | |
| $MgCO_3$ | lb/hr | 303,297 | 2,704.2 | 1,360.8 | 27.7 | 1,340.3 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 20.0 | 15.0 | 3.5 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 15,000 | 55 | 15,000 | 15,000 | 15,000 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | SERVICE WATER WATER TO ME WASH | SERVICE WATER WATER TO OXIDATION | RECLAIM WATER RETURN TO ABSORBER | | |
| Mass Flow | lb/hr | 33,811 | 387,149 | 77,814 | 4,955 | 150,557 | | |
| Volume Flow | gpm | 64 | 730 | 156 | 10.0 | 297 | | |
| Specific Gravity | -- | 1.058 | 1.058 | 0.995 | 0.995 | 1.016 | | |
| Density | lb/ft3 | 66.07 | 66.07 | 62.08 | 62.08 | 63.45 | | |
| Temperature | $^oF$ | 131 | 131 | 95 | 95 | 131 | | |
| Mass Flow Liquid | lb/hr | 32,642.0 | 373,761.6 | 78,124 | 4,955 | 150,549 | | |
| $Cl^-$ | lb/hr | 489.6 | 5,606.4 | 4.3 | 0.3 | 931 | | |
| $SO_4^{--}$ | lb/hr | 731.3 | 8,373.8 | 7.3 | 0.5 | 1,391 | | |
| $SO_3^{--}$ | lb/hr | 33.6 | 384.7 | 0.0 | 0.0 | 64 | | |
| $Ca^{++}$ | lb/hr | 29.4 | 337.0 | 11.1 | 0.7 | 68 | | |
| $Mg^{++}$ | lb/hr | 336.9 | 3,857.5 | 5.0 | 0.3 | 643 | | |
| $Na^+$ | lb/hr | 16.5 | 189.5 | 4.5 | 0.3 | 36 | | |
| $H_2O$ | lb/hr | 31,004.6 | 355,012.7 | 78,091 | 4,953 | 147,416 | | |
| Mass Flow Solids | lb/hr | 1,169.2 | 13,388.7 | 1.2 | 0.1 | 8.2 | | |
| $CaSO_4.2H_2O$ | lb/hr | 570.3 | 6,530.3 | 0.0 | 0.0 | 6.3 | | |
| $CaCO_3$ | lb/hr | 150.9 | 1,728.3 | 0.0 | 0.0 | 0.3 | | |
| Inert | lb/hr | 402.1 | 4,603.9 | 1.2 | 0.1 | 1.4 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 43.7 | 500.7 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 2.2 | 25.4 | 0.0 | 0.0 | 0.1 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.5 | 3.5 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 15,000 | 15,000 | 55 | 55 | 6,183 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

# MATERIAL BALANCE

FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 91.79 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.29 |
| $CaCO_3$ | wt.%, dry | 4.21 |
| Inerts | wt.%, dry | 1.81 |
| $MgCO_3$ | wt.%, dry | 1.9 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 17,250 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:

1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

**DOCUMENT NUMBER:**

BabcockPower ENVIRONMENTAL

# MATERIAL BALANCE
## WET FLUE GAS DESULFURIZATION

| | |
|---|---|
| **PROJECT NUMBER** | 100585 |
| **CUSTOMER NAME** | Louisville Gas & Electric (LG&E) |
| **PROJECT NAME** | Mill Creek Unit 3 |
| **LOCATION - CITY, STATE** | Louisville, KY |
| **DESCRIPTION** | CASE: Design - 50,000 ppm Cl - filtrate return via Clearwell Pond |
| | LOAD: 100% MCR |
| | FUEL: High Sulfur Bituminous Coal |
| | $SO_2$ Removal Efficiency: 98.5% |
| | REAGENT: Limestone |
| | WATER: Clearwell Pond Water & Service Water (ME wash) |

| | | |
|---|---|---|
| **PREPARED** | **NAME** | |
| | **DATE** | |
| **CHECKED** | **NAME** | |
| | **DATE** | |
| **APPROVED** | **NAME** | |
| | **DATE** | |

**REVISION HISTORY**

| | | **PREPARED BY** | **APPROVED BY** |
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**DISTRIBUTION LIST**

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| 4 | | 9 | |
| 5 | | 10 | |

**DOCUMENT NUMBER:** 0 **BABCOCK POWER ENVIRONMENTAL INC.**

0 Mill Creek Unit 3

# MATERIAL BALANCE

GAS PATH STREAMS

| Stream Number | | 11 | 13 | 15 | 16 | | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | FLUE GAS BEFORE ABSORBER | FLUE GAS AFTER ABSORBER | OXIDATION AIR AFTER BLOWER | OXIDATION AIR AFTER HUMIDIFCATION | | | |
| Mass Flow | lb/hr, wet | 4,942,271 | 5,298,824 | 110,824 | 115,779 | | | |
| | lb/hr, dry | 4,704,921 | 4,750,981 | 105,361 | 107,276 | | | |
| Volume Flow | acfm, wet | 1,652,827 | 1,357,712 | 44,249 | 17,550 | | | |
| | scfm, wet | 1,079,723 | 1,202,473 | 25,305 | 12,781 | | | |
| | scfm, dry | 995,132 | 1,007,273 | 23,358 | 23,358 | | | |
| Molecular Weight | lb/lb-mole, wet | 29.34 | 28.25 | 27.96 | 27.31 | | | |
| | lb/lb-mole, dry | 30.30 | 30.23 | 27.97 | 28.48 | | | |
| Density | lb/ft$^3$ | 0.050 | 0.065 | 0.042 | 0.110 | | | |
| Temperature | $^o$F | 357 | 131 | 327 | 158 | | | |
| Pressure | iwg | TBD | TBD | -- | -- | | | |
| | psig | -- | -- | TBD | TBD | | | |
| $N_2$ | lb/hr | 3,517,078 | 3,562,767 | 93,341 | 93,341 | | | |
| $O_2$ | lb/hr | 340,973 | 348,795 | 13,907 | 13,907 | | | |
| $CO_2$ | lb/hr | 820,682 | 838,648 | 28 | 28 | | | |
| $SO_2$ | lb/hr | 24,853 | 373 | 0 | 0 | | | |
| $SO_3$ | lb/hr | 522 | 261 | 0 | 0 | | | |
| HCl | lb/hr | 609 | 6 | 0 | 0 | | | |
| HF | lb/hr | 77 | 1 | 0 | 0 | | | |
| $H_2O$ | lb/hr | 237,349 | 547,708 | 3,548 | 7,360 | | | |
| Entrained Moisture | lb/hr | 0 | 135 | 0 | 1,143 | | | |
| Fly Ash | lb/hr | 128 | 130 | 0 | 0 | | | |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ | 2,503 | 37 | 0 | 0 | | | |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ | 42 | 21 | 0 | 0 | | | |
| HCl Concentration | ppmv, dry @ actual $O_2$ | 108 | 1 | 0 | 0 | | | |
| HF Concentration | ppmv, dry @ actual $O_2$ | 25 | 0 | 0 | 0 | | | |
| Dust Loading | gr/dscf @ actual $O_2$ | 0.015 | 0.015 | 0.000 | 0.000 | | | |

| | |
|---|---|
| Stream Number | |
| Notes | |
| Description | |
| Mass Flow | lb/hr, wet |
| | lb/hr, dry |
| Volume Flow | acfm, wet |
| | scfm, wet |
| | scfm, dry |
| Molecular Weight | lb/lb-mole, wet |
| | lb/lb-mole, dry |
| Density | lb/ft$^3$ |
| Temperature | $^o$F |
| Pressure | iwg |
| | psig |
| $N_2$ | lb/hr |
| $O_2$ | lb/hr |
| $CO_2$ | lb/hr |
| $SO_2$ | lb/hr |
| $SO_3$ | lb/hr |
| HCl | lb/hr |
| HF | lb/hr |
| $H_2O$ | lb/hr |
| Entrained Moisture | lb/hr |
| Fly Ash | lb/hr |
| $SO_2$ Concentration | ppmv, dry @ actual $O_2$ |
| $SO_3$ Concentration | ppmv, dry @ actual $O_2$ |
| HCl Concentration | ppmv, dry @ actual $O_2$ |
| HF Concentration | ppmv, dry @ actual $O_2$ |
| Dust Loading | gr/dscf @ actual $O_2$ |

**DOCUMENT NUMBER:** 0

0

**BABCOCK POWER ENVIRONMENTAL INC.**

Mill Creek Unit 3

# MATERIAL BALANCE

LIQUID AND SOLID STREAMS

| Stream Number | | 20 | 23 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | TOTAL RECYCLE FLOW | LIMESTONE SLURRY TO ABSORBER | BLEED FROM ABSORBER | PRIMARY HC OVERFLOW | PRIMARY HC UNDERFLOW | | |
| Mass Flow | lb/hr | 139,263,429 | 211,823 | 577,926 | 437,101 | 141,069 | | |
| Volume Flow | gpm | 220,000 | 367 | 913 | 733 | 181 | | |
| Specific Gravity | -- | 1.264 | 1.152 | 1.264 | 1.191 | 1.560 | | |
| Density | lb/ft3 | 78.92 | 71.92 | 78.91 | 74.34 | 97.43 | | |
| Temperature | $^oF$ | 131 | 94 | 131 | 131 | 131 | | |
| Mass Flow Liquid | lb/hr | 118,363,340 | 166,753 | 491,194 | 420,910 | 70,534 | | |
| $Cl^-$ | lb/hr | 5,915,421 | 9.2 | 24,548 | 21,042 | 3,526 | | |
| $SO_4^{--}$ | lb/hr | 7,902,605 | 15.6 | 32,795 | 28,086 | 5,503 | | |
| $SO_3^{--}$ | lb/hr | 414,952 | 0.0 | 1,722 | 1,475 | 289 | | |
| $Ca^{++}$ | lb/hr | 156,643 | 23.7 | 650 | 557 | 109 | | |
| $Mg^{++}$ | lb/hr | 3,969,002 | 10.8 | 16,471 | 14,110 | 2,765 | | |
| $Na^+$ | lb/hr | 180,594 | 9.5 | 749 | 642 | 126 | | |
| $H_2O$ | lb/hr | 99,824,123 | 166,685 | 414,258 | 354,998 | 58,217 | | |
| Mass Flow Solids | lb/hr | 20,900,089 | 45,069 | 86,733 | 16,191 | 70,541 | | |
| $CaSO_4.2H_2O$ | lb/hr | 17,273,923 | 0.0 | 71,685 | 7,168 | 64,504 | | |
| $CaCO_3$ | lb/hr | 1,174,585 | 40,743 | 4,874 | 1,954 | 2,934 | | |
| Inert | lb/hr | 1,920,718 | 1,623 | 7,971 | 6,369 | 1,594 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 202,731 | 0.0 | 841 | 672 | 169 | | |
| $MgCO_3$ | lb/hr | 328,131 | 2,704.2 | 1,361.7 | 27.5 | 1,340.2 | | |
| $Ca(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 15.0 | 21.3 | 15.0 | 3.7 | 50.0 | | |
| $Cl^-$ Concentration | ppm | 49,977 | 55 | 49,977 | 49,992 | 49,992 | | |
| pH | -- | 5 to 7 | > 7 | 5 to 7 | 5 to 7 | 5 to 7 | | |

| Stream Number | | 35 | 38 | 44 | 45 | 47 | | |
|---|---|---|---|---|---|---|---|---|
| Notes | | | | | | | | |
| Description | | CHLORIDE PURGE | HC OVERFLOW TO ABSORBER | SERVICE WATER WATER TO ME WASH | SERVICE WATER WATER TO OXIDATION | CLEARWELL POND RETURN TO ABSORBER | | |
| Mass Flow | lb/hr | 4,819 | 432,282 | 77,814 | 4,955 | 144,689 | | |
| Volume Flow | gpm | 8 | 725 | 156 | 10.0 | 272 | | |
| Specific Gravity | -- | 1.191 | 1.191 | 0.995 | 0.995 | 1.082 | | |
| Density | lb/ft3 | 74.36 | 74.36 | 62.08 | 62.08 | 67.54 | | |
| Temperature | $^oF$ | 131 | 131 | 95 | 95 | 131 | | |
| Mass Flow Liquid | lb/hr | 4,640.3 | 416,269.7 | 78,112 | 4,955 | 144,681 | | |
| $Cl^-$ | lb/hr | 232.0 | 20,810.1 | 4.3 | 0.3 | 3,139 | | |
| $SO_4^{--}$ | lb/hr | 309.6 | 27,776.6 | 7.3 | 0.5 | 4,191 | | |
| $SO_3^{--}$ | lb/hr | 16.3 | 1,458.5 | 0.0 | 0.0 | 220 | | |
| $Ca^{++}$ | lb/hr | 6.1 | 551.3 | 11.1 | 0.7 | 95 | | |
| $Mg^{++}$ | lb/hr | 155.6 | 13,954.1 | 5.0 | 0.3 | 2,107 | | |
| $Na^+$ | lb/hr | 7.1 | 634.9 | 4.5 | 0.3 | 100 | | |
| $H_2O$ | lb/hr | 3,913.6 | 351,084.2 | 78,080 | 4,953 | 134,829 | | |
| Mass Flow Solids | lb/hr | 178.6 | 16,012.4 | 1.0 | 0.1 | 8.2 | | |
| $CaSO_4.2H_2O$ | lb/hr | 79.1 | 7,088.7 | 0.0 | 0.0 | 6.5 | | |
| $CaCO_3$ | lb/hr | 21.6 | 1,932.7 | 0.0 | 0.0 | 0.3 | | |
| Inert | lb/hr | 70.3 | 6,299.3 | 1.0 | 0.1 | 1.3 | | |
| $CaSO_3.1/2H_2O$ | lb/hr | 7.4 | 664.5 | 0.0 | 0.0 | 0.0 | | |
| $MgCO_3$ | lb/hr | 0.3 | 27.2 | 0.0 | 0.0 | 0.1 | | |
| $Ca(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| $Mg(OH)_2$ | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| CaO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| MgO | lb/hr | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| Total Suspended Solids | wt.%, wet | 3.7 | 3.7 | 0.0 | 0.0 | 0.0 | | |
| $Cl^-$ Concentration | ppm | 49,992 | 49,992 | 55 | 55 | 21,695 | | |
| pH | -- | 5 to 7 | 5 to 7 | 6 to 8 | 6 to 8 | 6 to 8 | | |

| | | |
|---|---|---|
| **DOCUMENT NUMBER:** | 0 | **BABCOCK POWER ENVIRONMENTAL INC.** |
| | 0 | Mill Creek Unit 3 |

# MATERIAL BALANCE

FUEL DATA, BOILER DATA, AND NOTES

| | | |
|---|---|---|
| Unit Rating | MWg | 425 |
| Boiler Heat Input | MBtu/hr | 4,208 |
| Fuel Feed Rate | lb/hr | 386,068 |
| $SO_2$ Inlet Loading | lb $SO_2$/MBtu | 6.32 |
| $SO_2$ Removal Efficiency | % | 98.5 |
| Excess Air | % | 20.0 |
| Air Heater Leakage | % | 10.0 |
| Oxygen at FGD Inlet | vol.%, dry | 6.95 |
| | | |
| Site Elevation | ft above MSL | 460 |
| Ambient Pressure | in $H_2O$ | 14.45 |
| Ambient Temperature | $^oF$ | -23.1 - 105.4 |
| | | |
| **Coal Analysis** | | |
| Coal | -- | Performance Fuel |
| Carbon | wt.%, wet | 60.00 |
| Hydrogen | wt.%, wet | 4.00 |
| Nitrogen | wt.%, wet | 1.30 |
| Oxygen | wt.%, wet | 5.90 |
| Sulfur | wt.%, wet | 3.45 |
| Chlorine | wt.%, wet | 0.35 |
| Fluorine | wt.%, wet | 0.02 |
| Ash | wt.%, wet | 14.00 |
| Moisture | wt.%, wet | 11.00 |
| Higher Heating Value (HHV) | BTU/lb | 10,900 |
| | | |
| **Limestone Analysis** | | Note 4 |
| Total $CaCO_3$ | wt.%, dry | 94.6 |
| Reactive $CaCO_3$ | % | 91.3 |
| Total $MgCO_3$ | wt.%, dry | 2.4 |
| Reactive $MgCO_3$ | % | |
| Inerts | wt.%, dry | 3.0 |
| | | |
| **Gypsum Quality (at HC Underflow)** | | |
| Free Moisture | wt.% | -- |
| $CaSO_4$-$2H_2O$ | wt.%, dry | 91.79 |
| $CaSO_3$-$1/2H_2O$ | wt.%, dry | 0.29 |
| $CaCO_3$ | wt.%, dry | 4.21 |
| Inerts | wt.%, dry | 1.81 |
| $MgCO_3$ | wt.%, dry | 1.9 |
| Fly Ash | wt.%, dry | |
| Maximum Chloride Content | ppmvd | 17,250 |
| Total Suspended Solids (TSS) | wt.% | |
| Total Disolved Solids (TDS) | mg/L | |
| Average Particle Diameter | microns | |

Notes:

1. For stream references see Process Flow Diagram, document number 502718-103000100.
2. Values provided represent time-averaged values and do not necessarily represent equipment capacity or actual continuous operation.
3. Emergency Quench flow normally 0 gpm.
4. Assumes 96.5% $CaCO_3$ availability on total $CaCO_3$.

# DESIGN BASIS

BabcockPower ENVIRONMENTAL

**Flue Gas Desulfurization**
**Design Basis Spreadsheet**

| | |
|---|---|
| Project Number: | 100585 |
| Revision Number: | Rev. 0 |
| Customer Name: | LG&E Energy |
| Project Name: | Mill Creek Unit 3 |
| Location, City, State | Kosmodale, KY |
| Description | WFGD Upgrade |
| Report Title (shown on printed sheets) | |

| | | |
|---|---|---|
| Email changes to | | |
| **Prepared** | Name | Suzette Puski |
| **Prepared** | Date | 11/13/11 |
| **Checked** | Name | |
| **Checked** | Date | |
| **Customer Signed** | Name | |
| **Customer Signed** | Date | |
| **Remarks:** | | |

BabcockPower ENVIRONMENTAL

**Mill Creek Unit 3**
**Rev. 0**

**FGD Design Basis Spreadsheet**

| **Scope of Supply** | | |
|---|---|---|
| **Plant Name:** | | |
| **Plant Location** | | |
| | **U3 No Change to Spray Header Location** | **U3 High Removal** |
| **Flue Gas Path** | | |
| Equipment for Partical Removal | | |
| Equipment for Draft System | | |
| Inlet Duct Modifications | x | x |
| Equipment for SO2 Removal | | |
| Install Wall Rings on Spray Levels 2 and 3 | 8 Wall Rings | 8 Wall Rings |
| Install Up/Down Interior Spray Nozzles | 128 | 336 |
| Install Up/Down Interior Wall Ring Nozzles | 160 | 288 |
| Install Double-Down Interior Spray Nozzles | 128 | 112 |
| Install Double-Down Wall Ring Spray Nozzles | 160 | 96 |
| Replace Recycle Pumps | | |
| Replace Recycle Pump Piping | | |
| Replace Recycle Pump Gear Boxes | | 8 Pumps |
| Add Agitators and Air Lances | 10 | 10 |
| Equipment for SO3 Removal | | |
| Equipment for Hg Removal | | |
| Equipment for NOx Removal | | |
| Equipment for Mist Removal | | |
| Replace ME Section w/ DV210 | | x |
| other | | |
| **Waste Water Treatment** | | |
| | | |
| **Utilities** | | |
| Reagent | | |
| Equipment for Reagant Unloading | | |
| Equipment for Reagent Storage | | |
| Equipment for Reagent Day Storage | | |
| Equipment for Reagent Slurry Preparation | | |
| Increase Limestone Grind | | May be Required |
| Organic Acid | | |
| Equipment for Organic Acid System | | |
| Add organic feed system to Units 1 and 2 | | |
| Byproduct | | |
| Equipment for Byproduct Treatment | | |
| Equipment for Byproduct Storage | | |
| Equipment for Byproduct Loading | | |
| | | |
| Fly Ash | | |
| Equipment for Flyash Treatment | | |
| Equipment for Flyash Storage | | |
| Equipment for Flyash Loading | | |
| | | |
| Balance of Plant | | |
| Water Supply | | |
| Service Air Supply | | |
| Instrument Air Supply | | |
| Cooling Water Supply | | |
| | | |
| Process Control | | |
| Evaluate revising control logic for SO2 removal | x | x |
| Electrical Equipment | | |
| | | |
| Structural Steel | | |
| | | |
| Civil | | |
| | | |
| Construction | | |
| Process Equipment | | |
| Balance of Plant Equipment | | |
| Process Control incl. Wiring | | |
| Electrical Equipment incl. Wiring | | |
| Structural Steel | | |
| Civil | | |
| | | |
| Commissioning | | Yes |
| | | |
| Performance Test | | No |
| | | |

| BabcockPower ENVIRONMENTAL | FGD Design Basis Spreadsheet | Mill Creek Unit 3<br>Rev. 0 |
|---|---|---|
| **Plant Data Sheet** | Units | **DESIGN** |
| **Plant Name:** | | **Mill Creek Unit 3** |
| **Plant Location** | | **Kosmodale, KY** |
| | | |
| **Site Conditions** | | |
| Seismic Zone | | (Av/Aa) 0.09/0.07 |
| Design Ambient Temp | °F | 68 |
| Maximum Summer Ambient Temp | °F | 105.4 |
| Minimum Winter Ambient Temp | °F | -23.1 |
| Indoor Temperature Design / Range | °F | 36-76 |
| Plant Elevation @ Grade | ft | 460 |
| Elevation @ Absorber Inlet | ft above TOC | 28 |
| Atmospheric Pr. @ Absorber Inlet Elevation | psia | 14.44 |
| Absolute Humidity Average | % | 60 |
| Average Rainfall | inches/year | 44.5 |
| Wind Speed CRM 780 section 1611.0 | MPH | 90 |
| Snow Load CMR 780 Section 1610.0 | lb/sf | 15 |
| Earthquake Loads CMR 780 Section 1612.0 | | |
| | | |
| **FGD Operation** | | |
| Mode | Part/Continuous | Continuous |
| Months of FGD operation/yr - Design | Mon/yr | 12 |
| Months of FGD operation/yr - Future | Mon/yr | 12 |
| Number of Boilers served by one Scrubber | # | Unit has a dedicated 4 module absorber system |
| Bypass Operation required | Yes / No | No Bypass Allowed |
| Equipment Installation Indoor/Outdoor | | Indoor |
| | | |

| BabcockPower ENVIRONMENTAL | FGD Design Basis Spreadsheet | Mill Creek Unit 3 Rev. 0 |
|---|---|---|
| **Boiler Data Sheet** | Units | |
| | | **Unit 3** |
| LOAD | % MCR | 100 |
| Nominal Rating | MW, Gross | 410 |
| | MW, Net | 386 |
| Boiler Manufacturer | - | Babcock & Wilcox |
| Fuel Fired | Coal/Gas/Oil | Coal |
| Firing Method | Dry Bot/Wet Bot/Cyclone | Opposed Wall Fired Boiler (5x4 high) w/ LNB |
| MCR Steam Flow (Design) | pph | 3,144,000 |
| Boiler Type | Balanced Draft/Pressurized | Balanced Draft |
| Plant Capacity Factor | Percent of Year | 74.9 Gross/ 73.6 Net |
| Hours of operation per year | Hours | in 2000 7447 hrs |
| Number of Cold Starts per year | Target/Actual | 2 actual |
| Number of Hot Restarts per year | Target / Actual | 22 actual |
| Ignition Fuel Fired | Oil/Gas | Oil |
| Ignition Fuel Fired | Hours/Year | 800,000 gal |
| Minimum Load for FGD Operation | MWnet | 193 MW net |
| Flue Gas Recirculation | Y/N | N |
| **SCR** | | |
| SCR Reactor - Number Installed | | 2 |
| Catalyst Type | | Hitachi Plate |
| NOx inlet / outlet | lbs/Mbtu | 0.347 / 0.035 |
| NH3 Slip | ppmdv @ ref O2 | < 2.0 @ the End of Life |
| **Air Heater** | | |
| Air Heater - Number Installed | - | 2 |
| Air Heater Type | Rotary/Tubualr | Ljungstrom Rotary |
| Air Heater Orientation | V-Shaft or H-S | V-Shaft |
| Will Air Heater be changed? | Y/N & to what? | N |
| Air Heater Surface configuration | Model Numbers & Materials | 29-VI-54 |
| Air Heater Cleaning Device | - | Steam Soot Blowers |
| Air Heater Leakage | Percent | 8 @ as-found condition Baseline Test |
| **ESP** | | |
| ESP's - Number Installed | Number | 2 |
| ESP Info - Configuration | Single layer or Stacked | TBD by LG&E |
| ESP Info - Location | Cold or Hot | Cold |
| ESP Dust Loading @ ESP Temp | grains/ACF @°F | 3.375 @ 300 °F |
| Dust Loading @ Eco. Out Temp | grains/ACF @°F | 2.294 @ 64 8°F |
| ESP Info - Outlet Dust Loading | grains/ACF @°F | TBD by LG& E |
| ESP Efficiency | % | TBD by LG&E |
| **WFGD** | | |
| WFGD - Original Supplier | Name | American Filter |
| WFGD - Number Absorbers Operating / Installed | Number | 4 / 4 |
| WFGD Info - Type | Single Loop or Double Loop | Single |
| WFGD Info - Spray Configuration | Co-Current or Counter Current | Counter Current (Co-Current on Level 2) |
| WFGD Info - Spray Level Configuration | Operating + Spare | 4+0 + Tray |
| WFGD Info - Reagent | Lime or Limestone | Limestone |
| WFGD Info - Original Design SO2 Loading | lbs/Mbtu | 6.3 |
| WFGD Info - SO2 Removal Efficiency | % | Phase 1: 96, Phase 2: 98+ |
| **Other** | | |
| Ash Reinjection | Yes or No | No |
| **Draft System** | | |
| FD Fan, Existing | Number | 2 / American Standard (595 rpm @ 110°F) |
| Design Pressure | IWG | |
| Fan HP | HP | |
| ID Fan, Existing | Number | 2 / American Standard (834,950 cfm @ 300°F) |
| Design Pressure | IWG | 45 |
| Fan HP | HP | |
| ID Booster Fan, Existing | Number | N/A |
| Design Pressure | IWG | N/A |
| Booster Fan HP | HP | N/A |
| | | |

BabcockPower ENVIRONMENTAL

**FGD Design Basis Spreadsheet**

**LG&E Mill Creek**
**Rev. 0**

| **FGD Load Data Sheet** | Units | | | | |
|---|---|---|---|---|---|
| **Load Name** | | Unit 4 | Unit 3 | Unit 3 | |
| Load | MW | 525 | 425 | 425 | |
| Fuel Flow Rate | lb/hr | | | | |
| Firing Rate | Gross10^6 BTU/Hr | | | | |
| Excess Air | % | | | | |
| In-Leakage | % | | | | |
| **Flue Gas Conditions @ Inlet Scope of Supply** | | | SCR Test | Ratio to U4 Design Basis | |
| Flow Basis | per Absorber | 1 | 1 of 4 | 1 of 4 | |
| Flue Gas Flow Rate | lbs/h wet | 6,126,411 | 1,418,869 | 1,239,869 | |
| Flue Gas Flow Rate | lbs/h dry | 5,838,557 | 1,356,591 | 1,181,613 | |
| Flue Gas Flow Rate | scfm wet | 1,337,090 | 289,144 | 270,602 | |
| Flue Gas Flow Rate | scfm dry | 1,234,489 | 268,459 | 249,837 | |
| Flue Gas Flow Rate | acfm | 2,046,801 | 463,259 | 414,234 | |
| Flue Gas Temperature | °F | 357 | 313 | 357.0 | |
| Flue Gas Pressure | I.W.G. | 11 | 14.44 | 11.0 | |
| Flue Gas O2 | % vol, dry | 6.9 | 7.9 | 6.9 | |
| Flue Gas CO2 | % vol, dry | 12.1 | 11.0 | 12.1 | |
| Flue Gas H2O | % vol wet | 7.7 | 7.1 | 7.7 | |
| Flue Gas reference O2 | % vol dry | 6.0 | 6.0 | 6.0 | |
| Flue Gas SO2 *) | ppmdv @ act O2 / lbs/MBTu | 2,630/6.33 | 2,395 / 6.3 | 2,630/6.33 | |
| Flue Gas SO3 *) | ppmdv @ act O2 / lbs/MBTu | 44 | 8 | 44 | |
| Flue Gas HCl *) | ppmdv @ act O2 / lbs/MBTu | 235 | 44 | 235 | |
| Flue Gas HF*) | ppmdv @ act O2 / lbs/MBTu | 25 | 9 | 25 | |
| Flue Gas NOx *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas NH3 *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Dust *) | grains/ dcfm lbs/MBTU | 0.015/0.03 | 0.07 / 0.41 | 0.015/0.03 | |
| Flue Gas Hg *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Cd *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Heavy Metals *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| *) Concentration range is independent of the boiler load | | | | | |
| **Flue Gas Conditions @ outlet Scope of Supply expected values** | | | | | |
| Flue Gas Flow Rate | lbs/h wet | 10,356,857 | 1,518,574 | 1,467,221 | |
| Flue Gas Flow Rate | lbs/h dry | 8,704,210 | 1,276,255 | 1,233,096 | |
| Flue Gas Flow Rate | scfm wet | 2,184,799 | 320,346 | 309,513 | |
| Flue Gas Flow Rate | scfm dry | 1,861,975 | 273,012 | 263,780 | |
| Flue Gas Flow Rate | acfm | 2,624,304 | 384,789 | 371,776 | |
| Flue Gas Temperature | °F | 128 | 128 | 128 | |
| Flue Gas Pressure | I.W.G. | 14.62 | | | |
| Flue Gas O2 | % vol wet | 11.1 | 11.1 | 11.1 | |
| Flue Gas CO2 | % vol wet | 8 | 8 | 8 | |
| Flue Gas H2O | % vol wet | 14.8 | 14.8 | 14.8 | |
| Flue Gas SO2 *) | ppmdv @ act O2 / lbs/MBTu | 52 / 0.14 | 47 / 0.13 | 47 / 0.13 | |
| Flue Gas SO3 *) | ppmdv @ act O2 / lbs/MBTu | 8 | 2 | 2 | |
| Flue Gas HCl *) | ppmdv @ act O2 / lbs/MBTu | 0 | 0 | 0 | |
| Flue Gas HF*) | ppmdv @ act O2 / lbs/MBTu | 0 | 0 | 0 | |
| Flue Gas NOx *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Dust *) | grains/ dcfm lbs/MBTU | 0.02 / 0.12 | 0.02 / 0.12 | 0.02 / 0.12 | |
| Flue Gas Hg *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Cd *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| Flue Gas Heavy Metals *) | ppmdv @ act O2 / lbs/MBTu | | | | |
| *) Concentration range is independent of the boiler load | | | | | |



Date: 12/1/2011

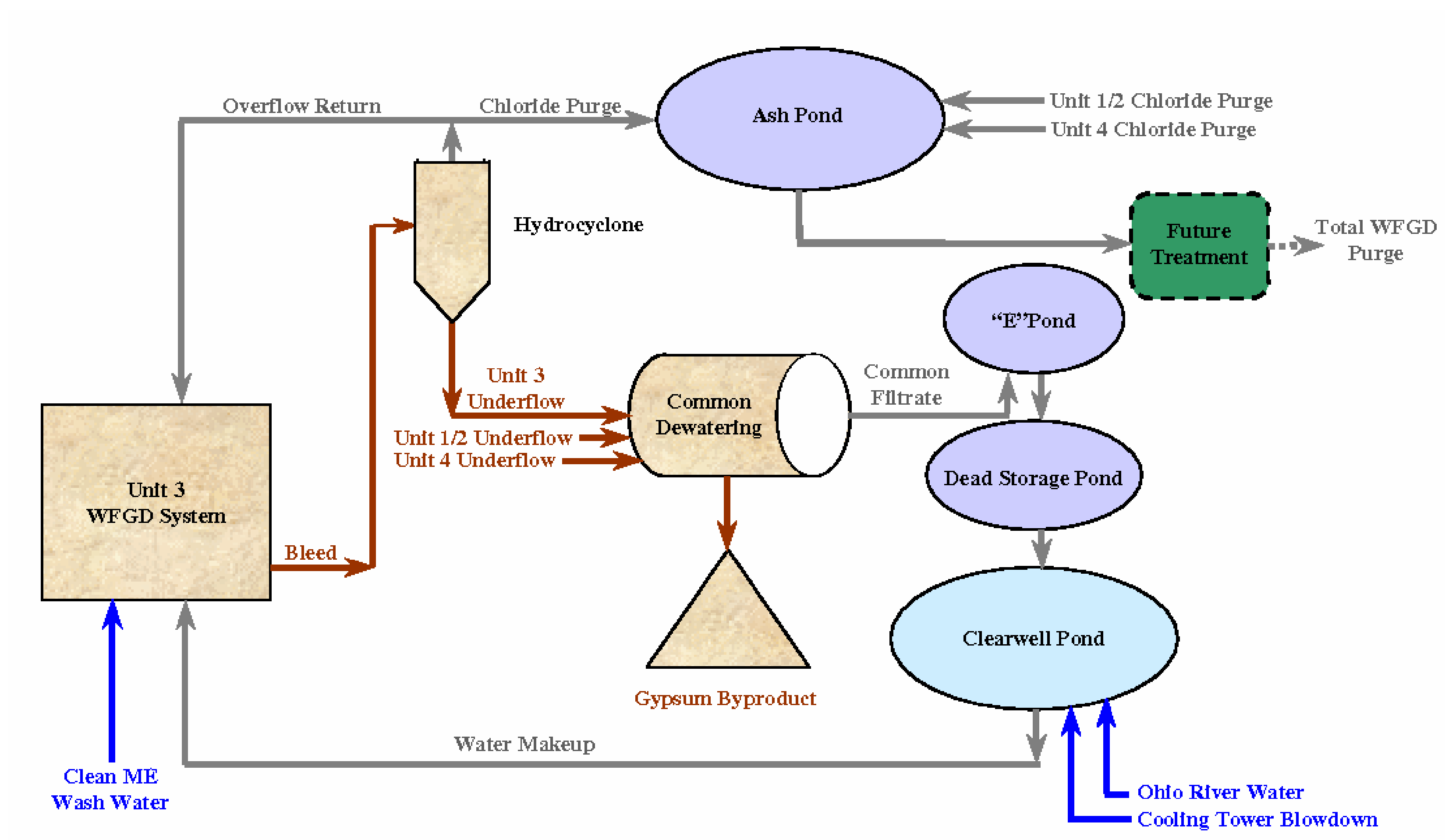
| BabcockPower ENVIRONMENTAL | FGD Design Basis Spreadsheet | LG&E Mill Creek Rev. 0 | | | | |
|---|---|---|---|---|---|---|
| **Coal & Reagent Data Sheet** | **Units** | **Unit 3** | **Unit 3** | **Unit 3** | | |
| **Design Coal Name** | Must be filled in | | | | | |
| Coal Source: | Coal Mine | 2009 | Original | Revised | | |
| Date Sample Taken: | Date | Average | Design | Design | | |
| **Coal Ultimate Analysis** | As Received | | | | | |
| Carbon (C) | Wt% | 61.61 | 61.20 | 60.00 | | |
| Hydrogen (H) | Wt% | 4.22 | 4.28 | 4.00 | | |
| Oxygen ($O_2$) | Wt% | 7.01 | 6.89 | 5.90 | | |
| Nitrogen ($N_2$) | Wt% | 1.28 | 1.27 | 1.30 | | |
| Sulfur (S) | Wt% | 3.02 | 3.36 | 3.45 | | |
| Chlorine (Cl) | Wt% | 0.06 | 0.16 | 0.35 | | |
| Fluorine (Fl) | Wt% | 0.01 | | | | |
| Moisture (Water $H_2O$) | Wt% | 11.43 | 11.00 | 11.00 | | |
| Ash | Wt% | 11.36 | 12.00 | 14.00 | | |
| Total | Wt% | 100.00 | 100.16 | 100.00 | | |
| | | | | | | |
| Wt. % Volatile | Wt% | 35.68 | | | | |
| Wt % Fixed Carbon | Wt% | 41.54 | | | | |
| Higher Heating Value | Btu/lb, As Recvd | 11,115 | 11,200 | 10,900 | | |
| **Reagent Name:** | | | | | | |
| Reagent Source: | | | | | | |
| Date Sample Taken: | | | | | | |
| | | | | | | |
| **Reagent Analysis** | | | | | | |
| CaCO3 | wt.% | | | | | |
| reactive CaCO3 | wt.% | | | | | |
| CaO | wt.% | | | | | |
| Ca(OH)2 | wt.% | | | | | |
| Fe2O3 | wt.% | | | | | |
| Al2O3 | wt.% | | | | | |
| SiO2 | wt.% | | | | | |
| MgCO3 | wt.% | | | | | |
| MgO | wt.% | | | | | |
| Mg(OH)2 | wt.% | | | | | |
| Chlorine (Cl) | ppm | | | | | |
| Fluorine (Fl) | ppm | | | | | |
| Moisture | wt% | | | | | |
| Inert | wt% | | | | | |

| BabcockPower ENVIRONMENTAL | FGD Design Basis Spreadsheet | Mill Creek Unit 3<br>Rev. 0 | | |
|---|---|---|---|---|
| **Process Water Data Sheet** | **Units** | **Design** | **Min** | **Max** |
| **Mist Eliminator Wash Water Analysis** | | | | |
| pH | | | | |
| Conductivity | mS/m | | | |
| Total hardness | mg/l | | | |
| Carbonate hardness | mg/l | 526 | | |
| Temperature | °F | | | |
| Suspended solids | mg/l | | | |
| Calcium as $CaCO_3$ | mg/l | 142 | | |
| Magnesium as CaCO3 | mg/l | 64 | | |
| Sodium as CaCO3 | mg/l | 57 | | |
| Chloride as CaCO3 | mg/l | 55 | | |
| Sulphate as CaCO3 | mg/l | 94 | | |
| Sulphite as CaCO3 | mg/l | | | |
| | | | | |
| **Make-Up Water Analysis** | | | | |
| pH | | | | |
| Conductivity | mS/m | | | |
| Total hardness | mg/l | | | |
| Carbonate hardness | mg/l | 526 | | |
| Temperature | °F | | | |
| Suspended solids | mg/l | | | |
| Calcium as $CaCO_3$ | mg/l | 142 | | |
| Magnesium as CaCO3 | mg/l | 64 | | |
| Sodium as CaCO3 | mg/l | 57 | | |
| Chloride as CaCO3 | mg/l | 55 | | |
| Sulphate as CaCO3 | mg/l | 94 | | |
| Sulphite as CaCO3 | mg/l | | | |
| | | | | |
| **Reclaim Water Analysis** | | | | |
| pH | | | | |
| Conductivity | mS/m | | | |
| Total hardness | mg/l | | | |
| Carbonate hardness | mg/l | 526 | | |
| Temperature | °F | | | |
| Suspended solids | mg/l | | | |
| Calcium as $CaCO_3$ | mg/l | 142 | | |
| Magnesium as CaCO3 | mg/l | 64 | | |
| Sodium as CaCO3 | mg/l | 57 | | |
| Chloride as CaCO3 | mg/l | 55 | | |
| Sulphate as CaCO3 | mg/l | 94 | | |
| Sulphite as CaCO3 | mg/l | | | |
| | | | | |
| **Service Water Analysis** | | | | |
| pH | | 7.70 | | |
| Conductivity | mS/m | | | |
| Total hardness | mg/l | | | |
| Carbonate hardness | mg/l | 444 | | |
| Temperature | °F | | | |
| Suspended solids | mg/l | 13 | | |
| Calcium as $CaCO_3$ | mg/l | 119 | | |
| Magnesium as CaCO3 | mg/l | 55 | | |
| Sodium as CaCO3 | mg/l | 48 | | |
| Chloride as CaCO3 | mg/l | 48 | | |
| Sulphate as CaCO3 | mg/l | 76 | | |
| Sulphite as CaCO3 | | | | |

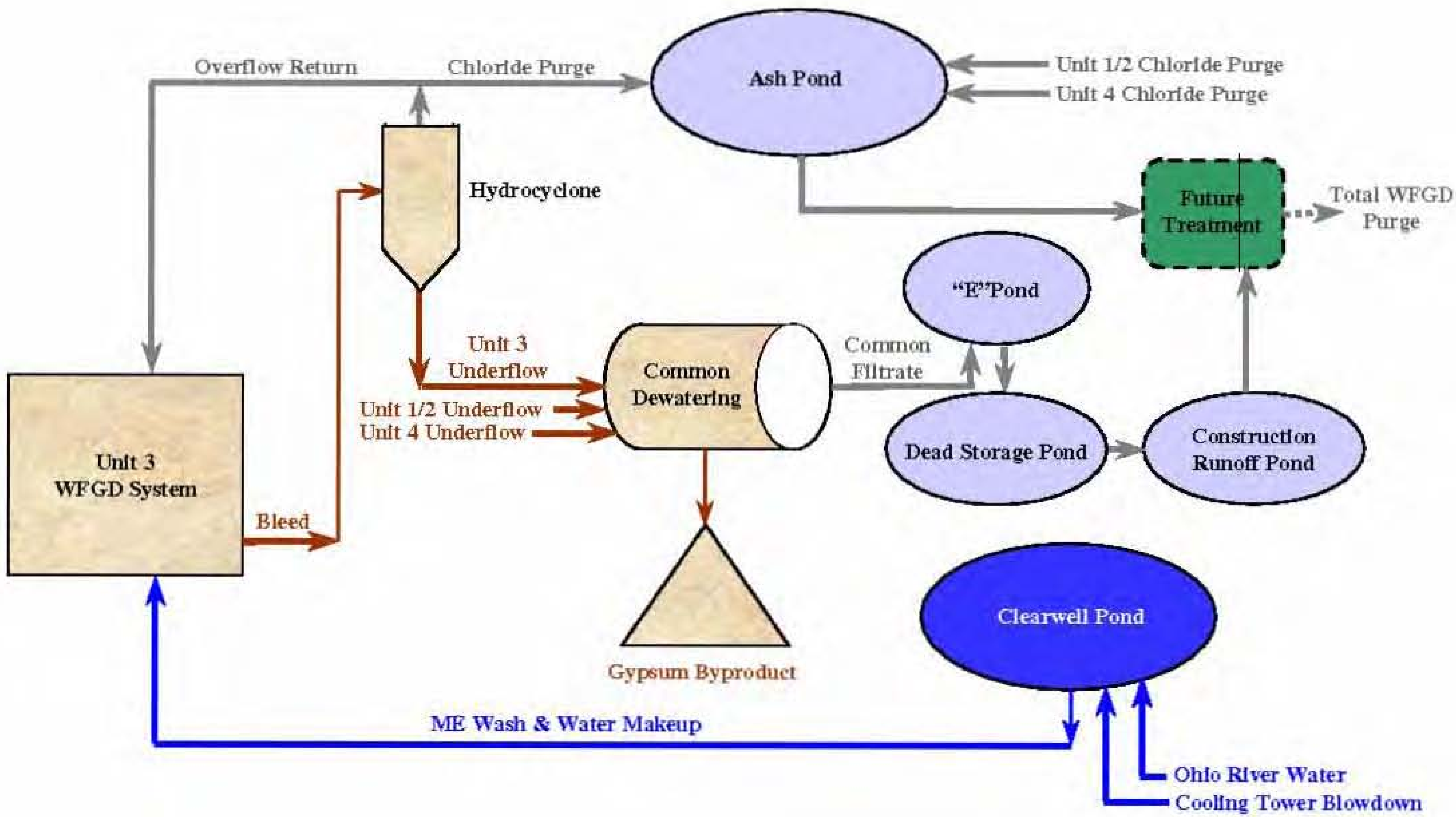
| BabcockPower ENVIRONMENTAL | FGD Design Basis Spreadsheet | Mill Creek Unit 3 Rev. 0 | |
|---|---|---|---|
| **Gypsum Slurry Data Sheet** | **Units** | **U3 No Change to Spray Header Location** | **U3 High Removal** |
| **Recycle Slurry Analysis** | | | |
| Mass Flow Rate, per pump | lb/hr | 15,000,000 | 15,000,000 |
| Volume Flow rate, per pump | gpm | 27,500 | 27,500 |
| Estimated TDH | | | |
| Spray Level 1 | ft, H2O | 56.4 | 59.7 |
| Spray Level 2 | ft, H2O | 61.2 | 64.7 |
| Spray Level 3 | ft, H2O | 64.6 | 69.7 |
| Spray Level 4 | ft, H2O | 68.0 | 74.7 |
| Specific Gravity | | 1.08-1.11 | 1.08-1.11 |
| Density | $lb/ft^3$ | 66.8-69.3 | 66.8-69.3 |
| Temperature | ℉ | 125-135 | 125-135 |
| pH | | 5 to 6 | 5 to 6 |
| Chloride as Cl- | mg/l | 5,000 | 5,000 |
| Viscosity | cp | 7.00 | 7.00 |
| Solids Content | wt.% | 14-18 | 14-18 |
| Solids Stream | | | |
| Gypsum | wt.% dry | 85-95 | 85-95 |
| Limestone | wt.% dry | 1-3 | 1-3 |
| Inert | wt.% dry | 5-15 | 5-15 |
| | | | |
| Special Notes: | | Compressed air is injected in the reaction tank to complete oxidation reaction<br>Pump TDH calculations are preliminary for cost estimate purposes only | |

# WATER FLOW SCHEMATIC

# Schematic of Water Flow – Filtrate Returns to WFGD System



## Schematic of Water Flow – Filtrate Does Not Returns to WFGD System



# BUDGET ENGINEERING AND PROCUREMENT ESTIMATE

LG&E-KU Services Company
Contract No. 843037
Mill Creek Unit 4 WFGD Performance Upgrade Analysis

## Budget Engineering and Procurement Estimate

December 2, 2011

| Description | Labor | Materials | Total |
|---|---|---|---|
| Case 1:Alloy 27–7MO Unit 4 (12,500 ppm chlorides) | $7,832,901 | $24,688,994 | $32,521,895 |
| Case 2: Alloy C-276 Unit 4 (50,000 ppm chlorides) | $7,832,901 | $27,369,596 | $35,202,498 |

Note: The estimate for the Mill Creek Unit 4 WFGD Performance Upgrade Analysis is a ROM (rough order of magnitude) estimate. The accuracy is based on +25% to –10%. The pricing is based on current 2011 dollars with no escalation.

The scope of pricing for the Mill Creek Unit 4 WFGD Performance Upgrade Analysis is limited to the Engineering and Procurement of the retrofit improvements. There are no allowances for BOP work, construction or maintenance upgrades to the WFGD structure.

11/30/2011

**LG&E - KU Services Company**
**Mill Creek Unit 3 gas to Unit 4 WFGD Systems Upgrade**
**ROM Price Estimate Revision 0**
**Alloy 27-7MO**

| Materials / Subcontracts | Labor Hours | Qty's | Units | Total Sell Price |
|---|---|---|---|---|
| **Absorber Recycle Pumps** | | | | **$2,584,891** |
| Recycle Pumps | | 8 | pcs | |
| Recycle Pumps - Special Tools | | 1 | lot | |
| Recycle Pumps - First Fill Lubricants | | 8 | pcs | |
| Recycle Pumps - NPSH,Noise, Vibration Test | | 1 | lot | |
| Recycle Pumps - Performance Test | | 1 | lot | |
| Recycle Pumps - MFG Field Service | | 5 | days | |
| Recycle Pumps - Exp.Jt. Non- Matalic @ recycle suction | | 8 | pcs | |
| Recycle Pumps - Exp.Jt. Non- Matalic @ recycle discharge | | 8 | pcs | |
| **Absorber Vessel** | | | | **$6,573,740** |
| Absorber Free Issue Plate - 32,000 sq ft plate (4) units | | 336,000 | lbs | |
| Absorber Fabrication | | 336,000 | lbs | |
| Awning - Free Issue Materials | | 2,100 | lbs | |
| Awning - Fabrication | | 2,100 | lbs | |
| Imtec Doors | | 20 | pcs | |
| **Absorber Vessel Wall Rings** | | | | **$428,081** |
| Wall Rings Support Clips | | 600 | lbs | |
| Wall Rings | | 8 | pcs | |
| Wall Rings - freight | | 1 | lot | |
| Wall Rings Support Clips - freight | | 1 | lot | |
| **Agitators & Sump Tank** | | | | **$2,748,186** |
| Absorber Agitators | | 10 | pcs | |
| Absorber Agitators - Model Study Test | | 1 | lot | |
| Absorber Agitators - 5% LOC / Surety Guarantee | | 1 | lot | |
| Absorber Agitators - Mfg Field Service | | 5 | days | |
| Absorber Agitators - freight | | 10 | pcs | |
| Agitator Metal Boxes for Mounting - 94 sq ft x 10 pcs = 940 sq ft | | 10 | pcs | |
| Absorber Sump Pumps | | 2 | pcs | |
| Absorber Sump Pumps Driver | | 2 | pcs | |
| Absorber Sump Agitators | | 1 | pcs | |
| Sump Covers and Bridges | | 2 | ea | |
| Ox Air Nozzles 10 pca 10"/ea approximately 6' lg per ea. | | 60 | lf | |
| Supply FRP Nozzles for Roof of Tank 60" x 4 pcs | | 4 | pcs | |
| Stebbins - Engineering for Agitator Boxes | | 10 | pcs | |
| Stebbins - Engineering to Evaluate the Tile Lined Tank | | 1 | lot | |
| Stebbins - Engineering to Design a New Concrete Roof | | 1 | lot | |
| Stebbins - Material Supply New Concrete Roof - prefab | | 6400 | sqft | |
| Stebbins - Engineering for Nozzles 12 pcs 10"/ea | | 12 | pcs | |
| Stebbins - Engineer large roof nozzles 60" times 4 pcs | | 4 | pcs | |

11/30/2011

**LG&E - KU Services Company**
**Mill Creek Unit 3 gas to Unit 4 WFGD Systems Upgrade**
**ROM Price Estimate Revision 0**
**Alloy 27-7MO**

| Materials / Subcontracts | Labor Hours | Qty's | Units | Total Sell Price |
|---|---|---|---|---|
| **Internal & External Recycle Pipe** | | | | **$5,474,463** |
| Internal Spray Headers - FRP | | 16 | pcs | |
| Internal Spray Headers - Recycle Spray Nozzles - 4" | | 832 | pcs | |
| Internal Spray Headers - Flanges 4" - 150# | | 832 | pcs | |
| Internal Spray Headers - Alloy Trusses | | 16 | pcs | |
| Internal Spray Headers - Freight | | 1 | lot | |
| External Recycle Piping | | 2000 | lf | |
| External Recycle Piping - Stress Analysis | | 1 | lot | |
| External Recycle Piping - Bolt & Gasket Sets | | 1 | lot | |
| External Recycle Piping - Anchors, Hangers & Supports | | 1 | lot | |
| External Recycle Piping - Freight | | 1 | lot | |
| External Recycle Piping - Temp Strainers | | 3 | pcs | |
| External Recycle Piping - Exp. Jts | | 32 | pcs | |
| External Recycle Piping - Freight | | 1 | lot | |
| Recycle Valves - Suction | | 8 | pcs | |
| Recycle Valves - Discharge | | 8 | pcs | |
| Recycle Valves - Mfg Field Service | | 1 | pcs | |
| Recycle Valves - Hydraulic Unit | | 1 | pcs | |
| Recycle Valves - Freight | | 1 | lot | |
| **Bleed Pump System** | | | | **$106,639** |
| Slurry Bleed Pumps | | 2 | pcs | |
| Slurry Bleed Pumps Driver | | 2 | pcs | |
| Slurry Bleed Pump - Expansion Joint | | 4 | pcs | |
| **Structural Steel** | | | | **$0** |
| Sump CS Plate | | Not Incl. | | |
| Grating - Replacement | | Not Incl. | | |
| Cover Plating Steel | | Not Incl. | | |
| Railing | | Not Incl. | | |
| Ladders | | Not Incl. | | |
| Safety Gates | | Not Incl. | | |
| **Valves & Piping** | | | | **$2,277,636** |
| Replace all Manual Values | | 1 | lot | |
| Replace all Actuated Valves | | 1 | lot | |
| Piping Specialties | | 1 | lot | |
| Large Bore Piping w/Hanger & Supports | | 1 | lot | |
| Misc. Hangers | | 1 | lot | |
| Nuts, Bolts & Gaskets CS | | 1 | lot | |
| Nuts, Bolts & Gaskets Alloy | | 1 | lot | |
| Oxidation Air Lances | | 10 | pcs | |
| Oxidation Air Lances - boltups | | 10 | pcs | |
| Oxidation Air Lances - Structural Steel Supports | | 10 | pcs | |
| Reactor to Sump FRP Piping | | 4 | pcs | |
| Sump Overflow FRP Piping | | 2 | pcs | |
| Sump Vent Piping Connected to the Ductwork | | 2 | pcs | |
| Bleed Piping | | 1 | lot | |
| Knife Gate Valves - Hydraulic Piping | | 1 | lot | |
| Emergency Quench Piping Header ( Internal to Duct) Alloy | | 1 | lot | |
| Emergency Quench - Nozzles | | 70 | pcs | |
| Emergency Quench - Expansion Joints | | 6 | pcs | |

11/30/2011

**LG&E - KU Services Company**
**Mill Creek Unit 3 gas to Unit 4 WFGD Systems Upgrade**
**ROM Price Estimate Revision 0**
**Alloy 27-7MO**

| Materials / Subcontracts | Labor Hours | Qty's | Units | Total Sell Price |
|---|---|---|---|---|
| **Instruments & Controls** | | | | **$504,560** |
| Analyzer - Sox | | 1 | lot | |
| Instruments & Controls | | 1 | lot | |
| Misc Tubing, Fittings & Hangers | | 1 | lot | |
| **Performance Test** | | | | **$222,006** |
| Physical Flow Model | | 1 | lot | |
| Performance Testing | | 1 | lot | |
| **Subcontractors** | | | | **$261,184** |
| BOP Electrical Design | | 1 | lot | |
| BOP Instrument Design | | 1 | lot | |
| **Ductwork & Expansion Joints** | | | | **$517,112** |
| Absorber Outlet Expansion Joints | | 180 | lf | |
| Absorber Outlet Expansion Joints - freight | | 4 | pcs | |
| Absorber Inlet Expansion Joints | | 256 | lf | |
| Absorber Inlet Expansion Joints - Freight | | 2 | pcs | |
| Inlet Duct - Replace plate with Alloy 16' x 16' x 12' | | 26,112 | lbs | |
| Inlet Duct - Fabrication | | 26,112 | lbs | |
| Inlet Duct - Stiffeners | | 39,014 | lbs | |
| Imtec Access Doors Inlet Duct | | 4 | pcs | |
| **Mist Eliminator & Supports** | | | | **$953,907** |
| Mist Eliminator - FRP DV 210 | | 4 | sets | |
| Mist Eliminator - Wash System | | 1 | lot | |
| Mist Eliminator - Installation Supervision | | 1 | lot | |
| Mist Eliminator - Alloy Supports | | 1 | lot | |
| Mist Eliminator - Water Wash Tank 40' x 40' | | 1 | pc | |
| Mist Eliminator - Water Wash Pumps | | 2 | pcs | |
| Mist Eliminator - Water Wash Pump Drivers | | 2 | pcs | |
| **Oxidation Air System** | | | | **$0** |
| **Site Work & Foundation Design** | | | | **$59,360** |
| Foundation Design | | 1 | lot | |
| **Secondary Hydrocycline System** | | | | **$1,710,109** |
| Primary Hydroclone | | 2 | ea | |
| Primary Hydroclone Feed Tank 48' x 51' | | 2 | ea | |
| Primary Hydroclone Pumps Expansion Joints | | 4 | ea | |
| Primary Hydroclone Underflow Feed Tank Agitator | | 2 | ea | |
| Primary Hydroclone - Feed Pumps | | 2 | ea | |
| Primary Hydroclone - Feed Pumps | | 2 | ea | |
| Cloride Purge Pumps | | 2 | ea | |
| Underflow Tanks FRP 5' x 5' | | 2 | ea | |
| **Engineering Total** | **22,604** | | | **$2,824,907** |
| **Project Management Total** | **18,861** | | | **$2,583,247** |
| **Field Service Total** | **2,108** | | | **$361,466** |
| **Site Engineer Total** | **8,431** | | | **$1,590,775** |
| **Misc. Items** | | | | **$267,120** |
| **BPEI Travel Expense** | | | | **$472,506** |
| | | | | |
| **Materials / Subcontracts** | | | | **$32,521,895** |

11/30/11

**LG&E - KU Services Company**
**Mill Creek Unit 3 gas to Unit 4 WFGD Systems Upgrade**
**ROM Price Estimate Revision 0**
**C-276 Materials**

| Materials / Subcontracts | Labor Hours | Qty's | Units | Total Sell Price |
|---|---|---|---|---|
| **Absorber Recycle Pumps** | | | | **$2,584,891** |
| Recycle Pumps | | 8 | pcs | |
| Recycle Pumps - Special Tools | | 1 | lot | |
| Recycle Pumps - First Fill Lubricants | | 8 | pcs | |
| Recycle Pumps - NPSH,Noise, Vibration Test | | 1 | lot | |
| Recycle Pumps - Performance Test | | 1 | lot | |
| Recycle Pumps - MFG Field Service | | 5 | days | |
| Recycle Pumps - Exp.Jt. Non- Matalic @ recycle suction | | 8 | pcs | |
| Recycle Pumps - Exp.Jt. Non- Matalic @ recycle discharge | | 8 | pcs | |
| **Absorber Vessel** | | | | **$9,254,343** |
| Absorber Free Issue Plate - 32,000 sq ft plate (4) units | | 336,000 | lbs | |
| Absorber Fabrication | | 336,000 | lbs | |
| Awning - Free Issue Materials | | 2,100 | lbs | |
| Awning - Fabrication | | 2,100 | lbs | |
| Imtec Doors | | 20 | pcs | |
| **Absorber Vessel Wall Rings** | | | | **$428,081** |
| Wall Rings Support Clips | | 600 | lbs | |
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| Absorber Agitators - Model Study Test | | 1 | lot | |
| Absorber Agitators - 5% LOC / Surety Guarantee | | 1 | lot | |
| Absorber Agitators - Mfg Field Service | | 5 | days | |
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| Absorber Sump Pumps | | 2 | pcs | |
| Absorber Sump Pumps Driver | | 2 | pcs | |
| Absorber Sump Agitators | | 1 | pcs | |
| Sump Covers and Bridges | | 2 | ea | |
| Ox Air Nozzles 10 pca 10"/ea approximately 6' lg per ea. | | 60 | lf | |
| Supply FRP Nozzles for Roof of Tank 60" x 4 pcs | | 4 | pcs | |
| Stebbins - Engineering for Agitator Boxes | | 10 | pcs | |
| Stebbins - Engineering to Evaluate the Tile Lined Tank | | 1 | lot | |
| Stebbins - Engineering to Design a New Concrete Roof | | 1 | lot | |
| Stebbins - Material Supply New Concrete Roof - prefab | | 6400 | sqft | |
| Stebbins - Engineering for Nozzles 12 pcs 10"/ea | | 12 | pcs | |
| Stebbins - Engineer large roof nozzles 60" times 4 pcs | | 4 | pcs | |

11/30/11

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| Internal Spray Headers - FRP | | 16 | pcs | |
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| External Recycle Piping - Anchors, Hangers & Supports | | 1 | lot | |
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| External Recycle Piping - Temp Strainers | | 3 | pcs | |
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| External Recycle Piping - Freight | | 1 | lot | |
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| Recycle Valves - Discharge | | 8 | pcs | |
| Recycle Valves - Mfg Field Service | | 1 | pcs | |
| Recycle Valves - Hydraulic Unit | | 1 | pcs | |
| Recycle Valves - Freight | | 1 | lot | |
| **Bleed Pump System** | | | | **$106,639** |
| Slurry Bleed Pumps | | 2 | pcs | |
| Slurry Bleed Pumps Driver | | 2 | pcs | |
| Slurry Bleed Pump - Expansion Joint | | 4 | pcs | |
| **Structural Steel** | | | | **$0** |
| Sump CS Plate | | Not Incl. | | |
| Grating - Replacement | | Not Incl. | | |
| Cover Plating Steel | | Not Incl. | | |
| Railing | | Not Incl. | | |
| Ladders | | Not Incl. | | |
| Safety Gates | | Not Incl. | | |
| **Valves & Piping** | | | | **$2,277,636** |
| Replace all Manual Values | | 1 | lot | |
| Replace all Actuated Valves | | 1 | lot | |
| Piping Specialties | | 1 | lot | |
| Large Bore Piping w/Hanger & Supports | | 1 | lot | |
| Misc. Hangers | | 1 | lot | |
| Nuts, Bolts & Gaskets CS | | 1 | lot | |
| Nuts, Bolts & Gaskets Alloy | | 1 | lot | |
| Oxidation Air Lances | | 10 | pcs | |
| Oxidation Air Lances - boltups | | 10 | pcs | |
| Oxidation Air Lances - Structural Steel Supports | | 10 | pcs | |
| Reactor to Sump FRP Piping | | 4 | pcs | |
| Sump Overflow FRP Piping | | 2 | pcs | |
| Sump Vent Piping Connected to the Ductwork | | 2 | pcs | |
| Bleed Piping | | 1 | lot | |
| Knife Gate Valves - Hydraulic Piping | | 1 | lot | |
| Emergency Quench Piping Header ( Internal to Duct) Alloy | | 1 | lot | |
| Emergency Quench - Nozzles | | 70 | pcs | |
| Emergency Quench - Expansion Joints | | 6 | pcs | |

11/30/11

**LG&E - KU Services Company**
**Mill Creek Unit 3 gas to Unit 4 WFGD Systems Upgrade**
**ROM Price Estimate Revision 0**
**C-276 Materials**

| Materials / Subcontracts | Labor Hours | Qty's | Units | Total Sell Price |
|---|---|---|---|---|
| **Instruments & Controls** | | | | **$504,560** |
| Analyzer - Sox | | 1 | lot | |
| Instruments & Controls | | 1 | lot | |
| Misc Tubing, Fittings & Hangers | | 1 | lot | |
| **Performance Test** | | | | **$222,006** |
| Physical Flow Model | | 1 | lot | |
| Performance Testing | | 1 | lot | |
| **Subcontractors** | | | | **$261,184** |
| BOP Electrical Design | | 1 | lot | |
| BOP Instrument Design | | 1 | lot | |
| **Ductwork & Expansion Joints** | | | | **$517,112** |
| Absorber Outlet Expansion Joints | | 180 | lf | |
| Absorber Outlet Expansion Joints - freight | | 4 | pcs | |
| Absorber Inlet Expansion Joints | | 256 | lf | |
| Absorber Inlet Expansion Joints - Freight | | 2 | pcs | |
| Inlet Duct - Replace plate with Alloy 16' x 16' x 12' | | 0 | lbs | |
| Inlet Duct - Fabrication | | 26,112 | lbs | |
| Inlet Duct - Stiffeners | | 39,014 | lbs | |
| Imtec Access Doors Inlet Duct | | 4 | pcs | |
| **Mist Eliminator & Supports** | | | | **$953,907** |
| Mist Eliminator - FRP DV 210 | | 4 | sets | |
| Mist Eliminator - Wash System | | 1 | lot | |
| Mist Eliminator - Installation Supervision | | 1 | lot | |
| Mist Eliminator - Alloy Supports | | 1 | lot | |
| Mist Eliminator - Water Wash Tank 40' x 40' | | 1 | pc | |
| Mist Eliminator - Water Wash Pumps | | 2 | pcs | |
| Mist Eliminator - Water Wash Pump Drivers | | 2 | pcs | |
| **Oxidation Air System** | | | | **$0** |
| **Site Work & Foundation Design** | | | | **$59,360** |
| Foundation Design | | 1 | lot | |
| **Secondary Hydrocyclone System** | | | | **$1,710,109** |
| Primary Hydroclone | | 2 | ea | |
| Primary Hydroclone Feed Tank 48' x 51' | | 2 | ea | |
| Primary Hydroclone Pumps Expansion Joints | | 4 | ea | |
| Primary Hydroclone Underflow Feed Tank Agitator | | 2 | ea | |
| Primary Hydroclone - Feed Pumps | | 2 | ea | |
| Primary Hydroclone - Feed Pumps | | 2 | ea | |
| Cloride Purge Pumps | | 2 | ea | |
| Underflow Tanks FRP 5' x 5' | | 2 | ea | |
| **Engineering Total** | 22,604 | | MHS | **$2,824,907** |
| **Project Management Total** | 18,861 | | MHS | **$2,583,247** |
| **Field Service Total** | 2,108 | | MHS | **$361,466** |
| **Site Engineer Total** | 8,431 | | MHS | **$1,590,775** |
| **Misc. Items** | | 1 | lot | **$267,120** |
| **BPEI Travel Expense** | | 1 | lot | **$472,506** |
| **Materials / Subcontracts** | **52,004** | | | **$35,202,498** |

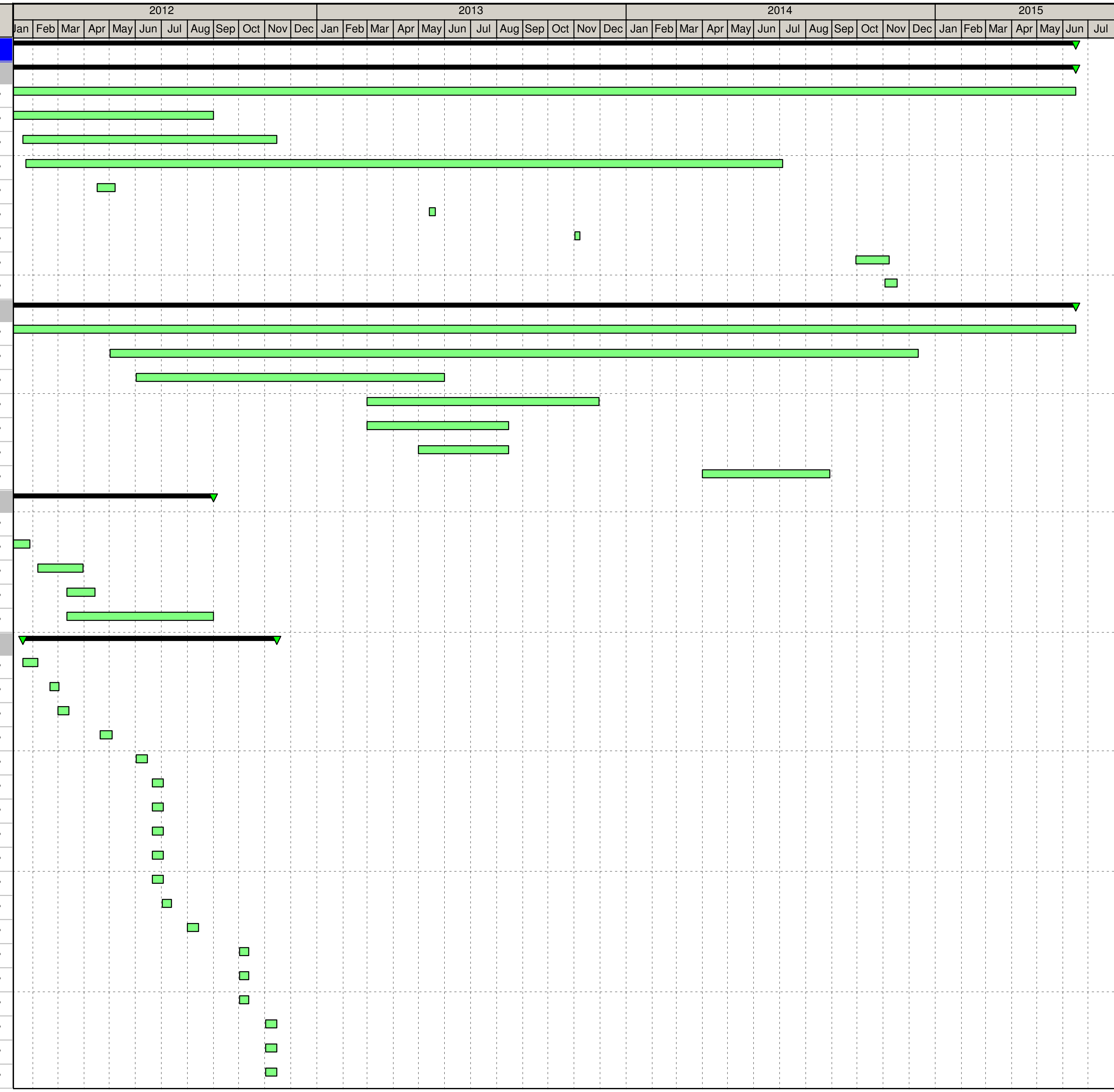
# WORK SCOPE

# Mill Creek Unit 4 WFGD
# Work Scope
# 11/8/2011

| | |
|---|---|
| Unit 4<br>• Year 1<br>2012 (4wks)<br>4/16-5/07 | • Sump Walls – (Agitators)<br>• Sump Roof<br>• Oxidation Air (Sump Internals) |
| Unit 4<br>• Year 2<br>2013 (2wks)<br>5/13 & 11/11 | • Replace All Valves & Instruments<br>• Replace Bleed Pumps<br>• Replace Hydrocyclone<br>• Replace FRP Piping for Bleed/Hydrocyclone<br>• Agitators |
| Unit 3<br>• Year 2<br>2013 (6wks) Fall | • Install U3 Outlet Duck Blank off Plate |
| Unit 4<br>• Year 3<br>2014 (8wks)<br>Fall 9/29-11/17 | • Replace Absorber vessel with Internals<br>- Spray Hdrs<br>- Spray Nozzles<br>- Mist Eliminator<br>- Wall Rings<br>- Trusses (if required)<br>• Nox Analyzers<br>• Knife gate Valves suction/discharge<br>• Rework Recycle Pipes to feed Hdrs<br>• Emergency Quench System<br>• Replace Scrubber Outlet Duct<br>• Replace Inlet Duct 4 places<br>• Inlet/Outlet expansion joints |
| Unit 3<br>• Year 3<br>2014 (1wk)<br>Fall | • Remove U3 Blank off Plate in Ductwork |
| General Work<br>• 2012 | • Run Oxidation Air Piping<br>• Structural Steel/Walkways (Clean/Paint or Replace) |
| • 2013 | • Continue Structural Steel/Walkways (Clean/Paint or Replace)<br>• Recycle Pumps & Foundation Replace (1) per month<br>• Run duct work Unit 3 to Unit 4 & Steel Supports<br>• Replace Required Pipe & Tubing for Valve & Instrument Replacement in the outage. |
| • 2014 | • Continue Structural Steel/Walkways (Clean/Paint or Replace)<br>• Replace Walkways for Recycle Pipe Changes |

**SCHEDULE (HIGH LEVEL)**

| Activity ID | Activity Name | Rem Dur | Start | Finish | % |
|---|---|---|---|---|---|
| **Mill Creek Unit 4 WFGD Conversion Study** | | 901 | 02-Jan-12 | 15-Jun-15 | |
| **Major Milestones** | | 901 | 02-Jan-12 | 15-Jun-15 | |
| A1168 | Construction | 901 | 02-Jan-12* | 15-Jun-15 | 0% |
| A1165 | Engineering | 175 | 02-Jan-12 | 31-Aug-12 | 0% |
| A1166 | Procurement | 214 | 20-Jan-12* | 14-Nov-12 | 0% |
| A1167 | Fabrication & Delivery | 640 | 23-Jan-12* | 04-Jul-14 | 0% |
| A1169 | Outages Unit 4 (2012) | 16 | 16-Apr-12* | 07-May-12 | 0% |
| A1170 | Outage Unit 4 (2013) | 6 | 13-May-13* | 20-May-13 | 0% |
| A1171 | Outage Unit 3 (2013) (Approximately) | 5 | 01-Nov-13* | 07-Nov-13 | 0% |
| A1172 | Outage Unit 4 (2014) | 30 | 29-Sep-14* | 07-Nov-14 | 0% |
| A1173 | Outage Unit 3 (2014) (Approximately) | 11 | 03-Nov-14* | 17-Nov-14 | 0% |
| **General Work Performed Between Outages** | | 901 | 02-Jan-12 | 15-Jun-15 | |
| A1176 | Miscellaneous Work to be Done | 901 | 02-Jan-12* | 15-Jun-15 | 0% |
| A1304 | Rework Existing Structural Steel | 684 | 01-May-12* | 12-Dec-14 | 0% |
| A1175 | Run Oxidation Air Piping & Hangers | 261 | 01-Jun-12* | 31-May-13 | 0% |
| A1177 | Recycle Pumps & Foundations Replace (1) per Month | 196 | 01-Mar-13* | 29-Nov-13 | 0% |
| A1179 | Replace Random Sec. of Pipe & Tubing on Valves & Instruments | 120 | 01-Mar-13* | 15-Aug-13 | 0% |
| A1178 | Run New Ductwork Unit 3 Outlet to Unit 4 & Support Steel | 77 | 01-May-13* | 15-Aug-13 | 0% |
| A1180 | Replace Reworked Platforms for Recycle Pipe Relocation | 109 | 01-Apr-14* | 29-Aug-14 | 0% |
| **Engineering** | | 175 | 02-Jan-12 | 31-Aug-12 | |
| A1183 | BPEI Recieves Notice to Proceed | 1 | 02-Jan-12 | 02-Jan-12 | 0% |
| A1184 | Design Calculations | 20 | 02-Jan-12 | 27-Jan-12 | 0% |
| A1185 | Conduct Physical Modeling | 40 | 06-Feb-12 | 30-Mar-12 | 0% |
| A1186 | Develop Equipment D&R Sheets | 25 | 12-Mar-12 | 13-Apr-12 | 0% |
| A1187 | Develop Mechanical Drawings | 125 | 12-Mar-12 | 31-Aug-12 | 0% |
| **Procurement** | | 214 | 20-Jan-12 | 14-Nov-12 | |
| A1201 | Issue P.O. Oxidation Air System | 12 | 20-Jan-12* | 06-Feb-12 | 0% |
| A1190 | Issue P.O. Recycle Pumps | 10 | 20-Feb-12 | 02-Mar-12 | 0% |
| A1192 | Issue P.O. Wall Rings | 10 | 01-Mar-12 | 14-Mar-12 | 0% |
| A1193 | Issue P.O. Agitators | 10 | 20-Apr-12* | 03-May-12 | 0% |
| A1191 | Issue P.O. Absorber Vessel | 10 | 01-Jun-12 | 14-Jun-12 | 0% |
| A1196 | Issue P.O. Instruments & Controls | 10 | 20-Jun-12 | 03-Jul-12 | 0% |
| A1197 | Issue P.O. Inlet/ Outlet Expansion Joints | 10 | 20-Jun-12 | 03-Jul-12 | 0% |
| A1198 | Issue P.O. Inlet Duct Sections | 10 | 20-Jun-12 | 03-Jul-12 | 0% |
| A1199 | Issue P.O. Manual & Automatic Valves | 10 | 20-Jun-12 | 03-Jul-12 | 0% |
| A1200 | Issue P.O. Mist Eliminator System | 10 | 20-Jun-12 | 03-Jul-12 | 0% |
| A1194 | Issue P.O. Analyzer SOX | 10 | 02-Jul-12* | 13-Jul-12 | 0% |
| A1195 | Issue P.O. Bleed Pump System | 10 | 01-Aug-12* | 14-Aug-12 | 0% |
| A1202 | Issue P.O. Hydrocyclone System | 10 | 01-Oct-12* | 12-Oct-12 | 0% |
| A1203 | Issue P.O. Recycle Spray Headers | 10 | 01-Oct-12 | 12-Oct-12 | 0% |
| A1204 | Issue P.O. Recycle Spray Nozzles | 10 | 01-Oct-12 | 12-Oct-12 | 0% |
| A1205 | Issue P.O. Recycle External Piping | 10 | 01-Nov-12* | 14-Nov-12 | 0% |
| A1206 | Issue P.O. Recycle Suction & Discharge Valves | 10 | 01-Nov-12 | 14-Nov-12 | 0% |
| A1207 | Issue P.O. Emergency Quench System | 10 | 01-Nov-12 | 14-Nov-12 | 0% |




Early Bar
Critical Remaining Work
Milestone
Summary

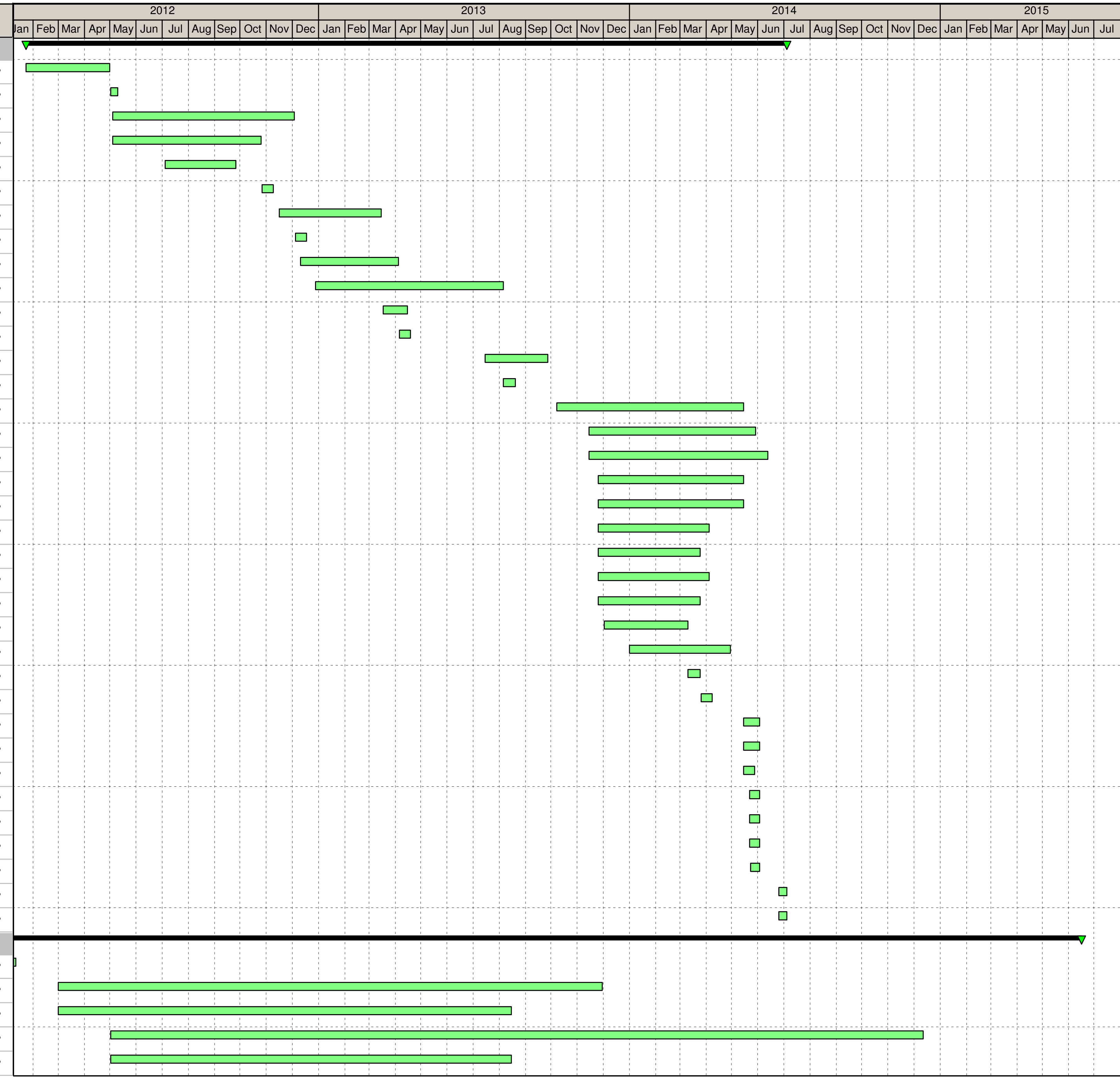
**100585 LG&E - KU Mill Creek**

**WFGD Retrofit Performance Upgrade Study**



BabcockPower

| Activity ID | Activity Name | Rem Dur | Start | Finish | % |
|---|---|---|---|---|---|
| **Fabrication and Delivery** | | 640 | 23-Jan-12 | 04-Jul-14 | |
| A1221 | Fabricate Oxidation Air System | 71 | 23-Jan-12* | 30-Apr-12 | 0% |
| A1239 | Deliver Oxidation Air System | 8 | 01-May-12 | 10-May-12 | 0% |
| A1210 | Fabricate Recycle Pumps | 152 | 04-May-12* | 03-Dec-12 | 0% |
| A1213 | Fabricate Agitators | 125 | 04-May-12 | 25-Oct-12 | 0% |
| A1216 | Fabricate Instruments & Controls | 60 | 04-Jul-12 | 25-Sep-12 | 0% |
| A1231 | Deliver Agitators | 10 | 26-Oct-12 | 08-Nov-12 | 0% |
| A1219 | Fabricate Manual & Automatic Valves | 87 | 15-Nov-12* | 15-Mar-13 | 0% |
| A1228 | Deliver Recycle Pumps | 10 | 04-Dec-12 | 17-Dec-12 | 0% |
| A1215 | Fabricate Bleed Pump System | 84 | 10-Dec-12* | 04-Apr-13 | 0% |
| A1222 | Fabricate Hydrocyclone System | 157 | 28-Dec-12* | 05-Aug-13 | 0% |
| A1237 | Deliver Manual & Automatic Valves | 21 | 18-Mar-13 | 15-Apr-13 | 0% |
| A1233 | Deliver Bleed Pump System | 10 | 05-Apr-13 | 18-Apr-13 | 0% |
| A1234 | Deliver Instruments & Controls | 55 | 15-Jul-13* | 27-Sep-13 | 0% |
| A1240 | Deliver Hydrocyclone System | 10 | 06-Aug-13 | 19-Aug-13 | 0% |
| A1226 | Fabricate Recycle Suction & Discharge Valves | 158 | 07-Oct-13* | 14-May-14 | 0% |
| A1211 | Fabricate Absorber Vessel | 140 | 15-Nov-13 | 29-May-14 | 0% |
| A1212 | Fabricate Wall Rings | 150 | 15-Nov-13 | 12-Jun-14 | 0% |
| A1217 | Fabricate Inlet/ Outlet Expansion Joints | 123 | 25-Nov-13* | 14-May-14 | 0% |
| A1218 | Fabricate Inlet Duct Sections | 123 | 25-Nov-13* | 14-May-14 | 0% |
| A1220 | Fabricate Mist Eliminator System | 95 | 25-Nov-13* | 04-Apr-14 | 0% |
| A1223 | Fabricate Recycle Spray Headers | 87 | 25-Nov-13* | 25-Mar-14 | 0% |
| A1224 | Fabricate Recycle Spray Nozzles | 95 | 25-Nov-13* | 04-Apr-14 | 0% |
| A1225 | Fabricate Recycle External Piping | 87 | 25-Nov-13* | 25-Mar-14 | 0% |
| A1227 | Fabricate Emergency Quench System | 71 | 02-Dec-13* | 10-Mar-14 | 0% |
| A1214 | Fabricate Analyzer SOX | 85 | 01-Jan-14* | 29-Apr-14 | 0% |
| A1245 | Deliver Emergency Quench System | 10 | 11-Mar-14 | 24-Mar-14 | 0% |
| A1243 | Deliver Recycle External Piping | 10 | 26-Mar-14 | 08-Apr-14 | 0% |
| A1235 | Deliver Inlet/ Outlet Expansion Joints | 13 | 15-May-14 | 02-Jun-14 | 0% |
| A1236 | Deliver Inlet Duct Sections | 13 | 15-May-14 | 02-Jun-14 | 0% |
| A1244 | Deliver Recycle Suction & Discharge Valves | 10 | 15-May-14 | 28-May-14 | 0% |
| A1232 | Deliver Analyzer SOX | 8 | 22-May-14* | 02-Jun-14 | 0% |
| A1238 | Deliver Mist Eliminator System | 8 | 22-May-14* | 02-Jun-14 | 0% |
| A1242 | Deliver Recycle Spray Nozzles | 8 | 22-May-14* | 02-Jun-14 | 0% |
| A1241 | Deliver Recycle Spray Headers | 7 | 23-May-14* | 02-Jun-14 | 0% |
| A1229 | Deliver Absorber Vessel | 8 | 25-Jun-14* | 04-Jul-14 | 0% |
| A1230 | Deliver Wall Rings | 8 | 25-Jun-14* | 04-Jul-14 | 0% |
| **Construction (General Work Between Outages)** | | 901 | 02-Jan-12 | 15-Jun-15 | |
| A1249 | Mobilize Construction | 8 | 02-Jan-12 | 11-Jan-12 | 0% |
| A1252 | Replace Recycle Pumps & Foundations (1) at a time | 457 | 01-Mar-12* | 29-Nov-13 | 0% |
| A1254 | Replace Pipe and Tubing for Valves & Instruments | 381 | 01-Mar-12* | 15-Aug-13 | 0% |
| A1251 | Repair Structural Steel and Walkways | 684 | 01-May-12* | 12-Dec-14 | 0% |
| A1253 | Install Duct work Unit 3 to Unit 4 and Steel Supports | 338 | 01-May-12* | 15-Aug-13 | 0% |




Early Bar
Critical Remaining Work
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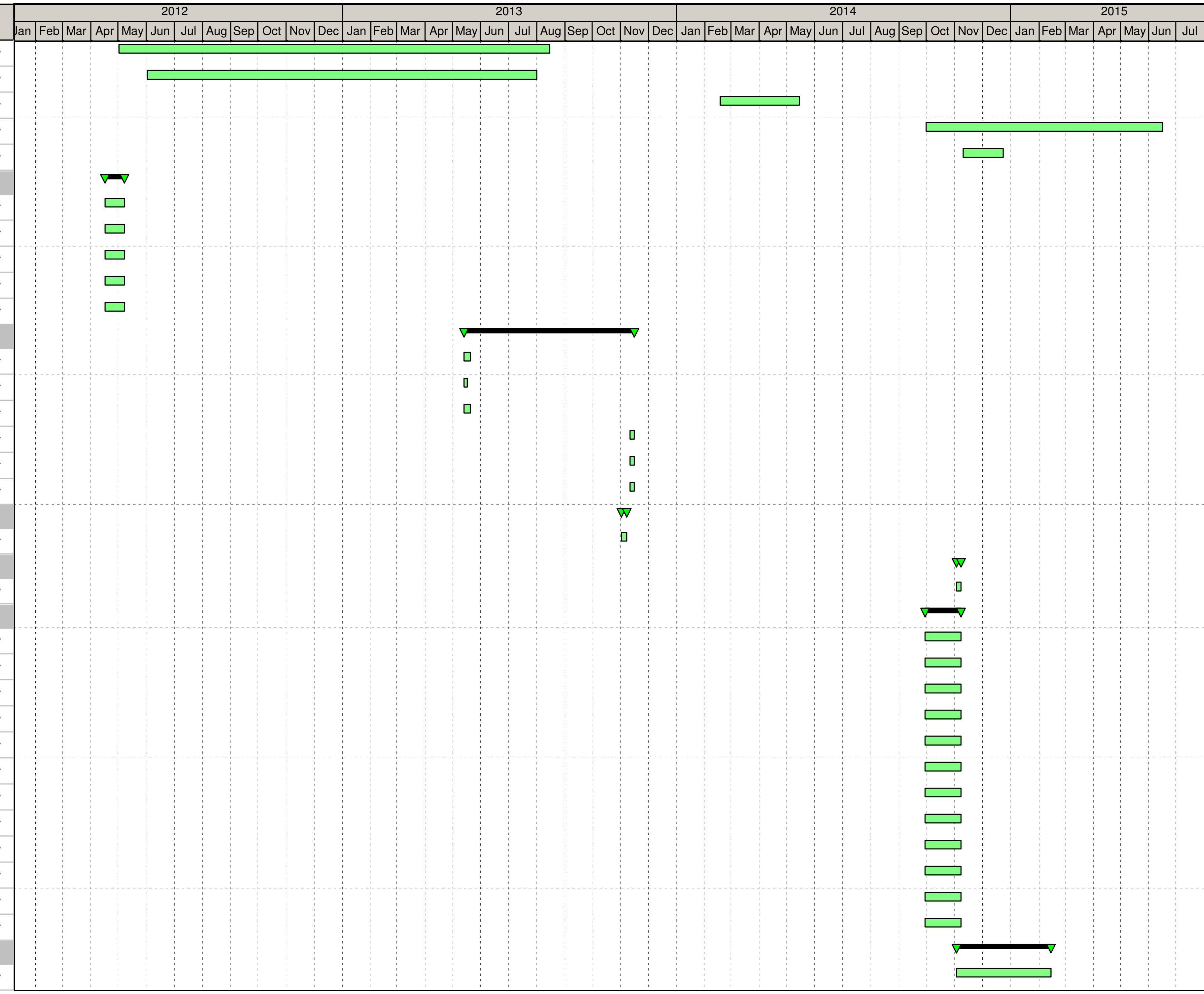
**100585 LG&E - KU Mill Creek**

**WFGD Retrofit Performance Upgrade Study**



BabcockPower

| Activity ID | Activity Name | Rem Dur | Start | Finish | % |
|---|---|---|---|---|---|
| A1255 | Install New Bleed Pump Foundation | 338 | 01-May-12* | 15-Aug-13 | 0% |
| A1250 | Run Oxidation Air Piping ( Outside Sump) | 305 | 01-Jun-12* | 01-Aug-13 | 0% |
| A1257 | Ground Fab Absorber Vessels | 64 | 17-Feb-14* | 15-May-14 | 0% |
| A1314 | General Work and Miscellaneous Activities | 184 | 01-Oct-14* | 15-Jun-15 | 0% |
| A1256 | Replace Platforms for new Recycle Piping | 32 | 10-Nov-14* | 23-Dec-14 | 0% |
| **Unit 4 2012 Outage (4 Weeks) 4/16 to 5/7** | | 16 | 16-Apr-12 | 07-May-12 | |
| A1260 | Repair Sump walls and Floor | 16 | 16-Apr-12* | 07-May-12 | 0% |
| A1261 | Install new Sump Nozzles | 16 | 16-Apr-12 | 07-May-12 | 0% |
| A1262 | Install new Concrete Panel Roof on Sump | 16 | 16-Apr-12 | 07-May-12 | 0% |
| A1263 | Install Agitator Wall Boxes | 16 | 16-Apr-12 | 07-May-12 | 0% |
| A1264 | Install Oxidation Air (Sump Internals) | 16 | 16-Apr-12 | 07-May-12 | 0% |
| **Unit 4 2013 Outage (2 Weeks) 5/13 & 11/11** | | 135 | 13-May-13 | 15-Nov-13 | |
| A1267 | Remove & Replace all Manual & Actuated Valves | 6 | 13-May-13* | 20-May-13 | 0% |
| A1269 | Install a New Bleed Pump System | 5 | 13-May-13* | 17-May-13 | 0% |
| A1272 | Install New Agitators | 6 | 13-May-13* | 20-May-13 | 0% |
| A1268 | Remove & Replace all Instruments | 5 | 11-Nov-13* | 15-Nov-13 | 0% |
| A1270 | Remove & Replace the Hydrocyclone | 5 | 11-Nov-13* | 15-Nov-13 | 0% |
| A1271 | Install New FRP Piping for Bleed/Hydrocyclone | 5 | 11-Nov-13* | 15-Nov-13 | 0% |
| **Unit 3 2013 Outage (6 Weeks) 9/29 & 11/7** | | 5 | 01-Nov-13 | 07-Nov-13 | |
| A1275 | Install Unit 3 Outlet Duck Blank Off Plate | 5 | 01-Nov-13* | 07-Nov-13 | 0% |
| **Unit 3 2014 Outage (1 Week) November** | | 5 | 03-Nov-14 | 07-Nov-14 | |
| A1291 | Remove Unit 3 Blank Off Plate in Ductwork | 5 | 03-Nov-14* | 07-Nov-14 | 0% |
| **Unit 4 2014 Outage (8 Weeks) 9/29 & 11/7** | | 30 | 29-Sep-14 | 07-Nov-14 | |
| A1277 | Unit 4 2014 Outage (8 wks) 9/29 to 11/7 | 30 | 29-Sep-14* | 07-Nov-14 | 0% |
| A1278 | Replace Absorber Vessels (4) | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1279 | Absorber Vessels Incl: Spray Headers | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1280 | Absorber Vessels Incl: Spray Nozzles | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1281 | Absorber Vessels Incl: Mist Eliminator | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1282 | Absorber Vessels Incl: Wall Rings | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1283 | Anaylzers SOX | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1284 | Knifegate Valves Suction/Discharge | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1285 | Emergency Quench System | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1286 | External Recycle Pipies | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1287 | Scrubber Inlet Duct | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| A1288 | Scrubber Inlet/Outlet Expansion Joints | 30 | 29-Sep-14 | 07-Nov-14 | 0% |
| **Start Up & Commissioning** | | 75 | 03-Nov-14 | 13-Feb-15 | |
| A1294 | Start Up & Commissioning | 75 | 03-Nov-14* | 13-Feb-15 | 0% |




Early Bar
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**100585 LG&E - KU Mill Creek**

**WFGD Retrofit Performance Upgrade Study**



BabcockPower

Exhibit JNV-2

Zachry New WFGD Estimate
for Mill Creek Unit 3

ZACHRY

# LG&E Mill Creek Environmental Compliance Project

## New Unit 3 WFGD – Scope description and Budget Estimate

**< September 11, 2012 >**

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Budget estimates for the following Unit 3 WFGD options are included:

- Option A = Stebbins Absorber Vessel – Base DOR [Absorber internals by EPC / Zachry]
- Option B = Solid C276 Absorber Vessel – Base DOR [Absorber internals by EPC / Zachry]
- Option C = Solid C276 Absorber Vessel – Modified DOR [Absorber Vessel by WFGD / Babcock]

The following information is included:

- Scope Summary – 6 pp.
- Preliminary Schedule [Options A ~ C] – 3 pp.
- Budget Estimate Comparison Summary – 2 pp.
- Budget Estimate Detail [Options A ~ C] – 6 pp.
- Babcock Budget Estimates [Options A ~ C] – 6 pp.

**Demolition**
The major demolition for Unit 3 is the ductwork on the outlet of the existing electrostatic precipitators (ESP). The ductwork from the discharge of the existing ESP will be replaced with new ductwork. The existing Unit 3 WFGD system will be abandoned in place. The existing ID fans will be removed and replaced.
We have also included the cost for a subcontractor to demolish the existing Unit 4 WFGD down to the anchor bolts, and we plan to self perform the demolition of the existing concrete foundation.

**Quantity Basis**
Please refer to Attachment A for Estimated Quantities.

**Civil Site Work**
Work will include the design and construction of all surveys, clearing, dewatering, grading, import and export of materials, as required, excavation, filling, trenching, shoring, backfilling, and paving, seeding, or other surfacing.
The EPC Contractor (Contractor) will establish and maintain benchmarks and control points, as required, to provide measurement control and to verify location of completed Work within the site coordinate system.
Contractor will design, furnish, and install temporary and permanent erosion and sediment controls for the Work.
Contractor will design and construct all excavation, trenching, and backfill and also design, furnish, install and maintain dewatering systems and/or shoring systems, as required.
Contractor will design, furnish and install final surfacing, including concrete and/or asphalt pavement, aggregate surfacing, and/or seeding, as required. Grade finished surfaces to drain without ponding.

**Structural Work**
Contractor will design, furnish, and install all required foundations, including deep foundation elements such as piling or caissons for structures and equipment, including:
- 1 PJFF(2-50%);
- WFGD system
- 2 ID fans located between the PJFF and the WFGD;
- Variable Frequency Drives (VFD) equipment and enclosures for the ID fans;
- PAC storage silos, associated transfer systems and buildings;
- SAMM storage silos, associated transfer systems, and buildings;
- Electrical transformers. These foundations will incorporate permanent construction for containing spills of oil, contaminated fire protection water and rainwater; and
- Any and all additional equipment identified as required during the execution of this Work.
- Contractor will design, furnish, and install all ductwork, associated supports, slide bearing assemblies, ductwork stiffeners (for both new and existing duct being reused), connections to existing ductwork, access doors, access platforms, stairs, ladders, handrails, and lifting lugs including:
- Gas ducts with, sampling, cleanout, instrumentation, and test ports, including turning vanes, as required, and flow straightening devices, as required, by the air flow model study, from the ESP outlet to the inlet of the PJFF;

- Gas ducts including duct from the PJFF outlet to the ID fans inlets, and test ports, including turning vanes, as required, and flow straightening devices, as required, by the air flow model study, and dampers;
- Gas ducts from the ID fans outlets to and including the inlet duct to the WFGD, and test ports, including turning vanes, as required, and flow straightening devices, as required, by the air flow model study, and dampers; and
- Gas duct from the WFGD outlet to the existing Unit 4 chimney breeching.
  - o Gas ducting includes 0.050 inch stainless steel type 304, 4x1 box rib Alclad conventional screwed system for duct roofs.
  - o Contractor assumes existing ESP outlet duct is structurally sound and no stiffening is required.

Contractor will design, furnish, and install all required structural steel for support of equipment and ductwork, including:

- Support of 2 – 50% PJFF structures for Unit 3. The structure will include stairs, platforms and vertical access elements provided by the PJFF supplier;
- Elevated concrete platform with support steel up to the equipment baseline under the PJFF.
- Support of the WFGD equipment building and all associated equipment provided by the WFGD supplier;
- Support of 2 PAC silos and all associated equipment and structures;
- Support of 2 SAMM silos and all associated equipment and structures;
- Support of the complete ash handling system provided by the Contractor;
- Support for new ductwork and re-support of modified existing ductwork;
- Miscellaneous steel structures for support of piping, raceway, and other utilities as may be required; and
- Miscellaneous steel structures and platforms for maintenance access to installed equipment, valves, and instruments;
  - o Contractor has assumed modifications to existing pipe racks are not required and that structure capacity is adequate for increased utility loadings;
  - o Contractor assumes existing building steel, isobus support steel, and concrete deck can be used to support the new isobus sections and cable bus.

Contractor will design, furnish, and install foundations, including deep foundation elements such as piling, required for the support of buildings and structures, including:

- PJFF support structure;
- WFGD absorber building, and associated equipment (including elevator);
- Electrical equipment building;
- PAC silos and equipment building;
- SAMM silos and equipment building;
- Ash handling equipment and building; and
- Miscellaneous yard structures for pipe, cable tray and other utility supports.

**Miscellaneous Work – Installation of Buyer-Furnished Equipment**

Contract will include designing of all necessary interfaces, receiving, unloading, inventorying, inspecting, storing, maintaining, removing from storage, protecting, handling, rigging, installing, field adjusting, aligning, commissioning, and testing of all of the following Buyer furnished equipment:

- PJFFs – Two 50% self-supporting PJFF modules furnished for control of particulates including:
  - o Casing, roof, hoppers, tube sheet, and appurtenances from the gas inlet manifolds to the gas outlet manifolds including flanges, access doors, struts;
  - o Structural steel framing up from foundations for support of slide bearing assemblies, all integrated with PJFF Vendor requirements and recommendations.
  - o Structural and miscellaneous steel for all permanent access platforms, both internal and external, including walkways, floor plated areas, stairways, ladders, and handrail (guard rail) from equipment baseline to the top equipment elevation of the PJFF, including access to fly ash removal equipment;
  - o Filter bags and cages;
  - o Filter bag cleaning system;
  - o Compressed air system including compressors, dryers, receivers, building enclosure and air distribution system required for filter bag cleaning and actuation of equipment;
  - o Weather enclosure;
  - o Gas flow distribution vanes and baffles;
  - o Compartment isolation dampers and actuators;
  - o Casing bypass dampers and actuators;
  - o Rain gutters and drains to grade;
  - o Electric hoists and trolleys,
  - o Access doors;
  - o Fly ash hoppers and nozzles including ash level detectors, outlet connections, pounding anvil, hopper vibrators, poke holes, anti-sneak baffles, electric hopper heaters, and insulation panels;
  - o All electrical equipment and motors; and
  - o Instruments, final control elements, and connections necessary to effectively control and monitor all equipment and systems for a complete and operable PJFF.
- PAC injection system for mercury control, including:
  - o Two storage silos including accessories;
  - o Reagent feeders for metering material;
  - o Conditioning equipment;
  - o Conveying equipment; and
  - o Flow monitoring and injection equipment.
- SAMM injection system for sulfuric acid and acid mist control, including:
  - o Two storage silos including accessories;
  - o Reagent feeders for metering material;
  - o Conditioning equipment;
  - o Conveying equipment; and
- Flow monitoring and injection equipment.
- Per the information received from Riley, the existing Unit 4 Oxidation Blowers will be reused for the new Unit 3 WFGD. We have included the cost to remove the existing pipe, and then re-pipe the oxidation air over to the new WFGD. It is assumed that the blowers, building, electrical, and controls, will be let untouched therefore not requiring any additional costs.

**Miscellaneous Work – Installation of Contractor-Furnished Equipment**

Contract will include designing all necessary interfaces, receiving, unloading, inventorying, inspecting, storing, maintaining, removing from storage, protecting, handling, rigging, installing, field adjusting, aligning, commissioning, and testing of all of the following below listed Contractor-furnished equipment.

- Expansion joints – furnish and install flue gas ductwork expansion joints at all necessary locations;
- Ductwork;
- Dampers;
- Fly ash conveying and storage system;
- Compressed air system;
- Service water;
- Potable water;
- Fire protection system;
- Wastewater system;
- Lube oil system; and
- ID fans (2X50%).

**AQCS Power Supply Systems**

Refer to Attachment B – Preliminary One lines for an overview of the electrical system.
Contractor will design, furnish, install, and commission new AC power supply systems (120v, 208v, 480v, 4160v, 13.8kV), 125 DC power supply system, and new uninterruptible power supply (UPS) system. All electrical equipment necessary will be included to provide a complete power supply system including isolated phase bus duct, non-segregated bus duct, transformers, cable bus, switchgear, motor control centers, variable frequency drives, panelboards, batteries, battery chargers, UPS systems, cable, raceway, etc. Equipment will include everything needed to tie into the existing plant system at agreed terminal points.
Protective relaying for unit aux transformers, 138kV to 13.8kV , and 13.8kV to 4,160V swithgear will be microprocessor based relays with primary differential protection and backup overcurrent protection. Breakers will be operated from DCS.
Contractor assumes the existing plant Diesel Generator is large enough to accommodate all changes/additions, a new Diesel Generator is not required

**Communication**

Contractor will extend the existing plant paging communications system to all new and /or replaced plant buildings and process areas as described herein. The scope of supply will include designing, furnishing, and installing all new equipment and system related components and interfacing with the existing plant page/party system. Contractor will design, furnish, and install raceway and space provisions for telephone/LAN equipment

**Lighting**

Contractor will design, furnish, and install permanent lighting in all new buildings and enclosures as well as outdoor areas as described herein. The lighting system will include convenience receptacles, power receptacles suitable for plant welding equipment, transformers, panelboards, cable, contactors, conduit, etc.
PJFF supplier shall supply lights and receptacles. Contractor will provide raceway, cable, power distribution panels and transformers as needed.

**Grounding and Lightning Protection**
Contractor will design, furnish, and install the grounding and lightning protecting system to tie into the existing plant ground grid and limit surface step potential values to the required level.

**Cathodic Protections and Freeze Protection**
Contractor will design, furnish and install the cathodic protection system for all underground metallic piping, underground steel tanks, and pad-mounted steel tanks and other critical above or below grade steel items for which corrosion is a significant concern.
Contractor will design, furnish, and install an electrical heat tracing system for freeze protection and process temperature maintenance for size 6-inch and smaller piping. This will include power feeder circuits, self-regulating heat trace devices, dry type distribution transformers, distribution panelboards, contactors, monitor panels, thermostats, raceway systems, and all materials required for powering and monitoring the heat tracing system.

**Instrumentation and Control Work**
Contractor will provide a complete and functional instrumentation and control system to satisfy the control and monitoring requirements of the Mill Creek AQCS systems.
Contractor shall not provide continuous monitoring systems as required by the specification and meeting the requirements of 40 CFR 75. This equipment was removed from the scope during negotiations. Contractor will provide CEM's building foundation, power, instrument air, umbilical cord, cables to the monitors on the monitoring platform, and installation of the CEMS shelter.
Contractor will obtain the services of the DCS original equipment manufacturer for all AQCS DCS engineering and design work such as DCS configuration and implementation. Contractor will be responsible for furnishing all control logics, control narratives, and system descriptions associated with the AQCS project.
Contractor will develop the master instrument and I/O lists to forward to the Buyer and/or DCS OEM to allow for I/O partitioning and DCS equipment sizing. The I/O list will be approved by the Buyer prior to partitioning.
Contractor will provide vibration Monitoring on all MV driven equipment and will wire vibration equipment provided by OEMs
The new Honeywell Experion PKS system will be integrated into the existing Plant Honeywell DCS . The new system shall incorporate a true distribution of controls by locating I/O equipment in the vicinity of the field equipment. Control System Architecture drawing will provide the DCS layout. DCS will be installed and commissioned per Honeywell’s recommendations and best practices.
Control system Performance and sizing will incorporate a design to achieve maximum efficiency, operability, reliability, and availability.
Hardware:
o Unit 3 Controller Subsystem & Marshaling
o 20% spare I/O and Record Drawings

Engineering Summary:
Configuration of IO¬
Experion HTML Graphics (Static¬ & Dynamic)
- Static Shape Library
- Pop-ups / faceplates
- System Diagnostic displays

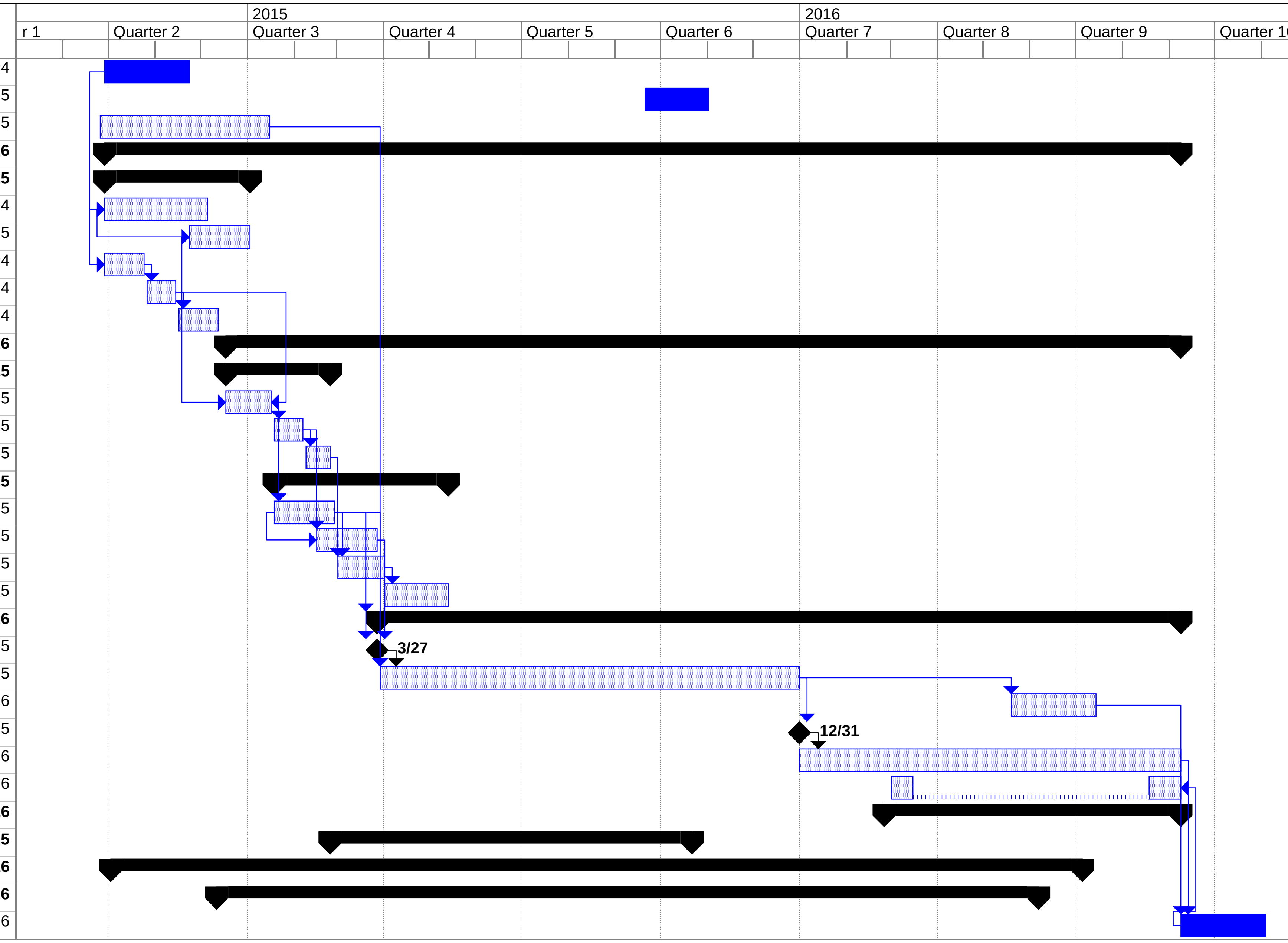
Control System Database¬
Logic configuration for AQCS upgrade¬
Third Party Interfaces¬
For the WFGD - use of Existing Unit # 4 DCS¬ controller for Unit #3. This includes software configuration, tag name changes and connection to existing unit #3 DCS. It is assumed that no new Honeywell DCS hardware is required to convert U #4 WFGD to U#3 and there are enough spares available in case of any additions.
Factory Acceptance Test¬
¬ Site Acceptance Test
New Historian Tags to be added to existing¬ Experion PKS Historian for Historical data storage & Retrieval
Fiber¬ & Ethernet interface to the existing DCS

**Other considerations taken;**

- **The PJFF has been rotated 90 degrees to facilitate better future access behind Unit 3**
- **We have included the additional cost for the piling and concrete foundation for the PJFF**
- **We have included the additional BOP electrical, piping, and controls that was not originally included**
- **We have utilized the schedules received from Riley for the three separate WFGD options, when looking at this additional cost please remember that the project has to be extended past our original demobilization date**
- **We have included the additional cost to remove the two 1280 D tower cranes at the end of the project, originally this was not required, but now because of the new location of the PJFF and new WFGD, we cannot access these tower cranes for removal, per our original plan**

Mill Creek - Unit 3 Preliminary Schedule - OPTION "A" - Stebbins WFGD

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | Unit 4 - Outage | 40 days | Mon 9/29/14 | Sun 11/23/14 |
| 2 | Unit 3 - Outage | 30 days | Mon 9/21/15 | Sun 11/1/15 |
| 3 | Winter Months | 80 days | Fri 9/26/14 | Thu 1/15/15 |
| 4 | **Unit 3 New** | **510 days** | **Mon 9/29/14** | **Fri 9/9/16** |
| 5 | **Demolition** | **70 days** | **Mon 9/29/14** | **Fri 1/2/15** |
| 6 | Unit 4 - WFGD Demolition Absorber (above grade) | 50 days | Mon 9/29/14 | Fri 12/5/14 |
| 7 | Unit 4 - WFGD Demolition Absorber Foundations | 30 days | Mon 11/24/14 | Fri 1/2/15 |
| 8 | Unit 4 - WFGD Demolition of hydrocclone and tank | 20 days | Mon 9/29/14 | Fri 10/24/14 |
| 9 | Unit 4 - WFGD Demolition oxidation air building | 15 days | Mon 10/27/14 | Fri 11/14/14 |
| 10 | Unit 4 - WFGD Demolition fly ash transfer tank | 20 days | Mon 11/17/14 | Fri 12/12/14 |
| 11 | **WFGD** | **452 days** | **Thu 12/18/14** | **Fri 9/9/16** |
| 12 | **Piling** | **49 days** | **Thu 12/18/14** | **Tue 2/24/15** |
| 13 | Unit 3 - Piling WFGD absorver tower Foundation | 22 days | Thu 12/18/14 | Fri 1/16/15 |
| 14 | Unit 3 - Piling WFGD building Foundation | 15 days | Mon 1/19/15 | Fri 2/6/15 |
| 15 | Unit 3 - Piling WFGD underflow tank Foundation | 12 days | Mon 2/9/15 | Tue 2/24/15 |
| 16 | **Foundation** | **83 days** | **Mon 1/19/15** | **Wed 5/13/15** |
| 17 | Unit 3 - WFGD - Place absorber foundation | 30 days | Mon 1/19/15 | Fri 2/27/15 |
| 18 | Unit 3 - WFGD - Place absorver building foundation | 30 days | Mon 2/16/15 | Fri 3/27/15 |
| 19 | Unit 3 - WFGD - Place underflow tank foundation | 23 days | Mon 3/2/15 | Wed 4/1/15 |
| 20 | Unit 3 - WFGD - place area foundations | 30 days | Thu 4/2/15 | Wed 5/13/15 |
| 21 | **Mechanical** | **380 days** | **Fri 3/27/15** | **Fri 9/9/16** |
| 22 | Unit 3 - WFGD - Release foundation for Stebbins mobilization | 0 days | Fri 3/27/15 | Fri 3/27/15 |
| 23 | Unit 3 - WFGD - Erect absorber shell (SUB) | 10 mons | Mon 3/30/15 | Thu 12/31/15 |
| 24 | Unit 3 - WFGD - Install floor & linner (SUB) | 2 mons | Fri 5/20/16 | Thu 7/14/16 |
| 25 | Unit 3 - WFGD - Release exclusion zone An absorber erectioı | 0 days | Thu 12/31/15 | Thu 12/31/15 |
| 26 | Unit 3 - WFGD - Install mechanical & piping | 9 mons | Fri 1/1/16 | Thu 9/8/16 |
| 27 | Unit 3 - WFGD - Tie into chimney (Existing) | 25 days | Wed 3/2/16 | Fri 9/9/16 |
| 28 | **Electrical** | **140 days** | **Fri 2/26/16** | **Thu 9/8/16** |
| 30 | **Fans** | **171 days** | **Wed 2/25/15** | **Wed 10/21/15** |
| 39 | **PJFF** | **459 days** | **Fri 10/3/14** | **Tue 7/5/16** |
| 59 | **Duct** | **388 days** | **Fri 12/12/14** | **Mon 6/6/16** |
| 70 | Unit 3 - Proposed New Unit 3 tie-in outage | 40 days | Fri 9/9/16 | Thu 11/3/16 |

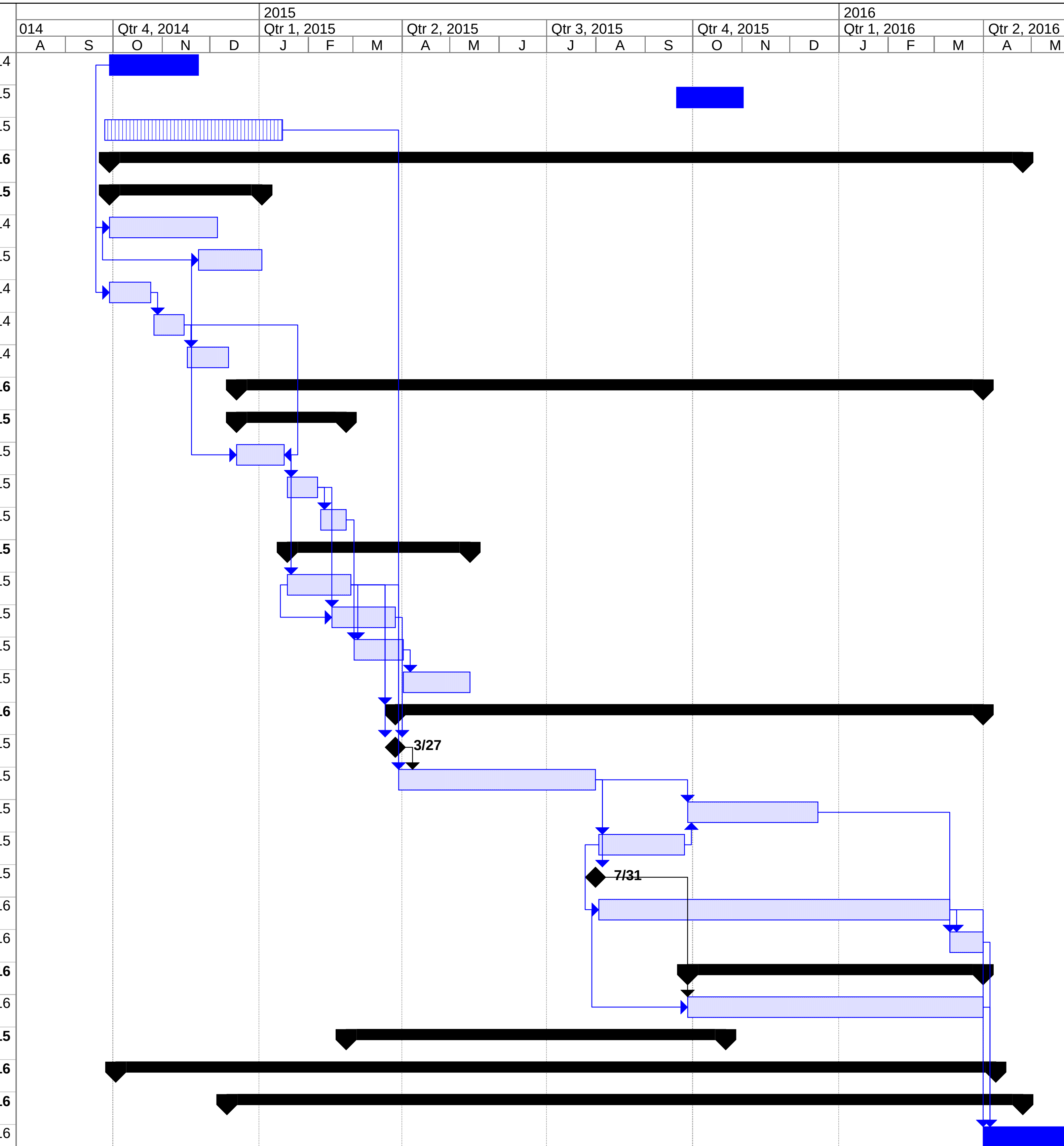



Project: Mill Creek Unit 3 WFGD optioı
Date: Tue 9/11/12

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | | Progress | | Summary | | External Tasks | | Deadline | |
| Split | | Milestone | | Project Summary | | External Milestone | | | |

Mill Creek - Unit 3 Preliminary Schedule - Option "B" - C276 - Internals installed by EPC

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | Unit 4 - Outage | 40 days | Mon 9/29/14 | Sun 11/23/14 |
| 2 | Unit 3 - Outage | 30 days | Mon 9/21/15 | Sun 11/1/15 |
| 3 | Winter Months | 80 days | Fri 9/26/14 | Thu 1/15/15 |
| 4 | **Unit 3 New** | **412 days** | **Mon 9/29/14** | **Mon 4/25/16** |
| 5 | **Demolition** | **70 days** | **Mon 9/29/14** | **Fri 1/2/15** |
| 6 | Unit 4 - WFGD Demolition Absorber (above grade) | 50 days | Mon 9/29/14 | Fri 12/5/14 |
| 7 | Unit 4 - WFGD Demolition Absorber Foundations | 30 days | Mon 11/24/14 | Fri 1/2/15 |
| 8 | Unit 4 - WFGD Demolition of hydrocclone and tank | 20 days | Mon 9/29/14 | Fri 10/24/14 |
| 9 | Unit 4 - WFGD Demolition oxidation air building | 15 days | Mon 10/27/14 | Fri 11/14/14 |
| 10 | Unit 4 - WFGD Demolition fly ash transfer tank | 20 days | Mon 11/17/14 | Fri 12/12/14 |
| 11 | **WFGD** | **337 days** | **Thu 12/18/14** | **Thu 3/31/16** |
| 12 | **Piling** | **49 days** | **Thu 12/18/14** | **Tue 2/24/15** |
| 13 | Unit 3 - Piling WFGD absorver tower Foundation | 22 days | Thu 12/18/14 | Fri 1/16/15 |
| 14 | Unit 3 - Piling WFGD building Foundation | 15 days | Mon 1/19/15 | Fri 2/6/15 |
| 15 | Unit 3 - Piling WFGD underflow tank Foundation | 12 days | Mon 2/9/15 | Tue 2/24/15 |
| 16 | **Foundation** | **83 days** | **Mon 1/19/15** | **Wed 5/13/15** |
| 17 | Unit 3 - WFGD - Place absorber foundation | 30 days | Mon 1/19/15 | Fri 2/27/15 |
| 18 | Unit 3 - WFGD - Place absorver building foundation | 30 days | Mon 2/16/15 | Fri 3/27/15 |
| 19 | Unit 3 - WFGD - Place underflow tank foundation | 23 days | Mon 3/2/15 | Wed 4/1/15 |
| 20 | Unit 3 - WFGD - place area foundations | 30 days | Thu 4/2/15 | Wed 5/13/15 |
| 21 | **Mechanical** | **265 days** | **Fri 3/27/15** | **Thu 3/31/16** |
| 22 | Unit 3 - WFGD - Release foundation for Sub mobilization | 0 days | Fri 3/27/15 | Fri 3/27/15 |
| 23 | Unit 3 - WFGD - Erect absorber shell (Sub) | 4.5 mons | Mon 3/30/15 | Fri 7/31/15 |
| 24 | Unit 3 - WFGD - Erect turret and transition (Sub) | 60 days | Mon 9/28/15 | Fri 12/18/15 |
| 25 | Unit 3 - WFGD - Install Internals EPC | 40 days | Mon 8/3/15 | Fri 9/25/15 |
| 26 | Unit 3 - WFGD - Release exclusion zone - absorber erection | 0 days | Fri 7/31/15 | Fri 7/31/15 |
| 27 | Unit 3 - WFGD - Install remaining mechanical & piping EPC | 8 mons | Mon 8/3/15 | Thu 3/10/16 |
| 28 | Unit 3 - WFGD - Tie into chimney (Existing) | 15 days | Fri 3/11/16 | Thu 3/31/16 |
| 29 | **Electrical** | **135 days** | **Mon 9/28/15** | **Thu 3/31/16** |
| 30 | Unit 3 - WFGD - Install Electrical | 135 days | Mon 9/28/15 | Thu 3/31/16 |
| 31 | **Fans** | **171 days** | **Wed 2/25/15** | **Wed 10/21/15** |
| 40 | **PJFF** | **397 days** | **Fri 10/3/14** | **Fri 4/8/16** |
| 60 | **Duct** | **358 days** | **Fri 12/12/14** | **Mon 4/25/16** |
| 71 | Unit 3 - Proposed New Unit 3 tie-in outage | 40 days | Fri 4/1/16 | Thu 5/26/16 |




Project: Mill Creek Unit 3 WFGD optio
Date: Tue 9/11/12

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | | Progress | | Summary | | External Tasks | | Deadline | |
| Split | | Milestone | | Project Summary | | External Milestone | | | |

Mill Creek - Unit 3 Preliminary Schedule - Option "C" - C276 "OPTION" - Internals installe by Babcock

| ID | | Task Name | Duration | Start | Finish |
|---|---|---|---|---|---|
| 1 | | Unit 4 - Outage | 40 days | Mon 9/29/14 | Sun 11/23/14 |
| 2 | | Unit 3 - Outage | 30 days | Mon 9/21/15 | Sun 11/1/15 |
| 3 | | Winter Months | 80 days | Fri 9/26/14 | Thu 1/15/15 |
| 4 | | **Unit 3 New** | **412 days** | **Mon 9/29/14** | **Mon 4/25/16** |
| 5 | | **Demolition** | **70 days** | **Mon 9/29/14** | **Fri 1/2/15** |
| 6 | | Unit 4 - WFGD Demolition Absorber (above grade) | 50 days | Mon 9/29/14 | Fri 12/5/14 |
| 7 | | Unit 4 - WFGD Demolition Absorber Foundations | 30 days | Mon 11/24/14 | Fri 1/2/15 |
| 8 | | Unit 4 - WFGD Demolition of hydrocclone and tank | 20 days | Mon 9/29/14 | Fri 10/24/14 |
| 9 | | Unit 4 - WFGD Demolition oxidation air building | 15 days | Mon 10/27/14 | Fri 11/14/14 |
| 10 | | Unit 4 - WFGD Demolition fly ash transfer tank | 20 days | Mon 11/17/14 | Fri 12/12/14 |
| 11 | | **WFGD** | **337 days** | **Thu 12/18/14** | **Thu 3/31/16** |
| 12 | | **Piling** | **49 days** | **Thu 12/18/14** | **Tue 2/24/15** |
| 13 | | Unit 3 - Piling WFGD absorver tower Foundation | 22 days | Thu 12/18/14 | Fri 1/16/15 |
| 14 | | Unit 3 - Piling WFGD building Foundation | 15 days | Mon 1/19/15 | Fri 2/6/15 |
| 15 | | Unit 3 - Piling WFGD underflow tank Foundation | 12 days | Mon 2/9/15 | Tue 2/24/15 |
| 16 | | **Foundation** | **83 days** | **Mon 1/19/15** | **Wed 5/13/15** |
| 17 | | Unit 3 - WFGD - Place absorber foundation | 30 days | Mon 1/19/15 | Fri 2/27/15 |
| 18 | | Unit 3 - WFGD - Place absorver building foundation | 30 days | Mon 2/16/15 | Fri 3/27/15 |
| 19 | | Unit 3 - WFGD - Place underflow tank foundation | 23 days | Mon 3/2/15 | Wed 4/1/15 |
| 20 | | Unit 3 - WFGD - place area foundations | 30 days | Thu 4/2/15 | Wed 5/13/15 |
| 21 | | **Mechanical** | **265 days** | **Fri 3/27/15** | **Thu 3/31/16** |
| 22 | | Unit 3 - WFGD - Release foundation for Sub mobilization | 0 days | Fri 3/27/15 | Fri 3/27/15 |
| 23 | | Unit 3 - WFGD - Erect absorber shell and internals(Sub) | 4.5 mons | Mon 3/30/15 | Fri 7/31/15 |
| 24 | | Unit 3 - WFGD - Erect turret and transition (Sub) | 65 days | Mon 8/3/15 | Fri 10/30/15 |
| 25 | | Unit 3 - WFGD - Release exclusion zone - absorber erection | 0 days | Fri 7/31/15 | Fri 7/31/15 |
| 26 | | Unit 3 - WFGD - Install remaining mechanical & piping EPC | 8 mons | Mon 8/3/15 | Thu 3/10/16 |
| 27 | | Unit 3 - WFGD - Tie into chimney (Existing) | 15 days | Fri 3/11/16 | Thu 3/31/16 |
| 28 | | **Electrical** | **135 days** | **Mon 9/28/15** | **Thu 3/31/16** |
| 29 | | Unit 3 - WFGD - Install Electrical | 135 days | Mon 9/28/15 | Thu 3/31/16 |
| 30 | | **Fans** | **171 days** | **Wed 2/25/15** | **Wed 10/21/15** |
| 39 | | **PJFF** | **397 days** | **Fri 10/3/14** | **Fri 4/8/16** |
| 59 | | **Duct** | **358 days** | **Fri 12/12/14** | **Mon 4/25/16** |
| 70 | | Unit 3 - Proposed New Unit 3 tie-in outage | 40 days | Fri 4/1/16 | Thu 5/26/16 |


Project: Mill Creek Unit 3 WFGD optio
Date: Tue 9/11/12

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | | Progress | | Summary | | External Tasks | | Deadline | |
| Split | | Milestone | | Project Summary | | External Milestone | | | |

| LG&E Scheduled Outage | Fall 2016 | Spring 2016 | Spring 2016 |
|---|---|---|---|
| | A | B | C |
| | BPI | | |
| BPI Base | $ 43,249,807 | $ 50,647,803 | $ 52,548,520 |
| Other Site Conditions | $ 1,374,303 | $ 1,178,197 | $ 1,178,197 |
| Bpi Total Number | $ 44,624,110 | $ 51,826,000 | $ 53,726,717 |
| | ZII Internals | ZII Internals | BPI Internals |
| BPI Pt-Pt Duration | 12 months | 9 months | 7 months |
| | | | 2 months not critical |
| Remove Internals from ZHI Scope | | | (21,037) |
| Assumed average rate for ZHI reduction | | | $ 63.60 |
| Resultant price to remove from B case for ZHI number | | | $ (1,337,867) |
| ZHI Number | $ 67,556,264 | $ 61,497,958 | $ 60,160,091 |
| ZHI Fee on BPI | $ 1,380,000 | $ 1,603,000 | $ 1,662,000 |
| Total ZHI Number | $ 68,936,264 | $ 63,100,958 | $ 61,822,091 |
| | | | |
| **TOTAL** | **$ 113,560,374** | **$ 114,926,958** | **$ 115,548,808** |
| Incremental Delta | Previous Base | $ 1,366,584 | $ 621,850 |
| | | increase | increase |
| BPI add for internals analysis | | | $ 1,900,717 |
| Average rate using BPI delta over ZHI removed DWH's | | | (90.35) |

# LG Mill Creek Unit 3 WFGD Comparison



ZACHRY

| | | | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 | 6/25/2012 | | 9/11/2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Quantity** | **UM** | **LABOR HOURS** | **Delta** | **LABOR HOURS** | **LABOR AMOUNT** | **Delta** | **LABOR AMOUNT** | **MAT AMOUNT** | **Delta** | **MAT AMOUNT** | **CONST EQUIP** | **Delta** | **CONST EQUIP** | **SUB AMOUNT** | **Delta** | **SUB AMOUNT** | **SUP AMOUNT** | **Delta** | **SUP AMOUNT** | **TOTAL AMOUNT** | **Delta** | **TOTAL AMOUNT** |
| WFGD Pipe | 8,390 | LF | | 26,160 | 26,160 | | $876,802 | $876,802 | | $743,203 | $743,203 | | | | | | | | | | | $1,620,006 | $1,620,006 |
| WFGD Demolition | 1 | EA | | 1,050 | 1,050 | | $31,138 | $31,138 | | | | | $4,518 | $4,518 | $321,939 | ($3,390) | $318,549 | | | | $321,939 | $32,266 | $354,205 |
| WFGD Site Improvments | 600 | SY | | 65 | 65 | | $1,925 | $1,925 | | $3,469 | $3,469 | | $2,710 | $2,710 | | $9,613 | $9,613 | | | | | $17,717 | $17,717 |
| WFGD U/G Utility Excavation/Backfill | 2,000 | CY | | 550 | 550 | | $16,180 | $16,180 | | $1,000 | $1,000 | | $11,390 | $11,390 | | $13,571 | $13,571 | | $250 | $250 | | $42,391 | $42,391 |
| WFGD Structural Excavation & Backfill | 6,215 | CY | 2,416 | (269) | 2,147 | $79,013 | ($9,500) | $69,514 | $13,572 | ($3,367) | $10,205 | $13 | $30,458 | $30,471 | $33,164 | ($5,341) | $27,823 | | | | $125,762 | $12,249 | $138,012 |
| WFGD Piling - Load Bearing | 454 | EA | 1,786 | (559) | 1,227 | $56,351 | ($17,588) | $38,763 | | | | | | | $2,959,248 | ($1,942,357) | $1,016,891 | | | | $3,015,599 | ($1,959,945) | $1,055,654 |
| WFGD Structural Concrete | 3,960 | CY | 25,398 | (2,616) | 22,781 | $802,094 | ($81,695) | $720,399 | $796,533 | ($86,001) | $710,532 | | | | $38,462 | ($4,292) | $34,170 | $49,650 | ($10,248) | $39,402 | $1,686,738 | ($182,236) | $1,504,503 |
| WFGD Structural Steel - UNIT 3 (W/YE | 697 | TN | 24,772 | 6,759 | 31,531 | $866,397 | $236,435 | $1,102,832 | $2,934,202 | $716,492 | $3,650,695 | | | | | | | $76,331 | ($5,523) | $70,808 | $3,876,931 | $947,404 | $4,824,335 |
| WFGD Buildings | 1 | SF | | | | | | | | | | | | | $3,022,807 | ($466,248) | $2,556,559 | | | | $3,022,807 | ($466,248) | $2,556,559 |
| WFGD U4 Fire Protection & Detection | 1 | PC | | | | | | | | | | | | | $279,028 | $134,618 | $413,646 | | | | $279,028 | $134,618 | $413,646 |
| WFGD Mechanical Equipment Unit # 3 | 808 | TN | 91,566 | (12,838) | 78,728 | $3,106,923 | ($434,779) | $2,672,143 | $3,977,235 | $44,267,016 | $48,244,251 | | | | $904,706 | $446,944 | $1,351,650 | $26,250 | | $26,250 | $8,015,114 | $44,279,180 | $52,294,294 |
| WFGD Electrical | 1 | EA | | 36,163 | 36,163 | | $1,220,156 | $1,220,156 | | $1,388,335 | $1,388,335 | | | | | $239,700 | $239,700 | | $6,521 | $6,521 | | $2,854,711 | $2,854,711 |
| WFGD Instrumentation | 165 | EA | 2,927 | 673 | 3,600 | $108,040 | $23,702 | $131,742 | $1,373,862 | ($803,517) | $570,345 | | | | | | | | | | $1,481,902 | ($779,816) | $702,087 |
| WFGD Other Piping Insulation U3 | 1 | LS | | | | | | | | | | | | | $211,050 | $250,400 | $461,450 | | | | $211,050 | $250,400 | $461,450 |
| WFGD 3 Field Finish Painting | 16,774 | SF | | 4,253 | 4,253 | | $136,318 | $136,318 | | $12,513 | $12,513 | | | | | | | | | | | $148,831 | $148,831 |
| WFGD Special Coatings | 9,648 | SF | | | | | | | | | | | | | | $400,142 | $400,142 | | | | | $400,142 | $400,142 |
| 12 - PJFF U/G Utility Excavation/Backfi | 1,175 | LF | | 41 | 41 | | $1,237 | $1,237 | | | | | $748 | $748 | | | | | | | | $1,985 | $1,985 |
| 13 - PJFF Structural Excavation & Back | 3,600 | CY | | 1,482 | 1,482 | | $48,640 | $48,640 | | $10,205 | $10,205 | | $21,282 | $21,282 | | $19,982 | $19,982 | | | | | $100,109 | $100,109 |
| 18 - PJFF Structural Concrete | 1,371 | CY | | 8,704 | 8,704 | | $276,673 | $276,673 | | $258,784 | $258,784 | | | | | $12,682 | $12,682 | | $25,200 | $25,200 | | $573,339 | $573,339 |
| 18 - PJFF Piling - Load Bearing | 66 | EA | | | | | | | | | | | | | | $1,187,643 | $1,187,643 | | | | | $1,187,643 | $1,187,643 |
| 20 - PJFF Structural Steel | 490 | TN | | 8,862 | 8,862 | | $299,678 | $299,678 | | $1,193,707 | $1,193,707 | | | | | | | | | | | $1,493,384 | $1,493,384 |
| 23 - Architectural Demo | 1 | EA | | | | | | | | | | | | | | ($239,604) | ($239,604) | | | | | ($239,604) | ($239,604) |
| 26 - PJFF-Mechanical | 1 | EA | | (4,819) | (4,819) | | ($157,765) | ($157,765) | | ($387,581) | ($387,581) | | | | | | | | | | | ($545,346) | ($545,346) |
| 42 - PJFF Electrical | 1 | EA | | 31,782 | 31,782 | | $1,065,779 | $1,065,779 | | $814,281 | $814,281 | | | | | $28,800 | $28,800 | | | | | $1,908,860 | $1,908,860 |
| 52 - PJFF Insulation U3 | (17,000) | SF | | | | | | | | | | | | | | ($267,750) | ($267,750) | | | | | ($267,750) | ($267,750) |
| 54 - PJFF Field Finish Painting | 11,750 | SF | | 2,441 | 2,441 | | $78,233 | $78,233 | | $7,619 | $7,619 | | | | | | | | | | | $85,852 | $85,852 |
| 50 - Instrumentation | 1 | LS | | 3,640 | 3,640 | | $119,912 | $119,912 | | $65,975 | $65,975 | | | | | | | | | | | $185,887 | $185,887 |
| 12 - Other U/G Utility Excavation/Backfi | 485 | LF | | 16 | 16 | | $495 | $495 | | | | | $299 | $299 | | | | | | | | $794 | $794 |
| 42 - Other Electrical | 1 | EA | | 6,888 | 6,888 | | $222,838 | $222,838 | | $697,265 | $697,265 | | | | | $7,200 | $7,200 | | | | | $927,303 | $927,303 |
| Craft Start Up Assistance | 100 | PC | 500 | | 500 | $22,252 | $23 | $22,275 | | | | | | | | | | | | | $22,252 | $23 | $22,275 |
| Sub Total Direct Cost | | | 149,364 | 118,427 | 267,791 | $5,041,071 | $3,954,836 | $8,995,906 | $9,095,404 | $48,899,396 | $57,994,800 | $13 | $71,406 | $71,419 | $7,770,404 | ($177,688) | $7,592,716 | $152,230 | $16,200 | $168,430 | $22,059,122 | $52,764,150 | $74,823,272 |
| Construction Equipment Owned & 3rd | 1 | LS | | 1,628 | 1,628 | | $51,402 | $51,402 | | | | $2,988,816 | $3,366,216 | $6,355,032 | | | | | $270,665 | $270,665 | $2,988,816 | $3,688,283 | $6,677,099 |
| Direct Labor Unallocated Supplies | 1 | LS | | | | | | | | | | | | | | | | $205,247 | $220,633 | $425,880 | $205,247 | $220,633 | $425,880 |
| Scaffolding Supplies | 1 | LS | | | | | | | | | | | | | | | | $45,750 | $101,250 | $147,000 | $45,750 | $101,250 | $147,000 |
| Small Tools | 1 | LS | | | | | | | | | | | $73,439 | $73,439 | | | | $900,608 | ($640,608) | $260,000 | $900,608 | ($567,170) | $333,439 |
| Craft Per Diem | 1 | LS | | | | $972,600 | $646,800 | $1,619,400 | | | | | | | | | | $972,600 | $646,800 | $1,619,400 | $1,945,200 | $1,293,600 | $3,238,800 |
| Construction Staff & Expenses | 1 | LS | 20,510 | 108,976 | 129,486 | $694,609 | $3,776,027 | $4,470,636 | | | | | | | | | | $913,470 | $1,237,219 | $2,150,689 | $1,608,079 | $5,013,246 | $6,621,325 |
| Sales Tax | 1 | EA | | | | | | | | | | | | | | | | $94,533 | $79,467 | $174,000 | $94,533 | $79,467 | $174,000 |
| Indirect Sundries | 1 | LS | | | | | | | | | | | | | | | | | $34,535 | $34,535 | | $34,535 | $34,535 |
| Home Office Support | 1 | LS | | 3,513 | 3,513 | | $108,847 | $108,847 | | | | | | | | | | | $170,166 | $170,166 | | $279,013 | $279,013 |
| Engineering Liason & Expenses | 1 | LS | | 2,080 | 2,080 | | $174,510 | $174,510 | | | | | | | | | | | $48,500 | $48,500 | | $223,010 | $223,010 |
| Engineering | 1 | LS | | | | | | | | | | | | | $2,000,000 | $3,740,866 | $5,740,866 | | | | $2,000,000 | $3,740,866 | $5,740,866 |
| Enterprise Start Up & Commissioning | 1 | LS | | | | | | | | | | | | | $1,512,100 | ($990,512) | $521,588 | | $230,457 | $230,457 | $1,512,100 | ($760,055) | $752,045 |
| Builders Risk | 1 | EA | | | | | | | | | | | | | | | | | $300,000 | $300,000 | | $300,000 | $300,000 |
| JV 6000 Joint Venture Indirects | 1 | LS | | 1,442 | 1,442 | | $243,031 | $243,031 | | | | | | | | | | $38,578 | $894,202 | $932,780 | $38,578 | $1,137,233 | $1,175,811 |
| Escalation | 1 | LS | | | | | $30,000 | $30,000 | | | | | $87,000 | $87,000 | | | | $535,000 | $3,826,280 | $4,361,280 | $535,000 | $3,943,280 | $4,478,280 |
| General & Administrative | 1 | LS | | | | | | | | | | | | | | | | $2,644,000 | $2,085,000 | $4,729,000 | $2,644,000 | $2,085,000 | $4,729,000 |
| Fee | 1 | LS | | | | | | | | | | | | | | | | $1,190,000 | $2,217,000 | $3,407,000 | $1,190,000 | $2,217,000 | $3,407,000 |
| Sub Total Indirect Cost | | | 20,510 | 117,639 | 138,149 | $1,667,209 | $5,030,618 | $6,697,827 | | | | $2,988,816 | $3,526,655 | $6,515,471 | $3,512,100 | $2,750,354 | $6,262,454 | $7,539,786 | $11,721,565 | $19,261,351 | $15,707,911 | $23,029,192 | $38,737,103 |
| Total Project | | | 169,874 | 236,066 | 405,939 | $6,708,280 | $8,985,454 | $15,693,733 | $9,095,404 | $48,899,396 | $57,994,800 | $2,988,829 | $3,598,061 | $6,586,889 | $11,282,504 | $2,572,667 | $13,855,171 | $7,692,016 | $11,737,764 | $19,429,781 | $37,767,033 | $75,793,342 | $113,560,374 |

ZACHRY

Zachry Industrial Incorporated
Estimate Detail Option "A" Stebbins Tower
Estimate: PFAQ12042 A
Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **New Unit 3 WFGD** | | | | | | | | | |
| 2.1 | WFGD Pipe | 8,390 | EA | 26,160 | $876,802 | $743,203 | | | | $1,620,006 |
| 2.2 | WFGD Demolition | 1 | EA | 1,050 | $31,138 | | $4,518 | $318,549 | | $354,205 |
| 2.3 | WFGD Site Improvments | 600 | SY | 65 | $1,925 | $3,469 | $2,710 | $9,613 | | $17,717 |
| 2.4 | WFGD U/G Utility Excavation/Backfill | 2,000 | CY | 550 | $16,180 | $1,000 | $11,390 | $13,571 | $250 | $42,391 |
| 2.5 | WFGD Structural Excavation & Backfill | 5,000 | CY | 2,147 | $69,514 | $10,205 | $30,471 | $27,823 | | $138,012 |
| 2.6 | WFGD Piling - Load Bearing | 281 | EA | 1,227 | $38,763 | | | $1,016,891 | | $1,055,654 |
| 2.7 | WFGD Structural Concrete | 3,694 | CY | 22,781 | $720,399 | $710,532 | | $34,170 | $39,402 | $1,504,503 |
| 2.8 | WFGD Structural Steel - UNIT 3 (W/YE | 1,426 | TN | 31,531 | $1,102,832 | $3,650,695 | | | $70,808 | $4,824,335 |
| 2.9 | WFGD Buildings | 1 | SF | | | | | $2,556,559 | | $2,556,559 |
| 2.10 | WFGD U3 Fire Protection & Detection | 1 | PC | | | | | $413,646 | | $413,646 |
| 2.11 | WFGD Mechanical Equipment Unit # 3 | 321 | TN | 78,728 | $2,672,143 | $48,244,251 | | $1,351,650 | $26,250 | $52,294,294 |
| 2.12 | WFGD Electrical | 1 | EA | 36,163 | $1,220,156 | $1,388,335 | | $239,700 | $6,521 | $2,854,711 |
| 2.13 | WFGD Instrumentation | 165 | EA | 3,600 | $131,742 | $570,345 | | | | $702,087 |
| 2.14 | Other Piping Insulation U3 | 23,499 | SF | | | | | $461,450 | | $461,450 |
| 2.15 | WFGD 3 Field Finish Painting | 21,093 | SF | 4,253 | $136,318 | $12,513 | | | | $148,831 |
| 2.16 | WFGD Special Coatings | 9,648 | SF | | | | | $400,142 | | $400,142 |
| **3** | **Unit 3 PJFF Modifications** | | | | | | | | | |
| 3.1 | 12 - PJFF U/G Utility Excavation/Backfi | 1,175 | LF | 41 | $1,237 | | $748 | | | $1,985 |
| 3.2 | 13 - PJFF Structural Excavation & Bacl | 3,600 | CY | 1,482 | $48,640 | $10,205 | $21,282 | $19,982 | | $100,109 |
| 3.3 | 18 - PJFF Structural Concrete | 1,371 | CY | 8,704 | $276,673 | $258,784 | | $12,682 | $25,200 | $573,339 |
| 3.4 | 18 - PJFF Piling - Load Bearing | 66 | EA | | | | | $1,187,643 | | $1,187,643 |
| 3.5 | 20 - PJFF Structural Steel | 490 | TN | 8,862 | $299,678 | $1,193,707 | | | | $1,493,384 |
| 3.6 | 23 - Architectural Demo | 1 | EA | | | | | ($239,604) | | ($239,604) |
| 3.7 | 26 - PJFF-Mechanical | 1 | EA | (4,819) | ($157,765) | ($387,581) | | | | ($545,346) |
| 3.8 | 42 - PJFF Electrical | 1 | EA | 31,782 | $1,065,779 | $814,281 | | $28,800 | | $1,908,860 |
| 3.9 | 52 - PJFF Insulation U3 | (17,000) | SF | | | | | ($267,750) | | ($267,750) |
| 3.10 | 54 - PJFF Field Finish Painting | 11,750 | SF | 2,441 | $78,233 | $7,619 | | | | $85,852 |
| 3.11 | 50 - Instrumentation | 1 | EA | 3,640 | $119,912 | $65,975 | | | | $185,887 |
| **4** | **Other Common Modifications** | | | | | | | | | |
| 4.1 | 12 - Other U/G Utility Excavation/Backfi | 485 | LF | 16 | $495 | | $299 | | | $794 |
| 4.2 | 42 - Other Electrical | 1 | EA | 6,888 | $222,838 | $697,265 | | $7,200 | | $927,303 |
| **5** | **Remainder of Construction** | | | | | | | | | |
| 5.1 | Craft Start Up Assistance | 100 | PC | 500 | $22,275 | | | | | $22,275 |
| 6.1 | Craft Inefficiency - Schedule Related | 1 | LS | | | | | | | |
| 7.1 | Craft Inefficiency - Special Conditions | 1 | LS | | | | | | | |
| 8.1 | Construction Equipment Owned & 3rd F | 100 | LS | 1,628 | $51,402 | | $6,354,523 | | $270,665 | $6,676,590 |
| 9.1 | Direct Labor Unallocated Supplies | 1 | LS | | | | | | $425,880 | $425,880 |
| 10.1 | Scaffolding Supplies | 1 | LS | | | | | | $147,000 | $147,000 |
| 11.1 | Small Tools | 1 | LS | | | | $73,439 | | $260,000 | $333,439 |
| 12.1 | Craft Per Diem | 1 | LS | | | | | | $1,619,400 | $1,619,400 |
| 17.1 | Pre Construction Costs | 1 | LS | | | | | | | |
| 18.1 | Mobilization Cost | 1 | LS | 1,016 | $32,931 | | | | $252,567 | $285,498 |
| 18.2 | Demobilization Cost | 1 | LS | 100 | $3,289 | | | | $573 | $3,862 |

Zachry Industrial Incorporated

Estimate Detail Option "A" Stebbins Tower

Estimate: PFAQ12042 A

Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| 20.1 | Construction Staff & Expenses | 1 | LS | 94,875 | $4,433,744 | | | | $1,645,050 | $6,078,794 |
| 22.1 | Support Labor & Indirect Supplies | 1 | LS | 33,495 | $1,000,672 | | $10,566 | | $1,252,499 | $2,263,737 |
| 23.1 | Sales Tax | 1 | Each | | | | | | $174,000 | $174,000 |
| 24.1 | Indirect Sundries | 1 | LS | | | | | | $34,535 | $34,535 |
| 25.1 | Home Office Support | 1 | LS | 3,513 | $108,847 | | | | $170,166 | $279,013 |
| 26.1 | Engineering Liason & Expenses | 1 | LS | 2,080 | $174,510 | | | | $48,500 | $223,010 |
| 27.1 | Cost Based Adjustments | 1 | LS | | | | | | | |
| 28.1 | Engineering | 1 | LS | | | | | $5,740,866 | | $5,740,866 |
| 29.1 | Enterprise Start Up & Commissioning | 1 | LS | | | | | $130,930 | $230,457 | $361,387 |
| 31.1 | Builders Risk | 1 | EA | | | | | | $300,000 | $300,000 |
| 32.1 | JV 6000 Joint Venture Indirects | 1 | LS | 2,253 | $243,031 | | | | $932,780 | $1,175,811 |
| 33.1 | Escalation | 1 | LS | | $30,000 | | $87,000 | | $4,361,280 | $4,478,280 |
| 34.1 | Contingency | 1 | LS | | | | | | | |
| 35.1 | General & Administrative | 1 | LS | | | | | | $4,729,000 | $4,729,000 |
| 36.1 | Fee | 1 | LS | | | | | | $3,407,000 | $3,407,000 |
| | Extended Totals by Category | | | 406,750 | $15,074,333 | $57,994,800 | $6,596,947 | $13,464,513 | $20,429,781 | $113,560,374 |

ZACHRY

Zachry Industrial Incorporated
Estimate Details Option "B" Alloy Tower
Estimate:  PFAQ12042 B
Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **New Unit 3 WFGD** | | | | | | | | | |
| 2.1 | WFGD Pipe | 8,390 | EA | 26,160 | $876,802 | $743,203 | | | | $1,620,006 |
| 2.2 | WFGD Demolition | 1 | EA | 1,050 | $31,138 | | $4,518 | $318,549 | | $354,205 |
| 2.3 | WFGD Site Improvments | 600 | SY | 65 | $1,925 | $3,469 | $2,710 | $9,613 | | $17,717 |
| 2.4 | WFGD U/G Utility Excavation/Backfill | 2,000 | CY | 550 | $16,180 | $1,000 | $11,390 | $13,571 | $250 | $42,391 |
| 2.5 | WFGD Structural Excavation & Backfill | 5,000 | CY | 2,147 | $69,514 | $10,205 | $30,471 | $27,823 | | $138,012 |
| 2.6 | WFGD Piling - Load Bearing | 281 | EA | 1,227 | $38,763 | | | $1,016,891 | | $1,055,654 |
| 2.7 | WFGD Structural Concrete | 3,694 | CY | 22,781 | $720,399 | $710,532 | | $34,170 | $39,402 | $1,504,503 |
| 2.8 | WFGD Structural Steel - UNIT 3 (W/YE | 1,426 | TN | 31,531 | $1,102,832 | $3,650,695 | | | $70,808 | $4,824,335 |
| 2.9 | WFGD  Buildings | 1 | SF | | | | | $2,556,559 | | $2,556,559 |
| 2.10 | WFGD U3 Fire Protection & Detection | 1 | PC | | | | | $413,646 | | $413,646 |
| 2.11 | WFGD Mechanical Equipment Unit # 3 | 321 | TN | 70,187 | $2,378,595 | $55,446,141 | | $1,351,650 | $26,250 | $59,202,635 |
| 2.12 | WFGD Electrical | 1 | EA | 36,163 | $1,220,156 | $1,388,335 | | $239,700 | $6,521 | $2,854,711 |
| 2.13 | WFGD Instrumentation | 165 | EA | 3,600 | $131,742 | $570,345 | | | | $702,087 |
| 2.14 | Other Piping Insulation U3 | 23,499 | SF | | | | | $461,450 | | $461,450 |
| 2.15 | WFGD 3 Field Finish Painting | 21,093 | SF | 4,253 | $136,318 | $12,513 | | | | $148,831 |
| 2.16 | WFGD Special Coatings | 9,648 | SF | | | | | $400,142 | | $400,142 |
| **3** | **Unit 3 PJFF Modifications** | | | | | | | | | |
| 3.1 | 12 - PJFF U/G Utility Excavation/Backfi | 1,175 | LF | 41 | $1,237 | | $748 | | | $1,985 |
| 3.2 | 13 - PJFF Structural Excavation & Back | 3,600 | CY | 1,482 | $48,640 | $10,205 | $21,282 | $19,982 | | $100,109 |
| 3.3 | 18 - PJFF Structural Concrete | 1,371 | CY | 8,704 | $276,673 | $258,784 | | $12,682 | $25,200 | $573,339 |
| 3.4 | 18 - PJFF Piling - Load Bearing | 66 | EA | | | | | $1,187,643 | | $1,187,643 |
| 3.5 | 20 - PJFF Structural Steel | 490 | TN | 8,862 | $299,678 | $1,193,707 | | | | $1,493,384 |
| 3.6 | 23 - Architectural Demo | 1 | EA | | | | | ($239,604) | | ($239,604) |
| 3.7 | 26 - PJFF-Mechanical | 1 | EA | (4,819) | ($157,765) | ($387,581) | | | | ($545,346) |
| 3.8 | 42 - PJFF Electrical | 1 | EA | 31,782 | $1,065,779 | $814,281 | | $28,800 | | $1,908,860 |
| 3.9 | 52 - PJFF Insulation U3 | (17,000) | SF | | | | | ($267,750) | | ($267,750) |
| 3.10 | 54 - PJFF Field Finish Painting | 11,750 | SF | 2,441 | $78,233 | $7,619 | | | | $85,852 |
| 3.11 | 50 - Instrumentation | 1 | EA | 3,640 | $119,912 | $65,975 | | | | $185,887 |
| **4** | **Other Common Modifications** | | | | | | | | | |
| 4.1 | 12 - Other U/G Utility Excavation/Backfi | 485 | LF | 16 | $495 | | $299 | | | $794 |
| 4.2 | 42 - Other Electrical | 1 | EA | 6,888 | $222,838 | $697,265 | | $7,200 | | $927,303 |
| **5** | **Remainder of Construction** | | | | | | | | | |
| 5.1 | Craft Start Up Assistance | 100 | PC | 500 | $22,275 | | | | | $22,275 |
| 6.1 | Craft Inefficiency - Schedule Related | 1 | LS | | | | | | | |
| 7.1 | Craft Inefficiency - Special Conditions | 1 | LS | | | | | | | |
| 8.1 | Construction Equipment Owned & 3rd F | 100 | LS | 1,138 | $35,838 | | $4,736,337 | | $200,527 | $4,972,703 |
| 9.1 | Direct Labor Unallocated Supplies | 1 | LS | | | | | | $404,355 | $404,355 |
| 10.1 | Scaffolding Supplies | 1 | LS | | | | | | $136,500 | $136,500 |
| 11.1 | Small Tools | 1 | LS | | | | $43,987 | | $250,000 | $293,987 |
| 12.1 | Craft Per Diem | 1 | LS | | | | | | $1,567,700 | $1,567,700 |
| 17.1 | Pre Construction Costs | 1 | LS | | | | | | | |
| 18.1 | Mobilization Cost | 1 | LS | 1,016 | $32,931 | | | | $236,967 | $269,898 |
| 18.2 | Demobilization Cost | 1 | LS | 100 | $3,289 | | | | $573 | $3,862 |

ZACHRY

Zachry Industrial Incorporated
Estimate Details Option "B" Alloy Tower
Estimate: PFAQ12042 B
Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| 20.1 | Construction Staff & Expenses | 1 | LS | 59,143 | $2,740,101 | | | | $1,047,350 | $3,787,451 |
| 22.1 | Support Labor & Indirect Supplies | 1 | LS | 34,083 | $1,075,726 | | $6,126 | | $1,470,247 | $2,552,100 |
| 23.1 | Sales Tax | 1 | Each | | | | | | $178,980 | $178,980 |
| 24.1 | Indirect Sundries | 1 | LS | | | | | | $23,592 | $23,592 |
| 25.1 | Home Office Support | 1 | LS | 2,343 | $76,438 | | | | $167,826 | $244,264 |
| 26.1 | Engineering Liason & Expenses | 1 | LS | 1,040 | $87,255 | | | | $24,300 | $111,555 |
| 27.1 | Cost Based Adjustments | 1 | LS | | | | | | | |
| 28.1 | Engineering | 1 | LS | | | | | $5,380,866 | | $5,380,866 |
| 29.1 | Enterprise Start Up & Commissioning | 1 | LS | | | | | $130,930 | $230,457 | $361,387 |
| 31.1 | Builders Risk | 1 | EA | | | | | | $300,000 | $300,000 |
| 32.1 | JV 6000 Joint Venture Indirects | 1 | LS | 1,387 | $149,616 | | | | $812,480 | $962,096 |
| 33.1 | Escalation | 1 | LS | | $15,000 | | $59,000 | | $3,817,050 | $3,891,050 |
| 34.1 | Contingency | 1 | LS | | | | | | | |
| 35.1 | General & Administrative | 1 | LS | | | | | | $4,305,000 | $4,305,000 |
| 36.1 | Fee | 1 | LS | | | | | | $3,448,000 | $3,448,000 |
| | Extended Totals by Category | | | 359,499 | $12,918,552 | $65,196,690 | $4,916,870 | $13,104,513 | $18,790,334 | $114,926,958 |

ZACHRY

Zachry Industrial Incorporated
Estimate Details Option "C" Alloy Tower
Estimate: PFAQ12042 C
Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **New Unit 3 WFGD** | | | | | | | | | |
| 2.1 | WFGD Pipe | 8,390 | EA | 26,160 | $876,802 | $743,203 | | | | $1,620,006 |
| 2.2 | WFGD Demolition | 1 | EA | 1,050 | $31,138 | | $4,518 | $318,549 | | $354,205 |
| 2.3 | WFGD Site Improvments | 600 | SY | 65 | $1,925 | $3,469 | $2,710 | $9,613 | | $17,717 |
| 2.4 | WFGD U/G Utility Excavation/Backfill | 2,000 | CY | 550 | $16,180 | $1,000 | $11,390 | $13,571 | $250 | $42,391 |
| 2.5 | WFGD Structural Excavation & Backfill | 5,000 | CY | 2,147 | $69,514 | $10,205 | $30,471 | $27,823 | | $138,012 |
| 2.6 | WFGD Piling - Load Bearing | 281 | EA | 1,227 | $38,763 | | | $1,016,891 | | $1,055,654 |
| 2.7 | WFGD Structural Concrete | 3,694 | CY | 22,781 | $720,399 | $710,532 | | $34,170 | $39,402 | $1,504,503 |
| 2.8 | WFGD Structural Steel - UNIT 3 (W/YE | 1,426 | TN | 31,531 | $1,102,832 | $3,650,695 | | | $70,808 | $4,824,335 |
| 2.9 | WFGD Buildings | 1 | SF | | | | | $2,556,559 | | $2,556,559 |
| 2.10 | WFGD U3 Fire Protection & Detection | 1 | PC | | | | | $413,646 | | $413,646 |
| 2.11 | WFGD Mechanical Equipment Unit # 3 | 321 | TN | 49,150 | $1,655,606 | $57,346,858 | | $1,351,650 | $26,250 | $60,380,364 |
| 2.12 | WFGD Electrical | 1 | EA | 36,163 | $1,220,156 | $1,388,335 | | $239,700 | $6,521 | $2,854,711 |
| 2.13 | WFGD Instrumentation | 165 | EA | 3,600 | $131,742 | $570,345 | | | | $702,087 |
| 2.14 | Other Piping Insulation U3 | 23,499 | SF | | | | | $461,450 | | $461,450 |
| 2.15 | WFGD 3 Field Finish Painting | 21,093 | SF | 4,253 | $136,318 | $12,513 | | | | $148,831 |
| 2.16 | WFGD Special Coatings | 9,648 | SF | | | | | $400,142 | | $400,142 |
| **3** | **Unit 3 PJFF Modifications** | | | | | | | | | |
| 3.1 | 12 - PJFF U/G Utility Excavation/Backfi | 1,175 | LF | 41 | $1,237 | | $748 | | | $1,985 |
| 3.2 | 13 - PJFF Structural Excavation & Back | 3,600 | CY | 1,482 | $48,640 | $10,205 | $21,282 | $19,982 | | $100,109 |
| 3.3 | 18 - PJFF Structural Concrete | 1,371 | CY | 8,704 | $276,673 | $258,784 | | $12,682 | $25,200 | $573,339 |
| 3.4 | 18 - PJFF Piling - Load Bearing | 66 | EA | | | | | $1,187,643 | | $1,187,643 |
| 3.5 | 20 - PJFF Structural Steel | 490 | TN | 8,862 | $299,678 | $1,193,707 | | | | $1,493,384 |
| 3.6 | 23 - Architectural Demo | 1 | EA | | | | | ($239,604) | | ($239,604) |
| 3.7 | 26 - PJFF-Mechanical | 1 | EA | (4,819) | ($157,765) | ($387,581) | | | | ($545,346) |
| 3.8 | 42 - PJFF Electrical | 1 | EA | 31,782 | $1,065,779 | $814,281 | | $28,800 | | $1,908,860 |
| 3.9 | 52 - PJFF Insulation U3 | (17,000) | SF | | | | | ($267,750) | | ($267,750) |
| 3.10 | 54 - PJFF Field Finish Painting | 11,750 | SF | 2,441 | $78,233 | $7,619 | | | | $85,852 |
| 3.11 | 50 - Instrumentation | 1 | EA | 3,640 | $119,912 | $65,975 | | | | $185,887 |
| **4** | **Other Common Modifications** | | | | | | | | | |
| 4.1 | 12 - Other U/G Utility Excavation/Backfi | 485 | LF | 16 | $495 | | $299 | | | $794 |
| 4.2 | 42 - Other Electrical | 1 | EA | 6,888 | $222,838 | $697,265 | | $7,200 | | $927,303 |
| **5** | **Remainder of Construction** | | | | | | | | | |
| 5.1 | Craft Start Up Assistance | 100 | PC | 500 | $22,275 | | | | | $22,275 |
| 6.1 | Craft Inefficiency - Schedule Related | 1 | LS | | | | | | | |
| 7.1 | Craft Inefficiency - Special Conditions | 1 | LS | | | | | | | |
| 8.1 | Construction Equipment Owned & 3rd F | 100 | LS | 1,138 | $35,838 | | $4,736,337 | | $200,527 | $4,972,703 |
| 9.1 | Direct Labor Unallocated Supplies | 1 | LS | | | | | | $351,330 | $351,330 |
| 10.1 | Scaffolding Supplies | 1 | LS | | | | | | $126,000 | $126,000 |
| 11.1 | Small Tools | 1 | LS | | | | $43,987 | | $230,000 | $273,987 |
| 12.1 | Craft Per Diem | 1 | LS | | | | | | $1,440,600 | $1,440,600 |
| 17.1 | Pre Construction Costs | 1 | LS | | | | | | | |
| 18.1 | Mobilization Cost | 1 | LS | 1,016 | $32,931 | | | | $235,267 | $268,198 |
| 18.2 | Demobilization Cost | 1 | LS | 100 | $3,289 | | | | $573 | $3,862 |

Zachry Industrial Incorporated

Estimate Details Option "C" Alloy Tower

Estimate: PFAQ12042 C

Zachry Industrial Inc. Custom Report

| Code | Description | Quantity | UM | LABOR WORKHOURS | LABOR AMOUNT | MATERIAL AMOUNT | EQUIPMENT AMOUNT | SUBCONTRT AMOUNT | SUPPLIES AMOUNT | TOTAL AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| 20.1 | Construction Staff & Expenses | 1 | LS | 59,143 | $2,740,101 | | | | $1,047,350 | $3,787,451 |
| 22.1 | Support Labor & Indirect Supplies | 1 | LS | 32,157 | $1,011,071 | | $6,126 | | $1,384,271 | $2,401,469 |
| 23.1 | Sales Tax | 1 | Each | | | | | | $170,100 | $170,100 |
| 24.1 | Indirect Sundries | 1 | LS | | | | | | $23,180 | $23,180 |
| 25.1 | Home Office Support | 1 | LS | 2,343 | $76,438 | | | | $167,826 | $244,264 |
| 26.1 | Engineering Liason & Expenses | 1 | LS | 1,040 | $87,255 | | | | $24,300 | $111,555 |
| 27.1 | Cost Based Adjustments | 1 | LS | | | | | | | |
| 28.1 | Engineering | 1 | LS | | | | | $5,380,866 | | $5,380,866 |
| 29.1 | Enterprise Start Up & Commissioning | 1 | LS | | | | | $130,930 | $230,457 | $361,387 |
| 31.1 | Builders Risk | 1 | EA | | | | | | $300,000 | $300,000 |
| 32.1 | JV 6000 Joint Venture Indirects | 1 | LS | 1,387 | $149,616 | | | | $812,480 | $962,096 |
| 33.1 | Escalation | 1 | LS | | $14,000 | | $59,000 | | $3,709,420 | $3,782,420 |
| 34.1 | Contingency | 1 | LS | | | | | | | |
| 35.1 | General & Administrative | 1 | LS | | | | | | $4,211,000 | $4,211,000 |
| 36.1 | Fee | 1 | LS | | | | | | $3,467,000 | $3,467,000 |
| | Extended Totals by Category | | | 336,536 | $12,129,908 | $67,097,407 | $4,916,870 | $13,104,513 | $18,300,110 | $115,548,808 |

## Kehm, Charles

**From:** doleary@babcockpower.com
**Sent:** Tuesday, September 11, 2012 12:49 PM
**To:** Wheat, T.W.
**Cc:** Brumage, Mike; Gappa, Rob (Contract); Gipson, John; Hecker, Thomas; Kehm, Charles; Pryor, Jennifer; Schmidt, Adam; Traphagan, Doug
**Subject:** RE: LG&E MC AQCS / FW: Mill Creek Unit 3 Budget Price (Riley)

Sorry, my oversight. The Turret will be installed by BPEI's contractor in option B and C.

Thanks Dan.


**Dan O'Leary**
Project Manager
Riley Power Inc.
5 Neponset Street
Worcester, MA 01606

T: 508-854-3964 F: 508-852-7122

doleary@babcockpower.com
http://www.babcockpower.com


From: "Wheat, T.W." <wheattw@zhi.com>
To: "Kehm, Charles" <kehmc@zhi.com>, "Gappa, Rob (Contract)" <GappaR@zhi.com>, "Hecker, Thomas" <heckert@zhi.com>, "Schmidt, Adam" <schmidta@zhi.com>, <doleary@babcockpower.com>
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Date: 09/11/2012 11:36 AM
Subject: RE: LG&E MC AQCS / FW: Mill Creek Unit 3 Budget Price (Riley)

---

I was under the assumption that the roof and turret would be installed by BPI for option B & C, the roof and turret are not mentioned in the scope of work for option B, Dan can you clarify this for me?

Thanks,
TW Wheat


**T.W. Wheat**
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LG&E

Babcock Power ENVIRONMENTAL

## LG&E Air Quality Compliance Program
## Mill Creek Unit 3 WFGD System

### Budget Estimate
**September 10, 2012**

A) Base Bid – Stebbins Absorber (No Internals)

| | |
|---|---|
| • Base Stebbins Absorber Island Scope | $43,249,807 |
| • Additional Site Conditions | $1,374,303 |
| • Schedule – 12 months | |
| Total Price | $44,624,110 |

B) Base Bid – Solid C276 Absorber (No Internals)

| | |
|---|---|
| • Base Solid C276 Absorber Island Scope | $50,647,803 |
| • Additional Site Conditions | $1,178,197 |
| • Schedule – 9 months (Note) | |
| Total Price | $51,826,000 |

C) Option Bid – Solid C276 Absorber (With Internals)

| | |
|---|---|
| • Option Solid C276 Absorber Island Scope | $52,548,520 |
| • Additional Site Conditions | $1,178,197 |
| • Schedule – 7 months | |
| Total Price | $53,726,717 |

Note: Zachry has added two months for the installation of internals. BPEI's Construction schedule is seven months.

**LG&E Air Quality Compliance Program**
**Mill Creek Unit 3 WFGD System**

**Scope Description**
**September 10, 2012**

**The scope of work included in Item A**, Base Bid; Stebbins Absorber with No Internals is as follows:

- Engineering and Project Labor
- Model Study
- Stebbins Absorber
- Oxidation Lances/Trusses/Turret
- Agitators
- Mist Eliminator System
- Recycle Spray Headers
- Spray Nozzles
- Recycle Pumps
- Mist Eliminator Wash System
- Structural Steel
- Piping Systems/ Valves and specialties
- Recycle External Piping
- Quench Water System
- Instruments and Controls
- Hoists and Cranes
- Hydroclone system
- Bleed Pumps

The Additional, site conditions for the Base Bid, Stebbins Absorber is as follows:

- Larger Concrete Pump Truck
- Material Reloading and Unloading Remote to the work area.
- Additional Hydraulic Yard Crane
- Crane Operator
- Additional Support & Supervision
- Additional Small tools & Consumables

**The work included in Item B**; Base Bid, Solid C276 Absorber with no Internals includes all Item Listed in Item A expect as follows:

- Remove Stebbins Absorber

- Replace with Solid C276 Absorber
- Field Construction of Solid C276 Absorber
- Inlet Duct Solid C686

The additional site conditions for the Base Bid, Solid C276 Absorber without Internals is as follows:

- Remote Lay down Labor
- Hydraulic Yard Crane
- Crane Operator
- Additional Support & Supervision
- Additional Small tools and Consumables
- Inefficiency due to two Construction Companies working in the same erection space.

**The work included in Item C**; Option Bid for the Solid C276 Absorber with the internals installed by BPEI. The work scope is the same as Item B. Plus the following Items:

- Oxidation Air Lances C276
- Oxidation Air Lance Supports C276
- Outlet Duct Seal
- Mist Eliminator and Spray Header Trusses
- Outlet Turret Solid C276
- Agitators
- Mist Eliminator & Wash System (inside vessel)
- Recycle Spray Headers
- Spray Nozzles
- Quench Piping and Nozzles

The additional site conditions are the same as Item B, Solid C276 Absorber without Internals.

**LG&E Air Quality Compliance Program**
**Mill Creek Unit 3 WFGD System**

## Estimating Assumptions
**Stebbins Absorber**
**September 10, 2012**

1. Oxidation Air Blowers have not been included; the plan is to reuse the existing Atlas Copco Blowers.

2. The underflow tank agitator will be carbon steel rubber lined.

3. All vendors will be the same as unit's ½ & 4 where possible.

4. All Hasleloy Studs will have two nuts, one on either end.

5. Escalation Risk Cap:

    a. Freight-Stebbins has included 4% per annum through completion of the project, and will place the threshold risk cap at 5% on all truckloads. (2012 basis $125,000)
    b. Rebar – Stebbins has allowed 4% per annum to procure late 2014, and will place the threshold risk cap at 5% on 700,000lbs of rebar. (2012 basis value $0.45/lb)
    c. Concrete – Stebbins has allowed 4% per annum, and will place the threshold risk cap at 5% on 2500CT, (2012 basis value $120/CY)
    d. Resinous Materials – Stebbins has allowed 4% per annum to procure late 2014, and will place the threshold risk cap at 5% (2012 basis value $130,000).
    e. Field Labor – Stebbins has allowed 4% per annum, and will place the threshold risk cap at 5% on 42,000 manhours. (2012 basis value $3,225,000)

6. BPEI is supporting Stebbins by fast tracking engineering, to support Stebbins procurement of major items starting no later than March 2013.

7. BPEI will Purchase all C276 at FNTP. This will lock in the lowest possible price for the Mill Creek Project.

8. FRP material has been escalated at 6% per year.

9. Please note that the C276 price is subject to a ceiling LME spot price for nickel of $7.83/lb.

LG&E Air Quality Compliance Program
Mill Creek Unit 3 WFGD System

**Estimating Assumptions**
**Solid C276 Absorber**
**September 10, 2012**

1. Oxidation Air Blowers have not been included; the plan is to reuse the existing Atlas Copco Blowers.
2. The underflow tank agitator will be carbon steel rubber lined.
3. All vendors will be the same as unit's ½ & 4 where possible.
4. All Hasteloy Studs will have two nuts, one on either end.
5. BPEI will purchase all C276 at FNTP.
6. Please note that the C276 price is subject to a ceiling LME spot price for nickel of $7.83/lb. The unit price for C276 alloy on Units 1, 2 & 4 is $15.24, Stebbins option. The offer from Special Metals for an Alloy Vessel is $15.00 per pound. This offer is valid till 1/15/2013 or until Nickel exceeds $7.83 / LB which ever come first.

Exhibit JNV-3

Update to Mill Creek 3
Retire/Retrofit Decision,
October 2012

# Update to Mill Creek 3 Retire/Retrofit Decision

PPL companies

Generation Planning & Analysis

October 2012

**Table of Contents**

## 1.0 Summary

On December 15, 2011, the Kentucky Public Service Commission ("KPSC") approved the unanimous settlement agreement in the 2011 environmental cost recovery ("ECR") case for LG&E and KU, which included refurbished wet flue gas desulfurization ("WFGD") equipment, a baghouse, and sulfuric acid mist ("SAM") mitigation/economizer modifications for Mill Creek 3. The cost assumptions included in the ECR filing for these projects were based on an engineering study completed in March 2011. In December 2011 and July 2012, more detailed engineering studies were prepared with updated estimates for capital and operating costs. Based on these studies, a new WFGD is more economical than a refurbished WFGD for Mill Creek 3. Since building a new WFGD requires a modified Certificate for Public Convenience and Necessity ("Certificate") and KPSC approval, the Companies updated their 2011 ECR analysis to confirm that retrofitting Mill Creek 3 (versus retiring the unit) is still the most economical option and that the least-cost retrofit option includes a new WFGD.

## 2.0 Updated Assumptions

### 2.1 Capital Costs

The 2011 Air Compliance Plan was developed in anticipation of the Companies' 2011 ECR filing and includes the analysis supporting the decision to retrofit Mill Creek 3. Additional analyses related to Mill Creek 3 were presented in the proceedings to the 2011 ECR case. The capital and operating costs for these analyses were taken from a March 2011 study prepared by Black & Veatch, which included preliminary information from a February 2011 study prepared by Babcock Power Environmental, Inc. ("Babcock"). The WFGD costs in this study ($74 million) reflected the estimated cost to refurbish the existing WFGD equipment on Mill Creek 4 and connect it to Mill Creek 3, replacing the existing WFGD on Mill Creek 3.

In December 2011, a more detailed engineering study was completed for the Mill Creek 3 projects by Babcock. Based on this study, the capital cost estimate for the Mill Creek 3 WFGD project increased to $161 million while the capital cost estimate for the baghouse decreased from $140 million to $113 million. In addition, the scope of the new baghouse estimate now includes the SAM mitigation/economizer modifications that were previously included as a separate project in the 2011 ECR Plan. In total, the new capital cost estimate for the Mill Creek 3 projects is $49 million higher than the estimate in the 2011 filing (see Table 1).

**Table 1 – Capital Costs with Refurbished WFGD (Nominal $M)**

| Equipment | 2011 ECR Plan | 2012 Update | Difference |
|---|---|---|---|
| WFGD | 74 | 161 | 86 |
| Baghouse | 140 | 113 | -27 |
| SAM Mitigation/Economizer Modifications | 10 | - | -10 |
| Total | 225 | 274 | 49 |

Because of the increase in the Mill Creek 3 WFGD capital costs, the Companies evaluated the cost of building a new WFGD as an alternative to retrofitting the existing Mill Creek 4 WFGD. According to a September 2012 engineering study by Zachry Holdings, Inc., the capital cost for building a new WFGD at

Mill Creek 3 is estimated to be $132 million. With a new WFGD, the total capital cost of the Mill Creek 3 environmental projects is only $21 million higher than the estimates in the 2011 ECR filing (see Table 2).

**Table 2 – Capital Costs with New WFGD (Nominal $M)**

| Equipment | 2011 ECR Plan | 2012 Update | Change |
|---|---|---|---|
| WFGD | 74 | 132 | 58 |
| Baghouse | 140 | 113 | -27 |
| SAM Mitigation/Economizer Modifications | 10 | - | -10 |
| Total | 225 | 245 | 21 |

## 2.2 Operating Expenses

Since the 2011 Air Compliance Plan was developed, the estimated operating expenses for the Mill Creek 3 baghouse have decreased (see Table 3; operating expenses for other Mill Creek projects are unchanged). When the 2011 Air Compliance Plan was developed, the Companies had limited operating experience with the Trimble County 2 baghouse. The updated operating expense estimates are based on almost two years of experience operating the Trimble County 2 baghouse.

**Table 3 – Baghouse Operating Expenses (2011 $)**

| Operating Expenses | 2011 ECR Plan | 2012 Update | Change |
|---|---|---|---|
| Variable O&M ($/MWh) | 2.76 | 1.45 | -1.31 |
| Fixed O&M ($M/yr) | 1.2 | 0.6 | -0.6 |

## 2.3 In-Service Dates

The schedule for completing the ECR projects at Mill Creek 3 has also changed due to the available space to construct the new Unit 3 WFGD requires the demolition of Unit 4's current WFGD to make the available space. This results in demolition of the existing Unit 4 WFGD beginning in the fall of 2014 when the tie-in outage of Unit 4 to its new WFGD and PJFF occur. Table 4 summarizes these changes.

**Table 4 – Project In-Service Dates**

| Equipment | 2011 ECR Plan | 2012 Update |
|---|---|---|
| WFGD | 11/2014 | 4/2016 |
| Baghouse | 10/2015 | 4/2016 |
| SAM Mitigation | 4/2013 | 4/2016 |

# 3.0 Updated Analysis

Table 5 summarizes the net present value of revenue requirements ("NPVRR") for two generation portfolios used in the proceedings to the 2011 ECR case to evaluate the decision to retire or retrofit Mill Creek 3. The total NPVRR differences in Table 5 are taken from the 2011 Air Compliance Plan and Supplemental Analysis. In the 'Retrofit Mill Creek 3' portfolio, Mill Creek 3 is retrofitted per the schedule summarized in Table 4. In the 'Retire Mill Creek 3' portfolio, Mill Creek 3 is retired in

December 2015. In the Base and CERA fuel price scenarios, the NPVRR savings associated with retrofitting Mill Creek 3 are $756 and $338 million, respectively.

**Table 5 – NPVRR from 2011 ECR Filing: Mill Creek 3 Retire/Retrofit Decision (2011 $M)**

| Fuel Price Scenario | NPVRR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
| | Prod Cost | Capital | Total | Prod Cost | Capital | Total | Prod Cost | Capital | Total |
| Base | 26,152 | 6,634 | 32,786 | 26,848 | 6,693 | 33,542 | 696 | 60 | 756 |
| CERA | 24,276 | 6,634 | 30,910 | 24,562 | 6,686 | 31,247 | 286 | 52 | 338 |

As discussed above, the updated capital and operating cost estimates for the Mill Creek 3 baghouse project have decreased while the capital cost estimate for the Mill Creek 3 WFGD project has increased. In the Base fuel price scenario, increasing the WFGD capital cost from $74 to $132 million increases NPVRR by $43 million, while the reductions in baghouse capital and operating expenses reduce NPVRR by $107 million. Clearly, the reductions in revenue requirements associated with the lower baghouse capital and operating expenses more than offset the increase in revenue requirements associated with the higher WFGD capital cost.

Table 6 summarizes the NPVRR of the two generating portfolios with updated cost estimates and project in-service dates. The NPVRR values in Table 6 reflect the cost of the new WFGD ($132 million) since this alternative is less expensive than the updated cost of the refurbished WFGD ($161 million). All other assumptions from the 2011 ECR filing are unchanged.[1] Based on the updated cost estimates (and despite the increase in the WFGD capital cost), the savings associated with retrofitting Mill Creek 3 are greater than the savings evaluated in the 2011 ECR filing.

**Table 6 – Updated Mill Creek 3 Retire/Retrofit Decision (2011 $M)**

| Fuel Price Scenario | NPVRR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
| | Prod Cost | Capital | Total | Prod Cost | Capital | Total | Prod Cost | Capital | Total |
| Base | 26,085 | 6,637 | 32,722 | 26,848 | 6,693 | 33,542 | 763 | 57 | 820 |
| CERA | 24,209 | 6,637 | 30,846 | 24,562 | 6,686 | 31,247 | 353 | 49 | 402 |

A modified Certificate and KPSC approval are required to proceed with the least-cost plan to construct a new WFGD for Mill Creek 3. However, due to project lead times, KPSC approval must be received on an expedited basis to place the WFGD in-service by the April 2016 compliance deadline for the Mercury and Air Toxics Standard. If KPSC approval is not received as requested, the Companies must either (a) proceed with the original more-costly plan to refurbish the Mill Creek 4 WFGD and connect it to Mill Creek 3 or (b) wait for KPSC approval and plan to place Mill Creek 3 on inactive reserve after April 2016 until the new WFGD can be commissioned.

To identify the least-cost way forward in the event of a delayed KPSC decision, the Companies' compared the revenue requirements of the 'Refurbished WFGD' option to a 'New WFGD – Delayed In-Service Date' option. In the latter option, the in-service date for the new WFGD is delayed by 6 months, during which the Companies enter into a power purchase agreement ("PPA") for capacity and energy to

[1] Please see Appendix A in the 2011 Air Compliance Plan for a summary of these assumptions.

replace Mill Creek 3. The cost of the PPA is assumed to be $58/kW-year or $19 million (in 2016 $).[2] Based on the results in Table 7 and
Table **8**, if the Companies do not receive approval on an expedited basis, the least-cost way forward is to proceed with the plan to refurbish the Mill Creek 4 WFGD and connect it to Mill Creek 3.

**Table 7 – NPVRR of 'Refurbished WFGD' Option (2011 $M)**

| Fuel Price Scenario | NPVRR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
| | Prod Cost | Capital | Total | Prod Cost | Capital | Total | Prod Cost | Capital | Total |
| Base | 26,085 | 6,662 | 32,748 | 26,848 | 6,693 | 33,542 | 763 | 31 | 794 |
| CERA | 24,209 | 6,662 | 30,872 | 24,562 | 6,686 | 31,247 | 353 | 23 | 376 |

**Table 8 – NPVRR of 'New WFGD – Delayed In-Service Date' Option (2011 $M)**

| Fuel Price Scenario | NPVRR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
| | Prod Cost | Capital | Total | Prod Cost | Capital | Total | Prod Cost | Capital | Total |
| Base | 26,122 | 6,638 | 32,760 | 26,848 | 6,693 | 33,542 | 727 | 55 | 782 |
| CERA | 24,240 | 6,638 | 30,878 | 24,562 | 6,686 | 31,247 | 322 | 48 | 370 |

Annual revenue requirements for all of the options considered in this analysis are included in the Appendix.

## 4.0 Conclusion

Table 9 summarizes the NPVRR savings for all options considered. Based on updated capital and operating cost estimates, the NPVRR savings associated with retrofitting Mill Creek 3 are greater than the savings presented in the 2011 ECR filing. Provided that the companies receive a modified Certificate on an expedited basis, a new WFGD is more economical for Mill Creek 3 than a refurbished WFGD.

**Table 9 – NPVRR Savings Associated with Retrofitting Mill Creek 3 (2011 $M)**

| Gas Price | 2011 ECR Plan | 2012 Update | | |
|---|---|---|---|---|
| | | Least-Cost Option | Delay Options | |
| | | New WFGD 4/2016 | Refurbished WFGD 4/2016 | New WFGD 10/2016 with PPA |
| Base Case | 756 | 820 | 794 | 782 |
| 2011 CERA | 338 | 402 | 376 | 370 |

[2] The cost of the PPA includes the cost of firm gas transportation and 330 MW of simple-cycle combustion turbine ("SCCT") capacity. Approximately 330 MW is needed to maintain a 16% reserve margin. The cost of SCCT capacity is based on a response to the Companies' December 2010 RFP for generating capacity and energy.

## 5.0 Appendix – Annual Revenue Requirements

**Appendix Table 1 – 2011 ECR Plan; Base Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,222 | 48 | 1,270 | 1,222 | 46 | 1,269 | 0 | -1 | -1 |
| 2013 | 1,264 | 129 | 1,393 | 1,262 | 125 | 1,387 | -2 | -4 | -6 |
| 2014 | 1,353 | 274 | 1,627 | 1,349 | 296 | 1,645 | -4 | 23 | 19 |
| 2015 | 1,449 | 427 | 1,876 | 1,442 | 474 | 1,915 | -8 | 47 | 40 |
| 2016 | 1,586 | 554 | 2,140 | 1,608 | 585 | 2,193 | 22 | 30 | 53 |
| 2017 | 1,623 | 582 | 2,204 | 1,604 | 578 | 2,182 | -19 | -4 | -22 |
| 2018 | 1,682 | 601 | 2,283 | 1,706 | 563 | 2,269 | 23 | -37 | -14 |
| 2019 | 1,765 | 597 | 2,362 | 1,818 | 556 | 2,374 | 54 | -41 | 12 |
| 2020 | 1,834 | 584 | 2,418 | 1,916 | 586 | 2,502 | 82 | 2 | 84 |
| 2021 | 1,938 | 576 | 2,513 | 2,048 | 618 | 2,667 | 111 | 43 | 153 |
| 2022 | 2,070 | 605 | 2,675 | 2,125 | 638 | 2,763 | 55 | 33 | 88 |
| 2023 | 2,143 | 639 | 2,783 | 2,164 | 633 | 2,797 | 21 | -6 | 14 |
| 2024 | 2,148 | 662 | 2,809 | 2,236 | 616 | 2,852 | 88 | -46 | 43 |
| 2025 | 2,247 | 662 | 2,909 | 2,363 | 612 | 2,976 | 117 | -50 | 66 |
| 2026 | 2,382 | 651 | 3,033 | 2,535 | 651 | 3,187 | 153 | 1 | 154 |
| 2027 | 2,389 | 640 | 3,029 | 2,525 | 694 | 3,220 | 137 | 54 | 191 |
| 2028 | 2,494 | 634 | 3,128 | 2,595 | 720 | 3,316 | 102 | 86 | 188 |
| 2029 | 2,543 | 683 | 3,225 | 2,615 | 725 | 3,340 | 72 | 42 | 115 |
| 2030 | 2,683 | 735 | 3,419 | 2,730 | 715 | 3,445 | 47 | -20 | 27 |
| 2031 | 2,657 | 765 | 3,422 | 2,771 | 700 | 3,471 | 115 | -65 | 49 |
| 2032 | 2,715 | 771 | 3,486 | 2,851 | 699 | 3,551 | 136 | -71 | 65 |
| 2033 | 2,829 | 756 | 3,584 | 2,973 | 730 | 3,703 | 144 | -25 | 118 |
| 2034 | 2,887 | 743 | 3,630 | 3,052 | 765 | 3,817 | 165 | 22 | 187 |
| 2035 | 2,987 | 740 | 3,727 | 3,079 | 788 | 3,867 | 92 | 48 | 140 |
| 2036 | 3,062 | 735 | 3,797 | 3,157 | 773 | 3,929 | 95 | 38 | 132 |
| 2037 | 3,116 | 737 | 3,854 | 3,223 | 752 | 3,975 | 107 | 15 | 121 |
| 2038 | 3,239 | 668 | 3,907 | 3,357 | 667 | 4,024 | 118 | -1 | 117 |
| 2039 | 3,257 | 654 | 3,912 | 3,393 | 662 | 4,054 | 135 | 7 | 143 |
| 2040 | 3,401 | 631 | 4,032 | 3,524 | 647 | 4,171 | 123 | 15 | 138 |
| NPVRR | 26,152 | 6,634 | 32,786 | 26,848 | 6,693 | 33,542 | 696 | 60 | 756 |

**Appendix Table 2 – 2011 ECR Plan; CERA Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,207 | 48 | 1,254 | 1,207 | 46 | 1,253 | 0 | -1 | -1 |
| 2013 | 1,251 | 129 | 1,381 | 1,249 | 125 | 1,374 | -2 | -4 | -6 |
| 2014 | 1,290 | 274 | 1,563 | 1,286 | 296 | 1,582 | -4 | 23 | 19 |
| 2015 | 1,366 | 427 | 1,793 | 1,359 | 474 | 1,833 | -8 | 47 | 40 |
| 2016 | 1,493 | 554 | 2,047 | 1,504 | 585 | 2,089 | 12 | 30 | 42 |
| 2017 | 1,502 | 582 | 2,083 | 1,476 | 578 | 2,054 | -26 | -4 | -29 |
| 2018 | 1,590 | 601 | 2,190 | 1,593 | 563 | 2,156 | 3 | -37 | -34 |
| 2019 | 1,602 | 597 | 2,200 | 1,632 | 556 | 2,188 | 30 | -41 | -12 |
| 2020 | 1,648 | 584 | 2,232 | 1,695 | 586 | 2,281 | 47 | 2 | 50 |
| 2021 | 1,752 | 576 | 2,328 | 1,824 | 618 | 2,442 | 72 | 43 | 114 |
| 2022 | 1,868 | 605 | 2,473 | 1,878 | 638 | 2,516 | 10 | 33 | 43 |
| 2023 | 1,921 | 639 | 2,560 | 1,901 | 633 | 2,534 | -20 | -6 | -26 |
| 2024 | 1,879 | 662 | 2,541 | 1,908 | 616 | 2,524 | 29 | -46 | -17 |
| 2025 | 1,955 | 662 | 2,617 | 2,001 | 605 | 2,607 | 47 | -57 | -10 |
| 2026 | 2,051 | 651 | 2,702 | 2,129 | 602 | 2,731 | 78 | -49 | 29 |
| 2027 | 2,118 | 640 | 2,758 | 2,191 | 615 | 2,806 | 73 | -25 | 48 |
| 2028 | 2,159 | 634 | 2,793 | 2,231 | 663 | 2,894 | 72 | 29 | 101 |
| 2029 | 2,253 | 683 | 2,936 | 2,324 | 717 | 3,041 | 71 | 34 | 105 |
| 2030 | 2,389 | 735 | 3,125 | 2,388 | 752 | 3,140 | -1 | 17 | 16 |
| 2031 | 2,408 | 765 | 3,174 | 2,447 | 750 | 3,197 | 39 | -15 | 23 |
| 2032 | 2,499 | 771 | 3,269 | 2,549 | 741 | 3,290 | 50 | -29 | 21 |
| 2033 | 2,620 | 756 | 3,376 | 2,675 | 734 | 3,409 | 55 | -22 | 33 |
| 2034 | 2,721 | 743 | 3,464 | 2,787 | 764 | 3,551 | 66 | 21 | 87 |
| 2035 | 2,832 | 740 | 3,571 | 2,895 | 799 | 3,694 | 63 | 59 | 122 |
| 2036 | 2,951 | 735 | 3,686 | 2,970 | 810 | 3,780 | 19 | 74 | 94 |
| 2037 | 3,040 | 737 | 3,778 | 3,068 | 800 | 3,869 | 28 | 63 | 91 |
| 2038 | 3,180 | 668 | 3,848 | 3,207 | 705 | 3,912 | 27 | 37 | 64 |
| 2039 | 3,254 | 654 | 3,909 | 3,299 | 677 | 3,977 | 45 | 23 | 68 |
| 2040 | 3,412 | 631 | 4,043 | 3,464 | 648 | 4,112 | 52 | 17 | 69 |
| NPVRR | 24,276 | 6,634 | 30,910 | 24,562 | 6,686 | 31,247 | 286 | 52 | 338 |

**Appendix Table 3 – New WFGD 4/2016; Base Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,222 | 47 | 1,269 | 1,222 | 46 | 1,269 | 0 | -1 | -1 |
| 2013 | 1,262 | 123 | 1,385 | 1,262 | 125 | 1,387 | 0 | 2 | 2 |
| 2014 | 1,349 | 265 | 1,614 | 1,349 | 296 | 1,645 | 0 | 32 | 32 |
| 2015 | 1,442 | 420 | 1,862 | 1,442 | 474 | 1,915 | 0 | 54 | 54 |
| 2016 | 1,578 | 556 | 2,134 | 1,608 | 585 | 2,193 | 30 | 29 | 59 |
| 2017 | 1,618 | 585 | 2,203 | 1,604 | 578 | 2,182 | -14 | -7 | -21 |
| 2018 | 1,677 | 604 | 2,281 | 1,706 | 563 | 2,269 | 28 | -41 | -12 |
| 2019 | 1,760 | 600 | 2,360 | 1,818 | 556 | 2,374 | 59 | -45 | 14 |
| 2020 | 1,829 | 587 | 2,415 | 1,916 | 586 | 2,502 | 87 | -1 | 86 |
| 2021 | 1,932 | 578 | 2,511 | 2,048 | 618 | 2,667 | 116 | 40 | 156 |
| 2022 | 2,065 | 608 | 2,672 | 2,125 | 638 | 2,763 | 61 | 30 | 91 |
| 2023 | 2,138 | 642 | 2,780 | 2,164 | 633 | 2,797 | 26 | -9 | 17 |
| 2024 | 2,142 | 665 | 2,806 | 2,236 | 616 | 2,852 | 94 | -48 | 46 |
| 2025 | 2,241 | 665 | 2,906 | 2,363 | 612 | 2,976 | 122 | -53 | 70 |
| 2026 | 2,376 | 653 | 3,029 | 2,535 | 651 | 3,187 | 159 | -2 | 157 |
| 2027 | 2,383 | 642 | 3,025 | 2,525 | 694 | 3,220 | 142 | 53 | 195 |
| 2028 | 2,487 | 636 | 3,123 | 2,595 | 720 | 3,316 | 108 | 85 | 193 |
| 2029 | 2,536 | 684 | 3,220 | 2,615 | 725 | 3,340 | 78 | 41 | 119 |
| 2030 | 2,677 | 737 | 3,413 | 2,730 | 715 | 3,445 | 53 | -21 | 32 |
| 2031 | 2,650 | 767 | 3,417 | 2,771 | 700 | 3,471 | 121 | -67 | 54 |
| 2032 | 2,708 | 772 | 3,480 | 2,851 | 699 | 3,551 | 143 | -72 | 71 |
| 2033 | 2,822 | 757 | 3,579 | 2,973 | 730 | 3,703 | 151 | -27 | 124 |
| 2034 | 2,880 | 745 | 3,624 | 3,052 | 765 | 3,817 | 172 | 21 | 193 |
| 2035 | 2,981 | 741 | 3,722 | 3,079 | 788 | 3,867 | 99 | 47 | 145 |
| 2036 | 3,054 | 736 | 3,791 | 3,157 | 773 | 3,929 | 102 | 36 | 139 |
| 2037 | 3,109 | 738 | 3,848 | 3,223 | 752 | 3,975 | 114 | 14 | 127 |
| 2038 | 3,231 | 669 | 3,900 | 3,357 | 667 | 4,024 | 125 | -2 | 124 |
| 2039 | 3,250 | 656 | 3,906 | 3,393 | 662 | 4,054 | 143 | 6 | 149 |
| 2040 | 3,393 | 633 | 4,026 | 3,524 | 647 | 4,171 | 131 | 13 | 145 |
| NPVRR | 26,085 | 6,637 | 32,722 | 26,848 | 6,693 | 33,542 | 763 | 57 | 820 |

**Appendix Table 4 – New WFGD 4/2016; CERA Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,207 | 47 | 1,254 | 1,207 | 46 | 1,253 | 0 | -1 | -1 |
| 2013 | 1,249 | 123 | 1,373 | 1,249 | 125 | 1,374 | 0 | 2 | 2 |
| 2014 | 1,286 | 265 | 1,551 | 1,286 | 296 | 1,582 | 0 | 32 | 32 |
| 2015 | 1,359 | 420 | 1,779 | 1,359 | 474 | 1,833 | 0 | 54 | 54 |
| 2016 | 1,485 | 556 | 2,041 | 1,504 | 585 | 2,089 | 19 | 29 | 48 |
| 2017 | 1,497 | 585 | 2,082 | 1,476 | 578 | 2,054 | -21 | -7 | -28 |
| 2018 | 1,585 | 604 | 2,189 | 1,593 | 563 | 2,156 | 8 | -41 | -32 |
| 2019 | 1,598 | 600 | 2,198 | 1,632 | 556 | 2,188 | 34 | -45 | -10 |
| 2020 | 1,643 | 587 | 2,229 | 1,695 | 586 | 2,281 | 53 | -1 | 52 |
| 2021 | 1,747 | 578 | 2,326 | 1,824 | 618 | 2,442 | 77 | 40 | 117 |
| 2022 | 1,862 | 608 | 2,470 | 1,878 | 638 | 2,516 | 16 | 30 | 46 |
| 2023 | 1,915 | 642 | 2,558 | 1,901 | 633 | 2,534 | -14 | -9 | -23 |
| 2024 | 1,873 | 665 | 2,538 | 1,908 | 616 | 2,524 | 35 | -48 | -13 |
| 2025 | 1,949 | 665 | 2,614 | 2,001 | 605 | 2,607 | 53 | -60 | -7 |
| 2026 | 2,045 | 653 | 2,698 | 2,129 | 602 | 2,731 | 84 | -51 | 33 |
| 2027 | 2,112 | 642 | 2,754 | 2,191 | 615 | 2,806 | 79 | -27 | 52 |
| 2028 | 2,152 | 636 | 2,788 | 2,231 | 663 | 2,894 | 79 | 27 | 106 |
| 2029 | 2,247 | 684 | 2,931 | 2,324 | 717 | 3,041 | 77 | 33 | 110 |
| 2030 | 2,383 | 737 | 3,119 | 2,388 | 752 | 3,140 | 6 | 15 | 21 |
| 2031 | 2,402 | 767 | 3,169 | 2,447 | 750 | 3,197 | 45 | -17 | 29 |
| 2032 | 2,492 | 772 | 3,264 | 2,549 | 741 | 3,290 | 57 | -31 | 26 |
| 2033 | 2,613 | 757 | 3,371 | 2,675 | 734 | 3,409 | 61 | -23 | 38 |
| 2034 | 2,714 | 745 | 3,458 | 2,787 | 764 | 3,551 | 73 | 20 | 93 |
| 2035 | 2,825 | 741 | 3,566 | 2,895 | 799 | 3,694 | 69 | 58 | 128 |
| 2036 | 2,943 | 736 | 3,680 | 2,970 | 810 | 3,780 | 27 | 73 | 100 |
| 2037 | 3,033 | 738 | 3,771 | 3,068 | 800 | 3,869 | 35 | 62 | 97 |
| 2038 | 3,172 | 669 | 3,841 | 3,207 | 705 | 3,912 | 35 | 36 | 71 |
| 2039 | 3,246 | 656 | 3,902 | 3,299 | 677 | 3,977 | 53 | 21 | 74 |
| 2040 | 3,403 | 633 | 4,037 | 3,464 | 648 | 4,112 | 60 | 15 | 76 |
| NPVRR | 24,209 | 6,637 | 30,846 | 24,562 | 6,686 | 31,247 | 353 | 49 | 402 |

**Appendix Table 5 – Refurbished WFGD 4/2016; Base Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,222 | 47 | 1,269 | 1,222 | 46 | 1,269 | 0 | -1 | -1 |
| 2013 | 1,262 | 123 | 1,385 | 1,262 | 125 | 1,387 | 0 | 2 | 2 |
| 2014 | 1,349 | 265 | 1,614 | 1,349 | 296 | 1,645 | 0 | 31 | 31 |
| 2015 | 1,442 | 422 | 1,863 | 1,442 | 474 | 1,915 | 0 | 52 | 52 |
| 2016 | 1,578 | 560 | 2,138 | 1,608 | 585 | 2,193 | 30 | 25 | 55 |
| 2017 | 1,618 | 589 | 2,207 | 1,604 | 578 | 2,182 | -14 | -11 | -25 |
| 2018 | 1,677 | 607 | 2,285 | 1,706 | 563 | 2,269 | 28 | -44 | -16 |
| 2019 | 1,760 | 604 | 2,364 | 1,818 | 556 | 2,374 | 59 | -48 | 11 |
| 2020 | 1,829 | 590 | 2,418 | 1,916 | 586 | 2,502 | 87 | -4 | 83 |
| 2021 | 1,932 | 582 | 2,514 | 2,048 | 618 | 2,667 | 116 | 37 | 153 |
| 2022 | 2,065 | 611 | 2,675 | 2,125 | 638 | 2,763 | 61 | 27 | 88 |
| 2023 | 2,138 | 645 | 2,783 | 2,164 | 633 | 2,797 | 26 | -12 | 14 |
| 2024 | 2,142 | 667 | 2,809 | 2,236 | 616 | 2,852 | 94 | -51 | 43 |
| 2025 | 2,241 | 668 | 2,908 | 2,363 | 612 | 2,976 | 122 | -55 | 67 |
| 2026 | 2,376 | 655 | 3,031 | 2,535 | 651 | 3,187 | 159 | -4 | 155 |
| 2027 | 2,383 | 644 | 3,027 | 2,525 | 694 | 3,220 | 142 | 51 | 193 |
| 2028 | 2,487 | 638 | 3,125 | 2,595 | 720 | 3,316 | 108 | 83 | 191 |
| 2029 | 2,536 | 686 | 3,222 | 2,615 | 725 | 3,340 | 78 | 39 | 117 |
| 2030 | 2,677 | 739 | 3,415 | 2,730 | 715 | 3,445 | 53 | -23 | 30 |
| 2031 | 2,650 | 769 | 3,419 | 2,771 | 700 | 3,471 | 121 | -69 | 52 |
| 2032 | 2,708 | 774 | 3,482 | 2,851 | 699 | 3,551 | 143 | -74 | 69 |
| 2033 | 2,822 | 759 | 3,581 | 2,973 | 730 | 3,703 | 151 | -28 | 122 |
| 2034 | 2,880 | 746 | 3,626 | 3,052 | 765 | 3,817 | 172 | 19 | 191 |
| 2035 | 2,981 | 742 | 3,723 | 3,079 | 788 | 3,867 | 99 | 45 | 144 |
| 2036 | 3,054 | 738 | 3,792 | 3,157 | 773 | 3,929 | 102 | 35 | 137 |
| 2037 | 3,109 | 740 | 3,849 | 3,223 | 752 | 3,975 | 114 | 12 | 126 |
| 2038 | 3,231 | 670 | 3,902 | 3,357 | 667 | 4,024 | 125 | -3 | 122 |
| 2039 | 3,250 | 657 | 3,907 | 3,393 | 662 | 4,054 | 143 | 4 | 147 |
| 2040 | 3,393 | 635 | 4,027 | 3,524 | 647 | 4,171 | 131 | 12 | 143 |
| NPVRR | 26,085 | 6,662 | 32,748 | 26,848 | 6,693 | 33,542 | 763 | 31 | 794 |

**Appendix Table 6 – Refurbished WFGD 4/2016; CERA Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,207 | 47 | 1,254 | 1,207 | 46 | 1,253 | 0 | -1 | -1 |
| 2013 | 1,249 | 123 | 1,373 | 1,249 | 125 | 1,374 | 0 | 2 | 2 |
| 2014 | 1,286 | 265 | 1,551 | 1,286 | 296 | 1,582 | 0 | 31 | 31 |
| 2015 | 1,359 | 422 | 1,781 | 1,359 | 474 | 1,833 | 0 | 52 | 52 |
| 2016 | 1,485 | 560 | 2,045 | 1,504 | 585 | 2,089 | 19 | 25 | 44 |
| 2017 | 1,497 | 589 | 2,086 | 1,476 | 578 | 2,054 | -21 | -11 | -32 |
| 2018 | 1,585 | 607 | 2,192 | 1,593 | 563 | 2,156 | 8 | -44 | -36 |
| 2019 | 1,598 | 604 | 2,201 | 1,632 | 556 | 2,188 | 34 | -48 | -14 |
| 2020 | 1,643 | 590 | 2,232 | 1,695 | 586 | 2,281 | 53 | -4 | 49 |
| 2021 | 1,747 | 582 | 2,329 | 1,824 | 618 | 2,442 | 77 | 37 | 114 |
| 2022 | 1,862 | 611 | 2,473 | 1,878 | 638 | 2,516 | 16 | 27 | 43 |
| 2023 | 1,915 | 645 | 2,560 | 1,901 | 633 | 2,534 | -14 | -12 | -26 |
| 2024 | 1,873 | 667 | 2,540 | 1,908 | 616 | 2,524 | 35 | -51 | -16 |
| 2025 | 1,949 | 668 | 2,616 | 2,001 | 605 | 2,607 | 53 | -62 | -10 |
| 2026 | 2,045 | 655 | 2,700 | 2,129 | 602 | 2,731 | 84 | -53 | 31 |
| 2027 | 2,112 | 644 | 2,756 | 2,191 | 615 | 2,806 | 79 | -29 | 50 |
| 2028 | 2,152 | 638 | 2,790 | 2,231 | 663 | 2,894 | 79 | 25 | 104 |
| 2029 | 2,247 | 686 | 2,933 | 2,324 | 717 | 3,041 | 77 | 31 | 108 |
| 2030 | 2,383 | 739 | 3,121 | 2,388 | 752 | 3,140 | 6 | 14 | 19 |
| 2031 | 2,402 | 769 | 3,170 | 2,447 | 750 | 3,197 | 45 | -19 | 27 |
| 2032 | 2,492 | 774 | 3,266 | 2,549 | 741 | 3,290 | 57 | -32 | 25 |
| 2033 | 2,613 | 759 | 3,372 | 2,675 | 734 | 3,409 | 61 | -25 | 36 |
| 2034 | 2,714 | 746 | 3,460 | 2,787 | 764 | 3,551 | 73 | 18 | 91 |
| 2035 | 2,825 | 742 | 3,567 | 2,895 | 799 | 3,694 | 69 | 57 | 126 |
| 2036 | 2,943 | 738 | 3,681 | 2,970 | 810 | 3,780 | 27 | 72 | 99 |
| 2037 | 3,033 | 740 | 3,773 | 3,068 | 800 | 3,869 | 35 | 60 | 96 |
| 2038 | 3,172 | 670 | 3,842 | 3,207 | 705 | 3,912 | 35 | 35 | 70 |
| 2039 | 3,246 | 657 | 3,904 | 3,299 | 677 | 3,977 | 53 | 20 | 73 |
| 2040 | 3,403 | 635 | 4,038 | 3,464 | 648 | 4,112 | 60 | 14 | 74 |
| NPVRR | 24,209 | 6,662 | 30,872 | 24,562 | 6,686 | 31,247 | 353 | 23 | 376 |

**Appendix Table 7 – New WFGD 10/2016; Base Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,222 | 47 | 1,269 | 1,222 | 46 | 1,269 | 0 | -1 | -1 |
| 2013 | 1,262 | 123 | 1,385 | 1,262 | 125 | 1,387 | 0 | 2 | 2 |
| 2014 | 1,349 | 265 | 1,614 | 1,349 | 296 | 1,645 | 0 | 31 | 31 |
| 2015 | 1,442 | 420 | 1,862 | 1,442 | 474 | 1,915 | 0 | 54 | 54 |
| 2016 | 1,629 | 554 | 2,183 | 1,608 | 585 | 2,193 | -20 | 31 | 10 |
| 2017 | 1,618 | 586 | 2,204 | 1,604 | 578 | 2,182 | -14 | -8 | -22 |
| 2018 | 1,677 | 604 | 2,281 | 1,706 | 563 | 2,269 | 28 | -41 | -13 |
| 2019 | 1,760 | 601 | 2,361 | 1,818 | 556 | 2,374 | 59 | -45 | 14 |
| 2020 | 1,829 | 587 | 2,416 | 1,916 | 586 | 2,502 | 87 | -1 | 86 |
| 2021 | 1,932 | 579 | 2,511 | 2,048 | 618 | 2,667 | 116 | 39 | 155 |
| 2022 | 2,065 | 608 | 2,673 | 2,125 | 638 | 2,763 | 61 | 30 | 90 |
| 2023 | 2,138 | 642 | 2,780 | 2,164 | 633 | 2,797 | 26 | -10 | 17 |
| 2024 | 2,142 | 665 | 2,807 | 2,236 | 616 | 2,852 | 94 | -49 | 45 |
| 2025 | 2,241 | 665 | 2,906 | 2,363 | 612 | 2,976 | 122 | -53 | 69 |
| 2026 | 2,376 | 653 | 3,029 | 2,535 | 651 | 3,187 | 159 | -2 | 157 |
| 2027 | 2,383 | 642 | 3,025 | 2,525 | 694 | 3,220 | 142 | 52 | 194 |
| 2028 | 2,487 | 636 | 3,123 | 2,595 | 720 | 3,316 | 108 | 84 | 192 |
| 2029 | 2,536 | 684 | 3,221 | 2,615 | 725 | 3,340 | 78 | 41 | 119 |
| 2030 | 2,677 | 737 | 3,414 | 2,730 | 715 | 3,445 | 53 | -22 | 32 |
| 2031 | 2,650 | 767 | 3,417 | 2,771 | 700 | 3,471 | 121 | -67 | 54 |
| 2032 | 2,708 | 772 | 3,480 | 2,851 | 699 | 3,551 | 143 | -73 | 70 |
| 2033 | 2,822 | 757 | 3,579 | 2,973 | 730 | 3,703 | 151 | -27 | 124 |
| 2034 | 2,880 | 745 | 3,625 | 3,052 | 765 | 3,817 | 172 | 20 | 193 |
| 2035 | 2,981 | 741 | 3,722 | 3,079 | 788 | 3,867 | 99 | 47 | 145 |
| 2036 | 3,054 | 737 | 3,791 | 3,157 | 773 | 3,929 | 102 | 36 | 139 |
| 2037 | 3,109 | 739 | 3,848 | 3,223 | 752 | 3,975 | 114 | 13 | 127 |
| 2038 | 3,231 | 669 | 3,901 | 3,357 | 667 | 4,024 | 125 | -2 | 124 |
| 2039 | 3,250 | 656 | 3,906 | 3,393 | 662 | 4,054 | 143 | 5 | 148 |
| 2040 | 3,393 | 634 | 4,026 | 3,524 | 647 | 4,171 | 131 | 13 | 144 |
| NPVRR | 26,122 | 6,638 | 32,760 | 26,848 | 6,693 | 33,542 | 727 | 55 | 782 |

**Appendix Table 8 – New WFGD 10/2016; CERA Fuel Price Scenario ($M)**

| | Retrofit Mill Creek 3 | | | Retire Mill Creek 3 | | | Difference | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Prod Costs | Capital | Total | Prod Costs | Capital | Total | Prod Costs | Capital | Total |
| 2011 | 1,142 | 7 | 1,148 | 1,142 | 7 | 1,148 | 0 | 0 | 0 |
| 2012 | 1,207 | 47 | 1,254 | 1,207 | 46 | 1,253 | 0 | -1 | -1 |
| 2013 | 1,249 | 123 | 1,373 | 1,249 | 125 | 1,374 | 0 | 2 | 2 |
| 2014 | 1,286 | 265 | 1,551 | 1,286 | 296 | 1,582 | 0 | 31 | 31 |
| 2015 | 1,359 | 420 | 1,779 | 1,359 | 474 | 1,833 | 0 | 54 | 54 |
| 2016 | 1,527 | 554 | 2,081 | 1,504 | 585 | 2,089 | -23 | 31 | 8 |
| 2017 | 1,497 | 586 | 2,083 | 1,476 | 578 | 2,054 | -21 | -8 | -29 |
| 2018 | 1,585 | 604 | 2,189 | 1,593 | 563 | 2,156 | 8 | -41 | -33 |
| 2019 | 1,598 | 601 | 2,198 | 1,632 | 556 | 2,188 | 34 | -45 | -11 |
| 2020 | 1,643 | 587 | 2,230 | 1,695 | 586 | 2,281 | 53 | -1 | 52 |
| 2021 | 1,747 | 579 | 2,326 | 1,824 | 618 | 2,442 | 77 | 39 | 116 |
| 2022 | 1,862 | 608 | 2,470 | 1,878 | 638 | 2,516 | 16 | 30 | 46 |
| 2023 | 1,915 | 642 | 2,558 | 1,901 | 633 | 2,534 | -14 | -10 | -24 |
| 2024 | 1,873 | 665 | 2,538 | 1,908 | 616 | 2,524 | 35 | -49 | -14 |
| 2025 | 1,949 | 665 | 2,614 | 2,001 | 605 | 2,607 | 53 | -60 | -7 |
| 2026 | 2,045 | 653 | 2,698 | 2,129 | 602 | 2,731 | 84 | -51 | 33 |
| 2027 | 2,112 | 642 | 2,754 | 2,191 | 615 | 2,806 | 79 | -27 | 51 |
| 2028 | 2,152 | 636 | 2,788 | 2,231 | 663 | 2,894 | 79 | 27 | 106 |
| 2029 | 2,247 | 684 | 2,931 | 2,324 | 717 | 3,041 | 77 | 32 | 110 |
| 2030 | 2,383 | 737 | 3,120 | 2,388 | 752 | 3,140 | 6 | 15 | 21 |
| 2031 | 2,402 | 767 | 3,169 | 2,447 | 750 | 3,197 | 45 | -17 | 28 |
| 2032 | 2,492 | 772 | 3,264 | 2,549 | 741 | 3,290 | 57 | -31 | 26 |
| 2033 | 2,613 | 757 | 3,371 | 2,675 | 734 | 3,409 | 61 | -24 | 38 |
| 2034 | 2,714 | 745 | 3,458 | 2,787 | 764 | 3,551 | 73 | 20 | 93 |
| 2035 | 2,825 | 741 | 3,566 | 2,895 | 799 | 3,694 | 69 | 58 | 127 |
| 2036 | 2,943 | 737 | 3,680 | 2,970 | 810 | 3,780 | 27 | 73 | 100 |
| 2037 | 3,033 | 739 | 3,772 | 3,068 | 800 | 3,869 | 35 | 61 | 97 |
| 2038 | 3,172 | 669 | 3,841 | 3,207 | 705 | 3,912 | 35 | 36 | 71 |
| 2039 | 3,246 | 656 | 3,903 | 3,299 | 677 | 3,977 | 53 | 21 | 74 |
| 2040 | 3,403 | 634 | 4,037 | 3,464 | 648 | 4,112 | 60 | 15 | 75 |
| NPVRR | 24,240 | 6,638 | 30,878 | 24,562 | 6,686 | 31,247 | 322 | 48 | 370 |