

## City of Alexandria, Virginia

## MEMORANDUM

**DATE:** JUNE 9, 2010

**TO:** THE HONORABLE MAYOR AND MEMBERS OF CITY COUNCIL

**FROM:** JAMES K. HARTMANN, CITY MANAGER

**SUBJECT:** CITY/MIRANT SETTLEMENT AGREEMENT – RECEIPT AND CONSIDERATION OF DRAFT PHASE II PROJECT REPORT (STACK PM2.5 EMISSION CONTROLS) AND MIRANT COMMUNITY MONITORING GROUP (MCMG) RECOMMENDATIONS

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**ISSUE:** City Council's receipt and consideration of the draft Phase II project report under the 2008 City/Mirant Agreement; and Council's consideration of the MCMG's recommendations made at the MCMG meeting of May 13, 2010.

**RECOMMENDATION:** That City Council:

Receive the draft Phase II project report (Attachment 1) prepared by the Engineer Worley Parsons and endorse MCMG's recommendations made at the MCMG meeting on May 13, 2010, as follows:

- Support the conclusion by the Engineer Worley Parsons that the baghouse is the preferred technology for stack fine particulate (PM<sub>2.5</sub>) emissions control, and that the City/Mirant proceed pursuant to the settlement agreement with steps to install it on as many boilers as possible within the Phase II project budget.
- Should the final report on the Phase II Project be significantly different than the current draft report under consideration by the MCMG and City Council (e.g., different control technology recommendations for boilers # 3, 4, and 5), direct that staff hold another meeting with MCMG to consider a new course of action.
- Based on the Engineer's budgetary cost estimate for the Phase II project of \$32 million and the revised and more accurate installed cost for the wind screens of \$1.02 million, which is higher than previously estimated, that the installation of the wind screens and the drip pans (two Phase I projects previously approved by City Council) be deferred until the cost for the phase II project have been determined accurately.

## **DISCUSSION:**

### **Draft Phase II Report by the Engineer WorleyParsons**

Worley Parson (Project Engineer) prepared the submitted draft Phase II project and presented the results of this report to the MCMG on May 13, 2010. The City, Mirant and Virginia DEQ officially now have 45 days (starting April 30, 2010) to comment on this draft before the Engineer finalizes it within the following 60 days.

The report recommends installation of polishing baghouses on boilers # 3, 4, and 5. This will be achieved by retrofitting existing cold side electrostatic precipitators with new baghouses. The report also recommends upgrades to the existing hot electrostatic precipitators for boilers # 1 and 2. **The Engineer's estimate for the Phase II project is \$27.01 million plus \$4.074 million in contingencies for a total of \$31.06 million. Due to the uncertainties normally associated with retrofitting projects, and since the budget cap for the Phase II project is \$32 million, it is not certain at the present time if the baghouse conversion could be done on two or three boilers until the firm bids are received, and contracts signed with appropriate terms and conditions.**

As you may recall, the City had previously argued in front of the State Air Pollution Control Board for the use of baghouses for PM2.5 emissions control at this facility. Since this project involves retrofitting an existing facility, there were significant technical challenges that needed to be overcome to insure that baghouse option was feasible. Additional time was needed to address numerous technical challenges of retrofitting a baghouse into the existing shell of the cold precipitator without compromising the plant's structural integrity and safety as well as not exceeding the budget cap of \$32 million.

### **Progress on the Phase I Projects**

As you may recall, Council authorized moving forward with the five projects targeting fugitive dust under Phase I in November 2009 which included a dust suppression system, a street sweeper, an ash loader, drip pans, and wind screens. The dust suppression system and street sweeper have been ordered and delivery is expected this summer. The new ash loader has been installed and currently being operated (with a temporary power supply).

With respect to the remaining two Phase I projects, the installation of the drip pans was put on hold because of requirement of a permit modification by VDEQ. With respect to the wind screens project, the projected cost has increased significantly by \$405,000 from the initial estimates and is now at \$1.02 million. This is primarily due to poor soil conditions at this site, resulting in a more extensive (and expensive) foundation for the poles supporting the screens.

### **MCMG Meeting of May 13, 2010**

The meeting (Attachment 2) was co-chaired by Councilwoman Del Pepper and Councilman Paul Smedberg. The objectives of this meeting were to: (i) review the Engineer Worley Parsons's draft Phase II report regarding controls on fine particulate (PM2.5) from the stacks; (ii) review

progress of the Phase I projects that were previously approved by City Council; and (iii) update the group members and attendees on recent regulatory developments and the recent Mirant/ RRI Energy merger.

Staff also discussed the two recent Notice of Violations (NOVs) issued by Virginia Department of Environmental Quality to Mirant. Mirant representative discussed the recent merger between Mirant and RRI Energy and confirmed that the City/Mirant agreement remains unaffected by the merger.

MCMG members also requested that the City Attorney's Office review the Escrow Account in consultation with the Office of Management and Budget due to concern about reduced interest yields on the principal balance. Following this meeting, the City Attorney's Office has reviewed the Settlement Agreement in connection with this concern. The City Attorney's Office, in consultation with OMB, advises that the Settlement Agreement was designed primarily to protect the \$34 million in principal, not generate particular yields from it. While the account chosen by Mirant in creating the Escrow Account has generated lower amounts of interest as market interest rates have dropped, the primary goal of preservation of principal continues to be met. Based on the information presented, there does not appear to be any issue of non-compliance with the Settlement Agreement associated with the reduced interest yields on the account.

In conclusion, staff agrees with and supports the conclusions and recommendations made by the Engineer Worley Parsons in their draft Phase II study. Furthermore, staff concurs with the MCMG's recommendations expressed at its meeting on May 13, 2010.

**FISCAL IMPACTS:** There is no fiscal impact involved since the costs of the projects will be paid for by the escrow account that was established as part of the Mirant/City Settlement Agreement.

**ATTACHMENTS:**

- Attachment 1: WorleyParsons, Draft Phase II PM2.5 Emissions Reduction Study, April 23, 2010
- Attachment 2: William J. Skrabak May 28, 2010, Memorandum to Honorable Mayor and Members of City Council

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MIRANT POTOMAC RIVER, LLC – POTOMAC RIVER GENERATING STATION  
PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY

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# MIRANT POTOMAC RIVER, LLC POTOMAC RIVER GENERATING STATION

## PHASE II

## PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY

PRGS-0-LI-022-0002-RC.doc

April 23, 2010

This document is a draft report for comments only.  
It is not intended to be used for any other purposes.

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### Disclaimer

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### PROJECT - PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY

REV	DESCRIPTION	ORIG	REVIEW	WORLEY- PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for preliminary review	<u>W.M.</u> W. Morris	<u>G.A.</u> G. Andes	<u>L.J.</u> L. Jones	15-May-09	<u>N/A</u>	
B	Preliminary Draft	<u>W.M.</u> W. Morris	<u>G.A.</u> G. Andes	<u>L.J.</u> L. Jones	6-July-09	<u>N/A</u>	
C	Final Draft	<u>T. SHIN</u> T. Shin	<u>G. Andes</u> G. Andes	<u>M. Holdridge</u> M. Holdridge	23-April-10		

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PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY**

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**PERTINENT TECHNOLOGY ACRONYMS, INITIALISMS, AND ABBREVIATIONS**

AQC	Air Quality Control
CESP	Cold-side ESP
CFD	Computational Fluid Dynamics (computer model)
DESP	Dry ESP
DFGD	Dry FGD
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization or WFGD ("Wet FGD")
FPCS	Fine Particulate Control System
gr/acf	Grains per actual cubic foot
H <sub>2</sub> SO <sub>4</sub>	Sulfuric Acid
HESP	Hot-side ESP
HFPS	High Frequency Power Supplies (also known as "Switch Mode Power Supply or SMPS")
Hg	Mercury
Lb/MMBtu	Pounds per Million British Thermal Units
LPHV	Low Pressure High Volume
MCC	Motor Control Center
MFT	Master Fuel Trip (boiler control scenario)
NO <sub>x</sub>	Nitrogen Oxides
PAC	Powdered Activated Carbon
PCF	Pounds per Cubic Foot
PFD	Process Flow Diagram
PJFF	Pulse Jet Fabric Filter (also known as "Baghouse" and "Fabric Filter")
PM	Particulate Matter
PM <sub>2.5</sub>	PM with an aerodynamic diameter that is less than or equal to 2.5 micrometers in size
PM <sub>10</sub>	PM with an aerodynamic diameter that is less than or equal to 10 micrometers in size
PPS	Polyphenylene Sulfide
PRGS	Potomac River Generating Station
RFP	Request For Proposal
SO <sub>2</sub>	Sulfur Dioxide
SO <sub>3</sub>	Sulfur Trioxide
T&M	Time and Material
T/R	Transformer/Rectifier
TPH	Tons Per Hour
V-I	Voltage-Current
WESP	Wet ESP





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## **1. EXECUTIVE SUMMARY**

On July 17, 2008, Mirant Potomac River, LLC ("Mirant") and the City of Alexandria ("City") entered an Agreement to implement emissions reduction controls with respect to the fugitive dust (Phase I) and fine particulate matter (PM<sub>2.5</sub>) emissions (Phase II) at Mirant's Potomac River Generating Station (PRGS). On October 24, 2008, WorleyParsons received a purchase order from Mirant to provide engineering services in support of this Project. The work was officially kicked off with a joint meeting between Mirant, the City, and WorleyParsons on October 30 and 31, 2008.

This study addresses the PM<sub>2.5</sub> Emission Reduction (Phase II) portion of this Agreement. A separate study addressed the fugitive dust emissions (Phase I) portion of the Agreement.

WorleyParsons' approach to evaluating the possible PM<sub>2.5</sub> Emission Reduction technologies and arriving at a recommendation for this Phase II report was as follows:

- Attend Kick-off Meeting with Mirant, the City, and the City Consultant to review scope documents;
- Review the listing of potential PM<sub>2.5</sub> Emission Reduction technologies given in the Agreement;
- Brainstorming with Mirant, the City, and the City Consultant to list additional PM<sub>2.5</sub> Emission Reduction technologies for consideration;
- In-house review with other Air Quality Control (AQC) specialists to list additional PM<sub>2.5</sub> Emission Reduction technologies for consideration;
- Literature and Internet search for additional PM<sub>2.5</sub> Emission Reduction technologies for consideration;
- Preparation of a letter-style performance specification and solicitation of technology solutions from leading AQC vendors and contractors for the latest commercially available PM<sub>2.5</sub> Emission Reduction technologies;
- Observation and collection of information on PRGS's existing electrostatic precipitator (ESP) systems, including coal analysis and ash samples;
- Review of available prior PM<sub>2.5</sub> emission reports and recommendations;
- Review of previous and on-going PM<sub>2.5</sub> control projects at the site;
- Preparation of a technology screening matrix listing all possible PM<sub>2.5</sub> Emission Reduction technologies;
- Research and conducting performance testing on PRGS's existing ID fans;



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- Research, conducting performance testing of pressure drop of in-duct silencers, and recommending pressure drop saving alternatives;
- Careful, methodical, and reasoned elimination of listed possible PM<sub>2.5</sub> Emission Reduction technologies (moved to the bottom of the matrix listing); and
- Regular progress meetings and on-site meetings to review and screen selections with Mirant, the City, and the City Consultant.

Most of the PM<sub>2.5</sub> Emission Reduction technologies reviewed involved modifications to the existing cold-side ESPs (CESPs) and/or hot-side ESPs (HESPs). Such modifications were either to upgrade the existing ESP(s) or convert the ESP(s) to pulse jet fabric filters (PJFFs). Although industry experience is that PJFFs are more capable of removing particulate, particularly PM<sub>10</sub> and PM<sub>2.5</sub>, than ESPs, it was found that a mix was required due to physical space constraints and financial limitations. Mirant has both base-loaded and cycling units at PRGS; therefore, to maximize the PM<sub>2.5</sub> Emissions Reduction, application of the PJFF technology was considered for the base-loaded units first.

PRGS's current ID fans were found to be capable of handling the future PJFF pressure drop with some modifications to the existing flue gas path. A transient analysis has been conducted and has verified that the existing control system can provide protection for typical furnace upset conditions such as MFTs due to operator initiation or positive furnace pressure excursions.

Recommendation: As a result of the above program, WorleyParsons recommends that the CESPs on base-loaded Units 3, 4, and 5 be converted to PJFF polishing baghouses and that T/R controller upgrades be added to the HESPs for Units 1 and 2, the cycling units. The installation of PJFF baghouses will provide improved particulate removal in a more consistent fashion than the current Air Quality Control (AQC) equipment is capable of providing.

Projected costs are estimated (±30%) to be \$31.1 million (April 2010 dollars) for the recommended technology. With the engineering required for preparing and following up on this report, the total projected costs are estimated (±30%) to be \$32 million. At this level of cost, it is further recommended that the CESP conversion be bid for two (2) of the three base loaded units with an option to include the third unit.

These modifications should provide the maximum PM<sub>2.5</sub> Emissions Reductions possible within the financial limits. Filterable PM<sub>2.5</sub> emissions of less than 0.010 lb/MMBtu may be achievable with the conversion of the CESPs on Units 3, 4, and 5 to PJFF baghouses.



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## 2. INTRODUCTION

The purpose of this engineering study is to compile, screen, and recommend the PM<sub>2.5</sub> Emissions Reduction technology(s) that would provide the greatest benefit in reducing the PM<sub>2.5</sub> emissions at Mirant's PRGS in Alexandria, VA. As part of the Agreement between Mirant and the City, the total installed cost of the recommended PM<sub>2.5</sub> Emissions Reduction technology(s) is limited to the thirty-four million dollars (\$34,000,000) in the Escrow Account, minus the up to two million dollars (\$2,000,000) spent on implementing the Phase I study, or approximately thirty-two million dollars (\$32,000,000).

WorleyParsons' approach to compiling, screening, and recommending the most beneficial PM<sub>2.5</sub> Emissions Reduction technology(s) was to prepare a matrix of potential PM<sub>2.5</sub> Emissions Reduction technologies through a brainstorming session with Mirant, the City, and the City Consultant personnel during the initial project kick-off meeting. Following the preparation of this matrix, criteria were added to the matrix by which the PM<sub>2.5</sub> Emissions Reduction technologies could be screened and ranked to come up with a final recommendation. The screening process was carried out in three phases with reviews with Mirant, the City, and the City Consultant:

- Coarse Screening – Criteria consisting of:
  - Technical Feasibility;
  - Estimated Level of PM<sub>2.5</sub> Reduction for Both Filterable and Condensable PM<sub>2.5</sub> Fraction (Levels – High, Medium, and Low);
  - Rough Order of Magnitude Estimated Cost (Supply and Installation) – Ranges of 0 to \$1 Million, \$1 to \$5 Million, \$5 to \$32 Million, and over \$32 Million; and
  - Schedule Constraints – Ranges of 0 to 12 Months, 12 to 36 Months, and over 36 months.
- Detailed Screening – Criteria consisting of:
  - Operation Issues;
  - Maintenance Issues;
  - Advantages; and
  - Disadvantages.
- Final Screening – Criteria consisting of:
  - Relative Importance Ranking (1 being the Highest).

The results of this screening process can be reviewed in Attachment 5.1 of this study. It should be noted that as control options were screened from the list of potential candidates; the options were retained in the lower section of the list thereby maintaining a record of the screening process.



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Additional comments were added to the options noting why any particular option was screened from the list of potential technologies.

## **2.1 Defining PM<sub>2.5</sub> Emissions**

PM<sub>2.5</sub> consists of particulate matter that has an aerodynamic diameter that is less than or equal to 2.5 microns in size. PM<sub>10</sub> consists of particulate matter that has an aerodynamic diameter that is less than or equal to 10 microns in size.

Actual PM<sub>2.5</sub> emissions are mostly aerosols present in the flue gas, mainly SO<sub>3</sub>. Fabric filters as standalone equipment are very efficient at removing particulate matter but not as efficient at removing aerosols. At the flue gas temperatures entering the fabric filter, the aerosols are still mostly in the gaseous phase and a high percentage will pass through the fabric filter bags.

PM<sub>2.5</sub> emissions due to H<sub>2</sub>SO<sub>4</sub> aerosols can be reduced by the injection on a sorbent such as lime, Trona, sodium bicarbonate, and other sorbents. The sorbent is injected prior to the fabric filter in the inlet duct where it collects on the filter bag and reacts very efficiently with the SO<sub>2</sub> and SO<sub>3</sub>.

## **2.2 Existing Plant Configuration**

There are five units at PRGS. Units 1 and 2 are rated at 93 MW and are cycling units. As the result of the recent stack merge project, their exhausts are combined and exit from the Unit 1 stack. Units 3, 4, and 5 are rated at 108 MW and are base-loaded units which exhaust through the Unit 4 stack.

To achieve the maximum overall PM<sub>2.5</sub> emissions reduction within the limits of the available funding, the larger capacity and base-loaded units are recommended for more extensive PM<sub>2.5</sub> controls than the smaller, cycling units.

## **2.3 Existing Unit Configuration**

For each of the five units, the existing gas flow is from the boiler, through the economizer and into ductwork that goes to the HESP. From the HESP the gas goes through the Air Preheater and on to the CESP. The gas flow then goes through the ID Fans and on to one of the two merged stacks. Trona is injected upstream of the HESP to promote SO<sub>2</sub> capture and reduction.

The following PFD (Process Flow Diagram) shows the basics of the existing unit configuration for all five units:

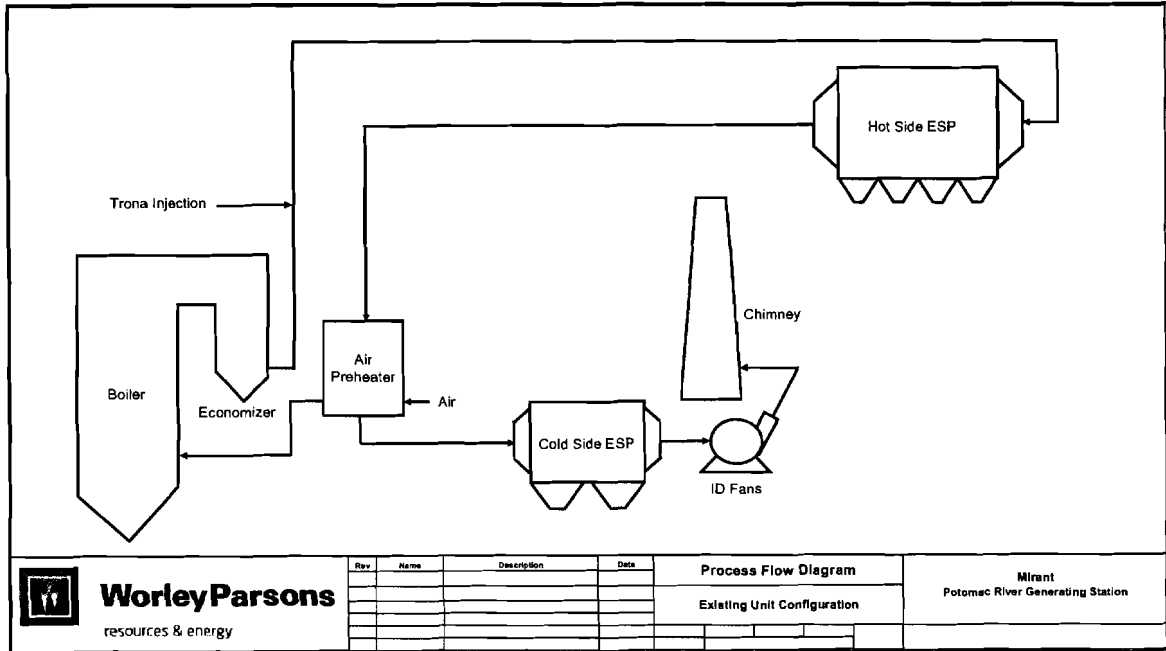


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### **3. DISCUSSION**

#### **3.1 PM<sub>2.5</sub> EMISSION REDUCTION ENGINEERING STUDY**

##### **3.1.1 Kick-off Meeting**

On October 30-31, 2008 a Project Kick-off Meeting was held at the Mirant PRGS site with Mirant, the City, the City Consultant, and WorleyParsons.

The Project Schedule and the Agreement ("Agreement") between Mirant and the City was reviewed. Section 4 of the Agreement specifically listed the following improvement technologies for consideration in the PM<sub>2.5</sub> Emissions Reduction Project:

- Install fabric filters or other technologies in the current housings for the hot-side and/or cold-side precipitators on Units 1 through 5, taking into account the cost of retrofitting such fabric filters on these boilers and any impacts to the structural integrity of the boilers and the facility.
- Improving the performance and reliability of existing hot-side and/or cold-side precipitators such as, but not limited to:
  - Supercharging (ESP re-sectionalization);
  - Gas conditioning; and
  - Increased collection area and/or residence time.
- Other commercially available technologies identified by the Engineer that may be applied in any location of the Facility including but not limited to hybrid PM<sub>2.5</sub> control systems such as:
  - COHPAC<sup>TM</sup>;
  - Advanced Hybrid Filter<sup>TM</sup>;
  - MAX-9 Electrostatic Fabric Filter<sup>TM</sup>; and
  - Polishing fabric filters serving combined stacks.

In addition, the Agreement stated that any PM<sub>2.5</sub> Emission Reduction technology must also:

- Address condensables via higher removal of sulfur acid, and
- Utilize Test Method 27 for PM<sub>2.5</sub> filterable and Test Method 202 or equivalent for PM<sub>2.5</sub> condensables.

A plant walk-thru and a brainstorming session were held to formulate a list for later screening. Twenty-six items were suggested for the original list, as tabulated in the matrix in Attachment 5.1.



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Additionally, during the same brainstorming session, five parameters were suggested to be followed in looking at PM<sub>2.5</sub> Emission Reduction control technology including:

- Must be commercially available and demonstrated technologies;
- No un-reasonable scale-up required to implement the technology;
- No R&D efforts;
- Buying from the United States of America is good, but not required; and
- Technology must have support infrastructure in the United States of America.

Over the course of reviewing technology proposals from outside sources, an additional parameter was developed:

- Exclude improvements which would come under routine maintenance.

WorleyParsons was directed by Mirant to use the 2004 coal and ash quantities from the City of Alexandria Table 4A – Coal Data. These quantities are:

- Coal: 900,000 tons annual consumption; 300,000 tons maximum quarterly consumption;
- Fly Ash: 120,000 tons annual generation; and
- Bottom Ash: 14,000 tons annual generation.

### **3.1.2 Site Visits**

In addition to the initial Project Kick-off Meeting at the site, additional site visits were made to observe and evaluate the existing equipment, review the technology screening document and design data, and to oversee fan performance testing and to oversee in-duct silencer performance testing.

### **3.1.3 Vendor Technology Proposals**

Nationally recognized AQC vendors were invited to propose technology solutions.

A pre-bid meeting was also held on site with all prospective Vendors in attendance. This meeting was held to review project requirements and allow the Vendors to observe and evaluate the existing equipment. Concept offerings were received, reviewed in detail, with follow-up questions sent to the Vendors, and follow-up discussions were held. Section 3.2 provides additional detail on the proposals and their evaluation.

### **3.1.4 PM<sub>2.5</sub> Emission Reduction Options – Technology Screening Document**

All PM<sub>2.5</sub> Emission Reduction Study options from the brainstorming session were compiled into an initial draft of a technology screening document. These options, along with other options added as a result of the site visits and progress meetings, were reviewed and screened through three screenings



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– “Coarse”, “Detailed”, and “Final” resulting in the recommended PM<sub>2.5</sub> emission control options. The final technology screening document is included as Attachment 5.1.

### 3.1.5 Explanation of PM<sub>2.5</sub> Emission Reduction Control Options

Although over 25 possible PM<sub>2.5</sub> emission control options were considered, they all fall into only a few general categories. A brief explanation of each of those general categories is as follows:

- Coal Cleaning – Coal, after it is mined, goes through a coal cleaning process to remove impurities from the coal in order to improve the coal's heat content. Impurities removed include rocks, overburden (soil), and pyrites (iron disulfide). Physical coal cleaning only reduces some of the inorganic sulfur (pyrites) from the coal. Sulfur in coal has the potential for forming condensable particulate matter. Coal cleaning is an off-site activity not considered to be within the limits of this study.
- Flue Gas Desulfurization - Flue Gas Desulfurization (FGD) systems are primarily designed to reduce SO<sub>2</sub> emissions from combustion exhaust. SO<sub>2</sub> in the exhaust has the potential for forming condensable particulate matter. There are three primary types of FGD systems - wet, dry, and dry sorbent injection.
  - Wet FGD: Wet flue gas desulfurization (WFGD) systems use alkaline slurries (containing limestone or lime) to saturate the exhaust gas to remove SO<sub>2</sub> and acid gas emissions. The SO<sub>2</sub> in the exhaust gas comes in contact with the reagent and a chemical reaction occurs producing insoluble calcium salts. The calcium salts are treated and dewatered and removed as a by-product that is either disposed of as a solid waste or sold for beneficial use.
  - Dry FGD: Dry flue gas desulfurization (DFGD) systems typically inject aqueous sorbent slurry similar to a WFGD system; but the slurry (typically lime) has higher solids content and does not saturate the flue gas. The sorbent slurry is injected into the exhaust stream, mixes with the flue gas, and reacts with SO<sub>2</sub> and acid gases to form solid particles. These particles are collected by particulate control equipment and removed. Most commonly the collection equipment is a fabric filter (FF) which provides improved performance by the additional acid gas absorption as the exhaust stream passes through the accumulated filter cake on the bags.
  - Dry Sorbent Injection: Dry Sorbent Injection systems inject dry powdered alkaline material into the flue gas stream to react with acid gases. Typical sorbent materials injected are: calcium based alkaline sorbent (lime or hydrated lime) and/or sodium based alkaline sorbents (Trona or sodium bicarbonate). The resulting solid salts and any excess alkaline material are collected by downstream particulate control equipment.
- Fabric Filter – A fabric filter uses filtration to separate the particulate from the flue gas. As the exhaust gas through fabric filter bags, the solid particles are captured on the filter bag





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and the cleaned gas is exhausted. In addition, if dry sorbent injection is used, particles of dry sorbent are captured on the bags forming a filter cake which enhances removal of the aerosols which would normally pass through the filter bag.

- COHPAC<sup>™</sup>: The EPRI COHPAC<sup>™</sup> Technology enhances particulate capture by installing a high ratio PJFF in series with an existing, energized ESP such that the PJFF serves as a polishing, or final collection device. The ESP removes most of the particulate prior to entering the PJFF where the filtration rate (air-to-cloth-ratio) can be increased, while maintaining the same performance.
- Advanced Hybrid Filter: The EERC / W.L. Gore ADVANCED HYBRID<sup>™</sup> filter technology combines two technologies: electrostatic precipitation and fabric filtration. The configuration consists of alternating rows of ESP components (discharge electrodes and collecting plates) and GORE-TEX<sup>®</sup> membrane filter bags within a collector. The flue gas passes into the ESP zone, which removes most of the particulate before reaching the FF zone.
- MAX-9<sup>™</sup> Electrostatic Fabric Filters: MAX-9<sup>™</sup> Electrostatic Fabric Filter (ES-FF) combines discharge electrodes and fabric filters in the same casing. General Electric Energy (GE) is the exclusive licensee of this EPA patented technology. The ES-FF technology is fundamentally an electrostatic precipitator/ pulse-jet fabric filter hybrid, employing high voltage discharge electrodes to charge the particles with the fabric filter used to collect the particles instead of collecting plates.
- Dry ESPs - An ESP uses electrical forces to remove dust particles from the exhaust gas stream and onto collection electrodes/plates. The particles are given an electric charge by forcing them to pass through the corona, a region that surrounds a highly charged electrode, frequently a wire. The electrical field then forces the charged particles to the opposite charged electrode, frequently a plate. The particles collected on the plate are removed by knocking them loose from the plate or "rapping", into a hopper for removal.
- Wet ESPs - Wet electrostatic precipitators (WESPs) can be configured as any of the previously discussed precipitators but with wet collection plates instead of dry. A WESP aids in further collection of particles by preventing the collected particulate from being re-entrained in the exhaust stream. This effect also improves the effectiveness at removing small particles. Small particle removal efficiency is also enhanced by the high humidity in the chamber by improving collection of highly resistive particles. A WESP facilitates removal of condensable particulate because the gas stream must be conditioned to a temperature below about 190°F. The disadvantages of WESPs are the complexity of handling the wash water and waste disposal. They are also unable to handle large particulate loads and could not serve as a primary particulate control device on a utility boiler.
- Condensing WESP: The condensing WESP is a proprietary self-cleaning device provided by Croll-Reynolds. The system includes: a pre-scrubbing and direct



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cooling/scrubbing section to remove large particulate. Water injected upstream or condensed within the device moves to the collecting surfaces. The resulting slurry slides off the collecting plates. No further cleaning is necessary.

- Wet Membrane ESP: Wet Membrane ESPs use the same principles as in traditional wet ESPs, but polypropylene is utilized as the collecting electrode rather than stainless steel. The membranes are corrosion-resistant fibers that transport flushing liquid by capillary action which promotes an even distribution of water throughout the entire membrane. In addition to flushing collected particles, the water acts as the charge-carrying electrode.
- Enhanced ESP - Several technologies have been developed to enhance the performance of ESPs. These enhancements include basic design modifications and add-on supplemental equipment, including:
  - High Frequency Power Supplies (HFPS): HFPS are considered to be the “state of the art” in ESP energization technology. High frequency technology has the ability to maximize the amount of power provided to the ESP under a wide range of operating conditions.
  - Indigo Agglomerator: The Indigo Agglomerator is essentially a pre-charging and conditioning device designed to enhance the collection efficiency of an existing ESP. The Indigo Agglomerator is located upstream of an existing ESP. It uses both electrostatic and fluidic methods to pre-treat all of the dust particles entering the ESP, agglomerating small and large particles together creating larger more easily collected particles and reducing the number of small particles for the existing ESP to collect.
  - Bi-Corona Technology (BCT): The principle is to divide each electrical field of the ESP into several different ionization and collection zones (Bi-Corona Principle) with special discharge and collecting electrodes for highly effective particle charging and collection. This technology is intended for new and retrofit applications.
- Innovative and Developing Fine Particulate Control Technologies - A review of the literature shows there are developing technologies that may be applicable for control of PM<sub>2.5</sub> emissions. These technologies include the ElectroCore™ electrostatic centrifuge, the Powerspan’s Electro-Catalytic Oxidation technology, EnviroScrub’s Pahlman™ Process, and the E-Scrub electron beam dry scrubbing process. However, one of the parameters for evaluation of all possible technologies is they must be commercially available and have been demonstrated on similar sized units. These emerging technologies do not meet that requirement.
- Other potential technologies for PM<sub>2.5</sub> Emissions Reductions at the PRGS, include:
  - Hot to Cold conversion on existing HESP: Converting the HESP to a CESP by rerouting of the ductwork and fan modifications which increase the particulate removal by routing a reduced volume flow of cooler gas through the large ESP designed for a higher gas flow.



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- Removing more SO<sub>2</sub> (to reduce the condensables fraction): Increasing the SO<sub>2</sub> removal can potentially remove the amount of H<sub>2</sub>SO<sub>4</sub> available to condense, and thus reduce the condensable portion of the particulate.
- Technology Combinations - Combinations of control technologies are possible. This can be both multiple control technologies applied to a single unit, as well as multiple technologies being applied across the 5 units (as stated in the previous section, budget limits may require that not all five units receive the same technology solution).



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## **3.2 SUMMARY OF VENDOR TECHNOLOGY CONCEPTS**

### **3.2.1 Scope**

An inquiry was issued to nationally recognized AQC Vendors to provide technical concepts and solutions (along with budgetary information) for Mirant's PRGS PM<sub>2.5</sub> Emissions Reduction Program.

A total of twelve potential Vendors were identified who could offer technologies to address Mirant's PM<sub>2.5</sub> Emissions Reduction Program. Of that listing, eleven expressed interest in responding to the inquiry. In turn, eight of the Vendors attended a site visit and discussion on the details of the program. Seven Vendors submitted a technology concept and remained active throughout an in-depth review of their proposal, to include responses to follow-up questions and attending face-to-face meetings or teleconferences, as appropriate.

The technology concepts from the responding Vendors are summarized below, along with a summary of the budgetary information that was provided.

### **3.2.2 Vendor A**

One Vendor limited their technical proposal to modifications to the existing Trona system. While modifications to the existing Trona system are appropriate and may help reduce current PM<sub>2.5</sub> emissions, this technology alone was considered insufficient to provide all of the emissions reduction desired. The team felt that this single control, by itself, did not merit further consideration.

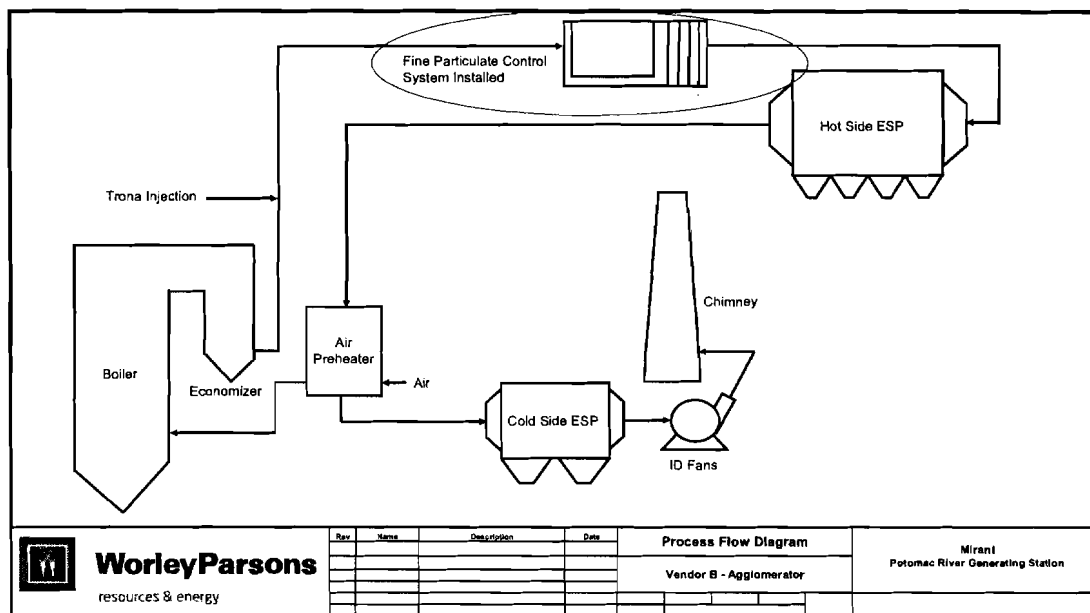
### **3.2.3 Vendor B**

One Vendor proposed their patented Fine Particulate Control System. This system is a bi-polar agglomerator that would be installed immediately upstream of the HESP.

The PFD on the following page shows the basics of this Vendor's concept:



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Although the Vendor provided predicted emission reductions ranging from 30 – 50%, the team felt that inconsistent results did not support these values nor the further consideration of this technology.



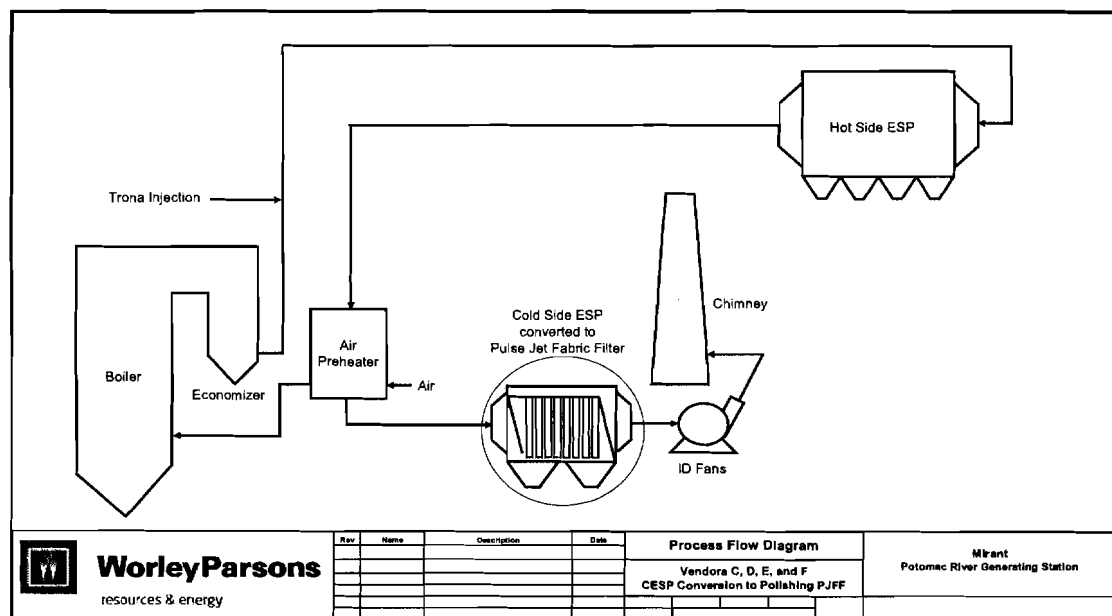
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### 3.2.4 Vendors C, D, E, and F

Four Vendors proposed converting some of the CESP's into PJFFs as polishing baghouses. (For one of those Vendors, this was given as an alternate to their preferred solution.) In each case, the CESP conversion was only the preliminary feature of the Vendors' proposal. Each Vendor also recommended various upgrades to the HESPs, to the CESP's that were not converted, and/or to the Trona injection system. Those upgrades included:

- Replace the conventional HESP T/R (Transformer/Rectifier) control sets with High Frequency Power Supplies (HFPS);
- ESP optimization studies;
- General ESP repairs;
- Upgrading the ESP controls to new microprocessor controls;
- Upgrade Trona injection system (and injection locations); and/or
- Include state-of-the-art filter bags with microdenier PPS for CESP's converted to PJFFs.

The following PFD shows the basic Vendors' concept to go with the CESP conversion, but without showing the various enhancements that the different Vendors proposed:



There would be approximately 6 inches of additional pressure drop that would have to be overcome if this option was implemented.



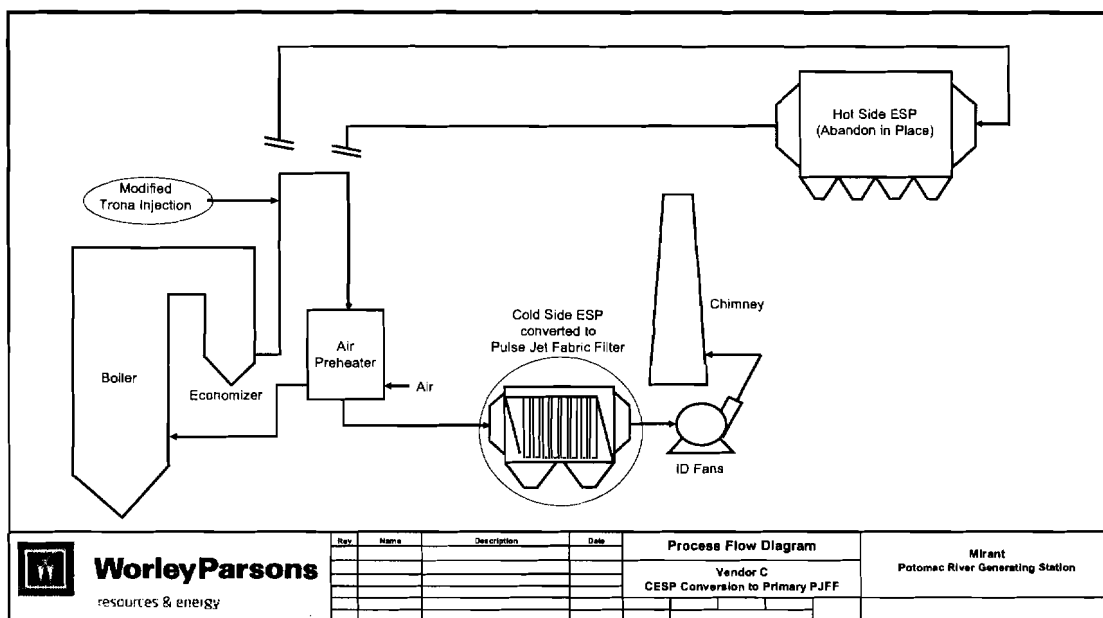
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Normal lead-time to design and supply a PJFF of this size was 32 - 36 weeks from date of award. It is estimated that the work would require a major outage of 8 – 10 weeks per unit.

### 3.2.5 Vendor C

One Vendor, who proposed conversion of some of the CESP's into PJFFs as polishing baghouses, also proposed a different solution. Their preferred solution was converting some of the CESP's into PJFFs as the primary particulate collectors and bypassing the HESPs. The two primary advantages to this approach were the lower additional pressure drop versus the CESP conversion to PJFF as polishing baghouses and the power savings and improvement in the plant heat rate by deactivating the HESPs and associated T/R sets.

The following PFD shows the basics of this Vendor's concept:



However, Vendor C's conceptual proposal is based upon the existing ash system of the CESP's having adequate capacity for the increased loading that it would see. Without the HESP in service, the full ash loading in the flue gas would have to be removed by the converted CESP/PJFF. This would overwhelm the existing ash hoppers and the existing ash collection system, which would be subject to loading beyond their original design parameters. Therefore the ash hoppers would be a bottleneck if the CESP/PJFF is made the primary particulate collector. Modifications required to expand the ash hoppers, and increase capacity of the ash collection system would be significant due to space constraints with their location in the basement of the boiler house.



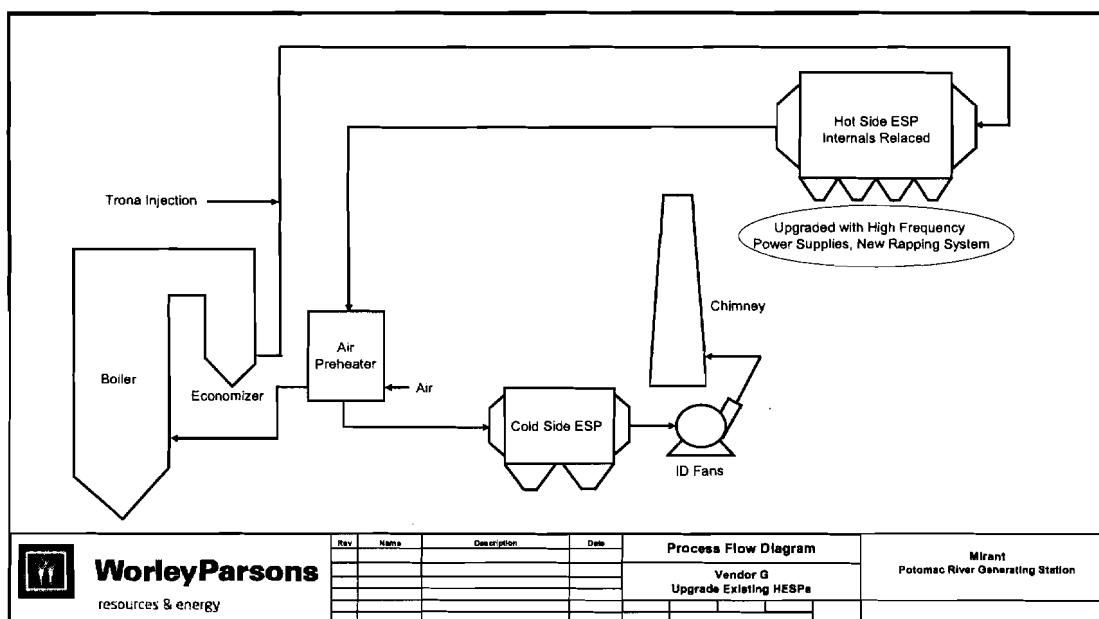
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### 3.2.6 Vendor G

One Vendor proposed to upgrade the existing HESPs with the methods listed below:

- Replace the existing discharge electrodes with Rigid Discharge Electrodes.
- Add Switch Mode Power Supplies.
- Modify the existing HESP designs with wide (16") collecting plate spacing.

The following PFD shows the basics of this Vendor's concept:



It is WorleyParsons opinion that even though this vendors ESP upgrade option guarantees meet the PM<sub>2.5</sub> reduction goals, as a long term solution for reductions in PM<sub>2.5</sub> emissions, this solution would not offer the same long term advantages as the proposed recommendation of a polishing baghouse.





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### 3.2.7 Vendor Predicted Performance

The Vendors were provided with emission rate targets for filterable and condensable particulate at the stack outlets (using EPA CTM 40/202). These targets were discussed during an early project meeting and represent WorleyParsons best estimate of the current stat-of-the-art for PM<sub>2.5</sub> emissions. Five of the seven Vendors predicted that the performance targets could be met and provided values as follows:

Present Permit Limits	PM - lb/MMBtu	PM <sub>10</sub> - lb/MMBtu	PM <sub>2.5</sub> - lb/MMBtu
(Filterable + Condensable PM)	0.045	0.030	0.016
Emission Targets	0.030	0.020	0.010
Vendor Predictions			
Vendor B (Agglomerator)	0.030 (1)	0.020 (1)	0.015 (1)
Vendor C (Primary PJFF)	0.030	0.020	0.010
Vendor D (Polishing PJFF)	0.010 (2)	0.010 (2)	0.010 (2)
Vendor F (Polishing PJFF)	0.005 (2)		
Vendor G (HESP Upgrades)	0.0122 (0.0170 guarantee)	0.0103 (0.0135 guarantee)	0.0100 (0.0131 guarantee)

(1) Using EPA Modified Test Method 202 for condensable fraction

(2) Filterable PM<sub>2.5</sub> only

The vendor predictions above represent their best estimate of guarantee levels based on their understanding of the design conditions, test methodology to be used, and typical T's and C's (to be negotiated). The Vendors each provided indicative cost estimates, for their own particular recommended PM<sub>2.5</sub> Emissions Reduction control technology. Most of these estimates excluded installation cost and all excluded any Balance of Plant (BOP) costs. For this type of retrofit work, the installation costs typically exceed the capital equipment costs and the BOP costs can also exceed the capital equipment costs. There were also substantial differences between the Vendors for similar scopes. WorleyParsons estimated these additional costs. Attachment 5.2 provides the capital cost, installation cost, and BOP cost for the recommended option as well as for three other options.



### 3.3 BOP CONSIDERATIONS

An installation concept was established for mechanical, electrical, structural, civil, and controls modifications for each Vendor's technology concept and an estimate or appropriate allowance was prepared. The following discussion represents the major BOP considerations for the project.

#### 3.3.1 Current ID Fan Capacity Study

Performance testing of the current ID fan capacity was done by Howden as well as PRGS. It was determined that the current ID fans could be sufficient to handle future PJFF operating conditions by modification to the existing gas path pressure drop and to current operating parameters. Below is the list of fan conditions as well as system conditions for a future PJFF.

- ID Fans currently operate at 1180 RPM, but will be speeded up to operate at 1320 RPM (the maximum speed allowed for continuous fan and motor operation).
- The ID Fan motors currently operate at 140 A but will be required to operate at 166 A (the design rating).
- The ID Fan inlet damper will have 4 in W.G. pressure drop across for boiler protection and unit operating response.
- The PJFF vendors will be required to guarantee a pressure drop of no more than 6 in W.G. during normal operating conditions.
- The current silencers downstream of the ID fans will be modified by removing one baffle to gain a minimum of 1.8 in W.G. pressure.
- Five thin turning vanes will be added to the Stack 4's inlet breaching to gain a minimum of 0.9 in W.G. pressure.

#### Electrical System Capacity

Because the ID fan motors will run at their design rating for future PJFF conditions, the current electrical system should be able to handle the future load. Also the cold ESP electrical components will be taken out of service offsetting the electrical demand for the PJFF equipment.

#### 3.3.2 Transient Analysis of Draft Equipment

A transient analysis was recommended for the future PJFF configuration due to the ID Fans operating at maximum capacity. That analysis has been performed and predicts the furnace transient pressure during a typical operator initiated Master Fuel Trip (MFT) (not a MFT initiated due to a negative furnace pressure). During a typical MFT, the furnace pressure will drop due to a sudden flame collapse and the inlet dampers of the ID Fans receive a decrease-demand signal to control the furnace pressure from going more negative. For the future PJFF configuration, the transient analysis



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determined that the current inlet damper operating settings are adequate to protect the furnace when the ID fans are operating at maximum capacity. In addition, the transient analysis predicted the furnace transient pressure during a positive furnace pressure MFT. In this case, the inlet dampers receive an increase-demand signal when the furnace pressure starts to increase. The transient analysis predicts that the ID fan inlet dampers control of furnace pressure during a positive pressure excursion at maximum capacity will work satisfactorily.

Below is the summary result of the transient analysis for a future PJFF configuration. The MFT case and the Positive Transient Case columns show the pressure ranges from the minimum to maximum during the analysis.

Location	Original Design Pressure <sup>(1)</sup>	Operating Pressure (in. w.g.)	MFT Case (in. w.g.)		Positive Transient (in. w.g.)	
			Minimum Transient Pressure	Maximum Transient Pressure	Minimum Transient Pressure	Maximum Transient Pressure
Furnace	-4	-0.2	-2.77	+0.15	-0.23	+10.38
Econ Outlet	-20	-3.63	-5.35	-1.67	-3.65	+6.24
Hot ESP Outlet	-20	-6.7	-7.90	-2.71	-6.72	+1.88
AH Gas Side Outlet	-20	-13.33	-13.76	-4.4	-13.34	-7.58
PJFF Outlet	NA	-19.65	-19.68	-5.91	-19.66	-16.55
ID Fan Outlet	+/- 40	+12.79	+5.81	+12.84	+12.78	+16.0
Stack Inlet	+/- 20	+11.2	+ 5.4	+11.25	+11.19	+13.72

(1) S&L Report – "Flue Gas System Design Pressure Review (NFPA 85) for Potomac River Stack Merge Project". Revision 2, June 30, 2009

According to the transient analysis result, there are no significant increases in transient pressure resulting from the addition of the PJFF system. Therefore the current control scheme for boiler protection is and will be sufficient to protect the furnace from excessive pressure excursion for the PJFF configuration. Also the furnace and most of the ductwork design pressures are adequate for the PJFF installation. The pressure ratings of the ductwork between the new PJFF and the ID fans will need to be evaluated and may require reinforcement to ensure safe operation.



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### 3.3.3 Trona System Impact

For the scenario of turning the CESP into the primary particulate filter, the Trona injection needs to be moved. For the remaining scenarios, modification of the Trona injection point is considered as a potential future enhancement and is not included in this study's recommendations for implementation nor in cost. As a future enhancement, it may be possible to modify the Trona injection location by splitting the Trona flow to both the HESP and to the new PJFF (at the inlet to the CESP). The potential benefits would be a reduction of Trona consumption while maintaining the same SO<sub>2</sub> removal as currently achieved and a reduction of condensable particulate via use of the PJFF in place of the CESP. Trona is very effective at removing sulfur compounds and condensed acids due to interaction with the alkaline filter cake on the bags. The more the Trona injection split favors the PJFF, the more reagent that can be saved. If all Trona goes to the PJFF, the HESP ash catch may be re-used instead of disposed along with the Trona by-product. Although modification to the existing Trona injection system is outside the scope of this PM<sub>2.5</sub> project, it could be very beneficial at PRGS.

Solvay, provider of Trona for Mirant PRGS, was contacted and they recommended trials at potential injection locations to determine the SO<sub>2</sub> removal rate. Solvay also provided graphs that plotted the Normalized Stoichiometric Ratio (NSR) for typical reagents against SO<sub>2</sub> removal efficiencies. The table below shows NSR at 70% SO<sub>2</sub> removal efficiency:

Normalized Stoichiometric Ratio @ 70% SO <sub>2</sub> Removal		
	NSR for Baghouse	NSR for ESP
Trona	1.25 - 1.95	2.6 - 3.5
Bicarbonate	0.8 - 1.01	1.2 - 2

When injecting Trona downstream of the air heater, the residence time would be shortened. Solvay has stated that a PJFF will perform better at acid gas removal than an ESP even though the flue gas residence time is shorter. Trona and/or bicarbonate use would be less than the current injection rate; however, the injection conditions and other variables would need to be examined to determine the new Trona injection stoichiometry. Solvay has stated that when injected downstream of the air heater, good mixing between Trona and flue gas is the key; a mixing device would be helpful, but not always required. A Computational Fluid Dynamic (CFD) model would be needed to define the optimum configuration. Additionally, modifications to the current CESP ash collection system would likely be needed if Trona is injected at the PJFF inlet.



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### 3.3.4 Ash Handling Systems

There are 4 ash handling sub-systems, two associated with the bottom ash and CESP and two associated with the HESP. All four systems have both a vacuum and a pressure component. The four systems are as follows:

1. Bottom Ash System A for Units 1, 2, and 3
2. Bottom Ash System B for Units 4 and 5
3. Fly Ash System A for Units 1, 2, and 3
4. Fly Ash System B for Units 4 and 5

Bottom Ash systems handle the ash that falls to the bottom of the boiler, ash collected by the CESP, and ash that accumulates in the economizer hoppers. Fly Ash systems handle all ash collected by the HESPs. The design capacity of each bottom ash system is 15 TPH for the vacuum system and 25 TPH for the pressure system. The design capacity for the fly ash system is 43 TPH for the vacuum system and 75 TPH for the pressure system.

#### **Current Conditions:**

The HESP design conditions are 585,000 acfm, with inlet dust loading of 4.5 gr/acf = 11.25 TPH (from Jan 1977 data). The HESP hoppers are designed to provide 12 hours storage with fly ash bulk density of 35 PCF (from Jan 1977 data). The HESP guaranteed collection efficiency is 99.5% with one field out of service which produces an outlet dust loading of 0.022 gr/acf. This means that at design conditions, 0.056 TPH of flyash is going to the CESP (from Jan 1977 data).

The CESP hopper design condition is unknown, but assumed to have been based on fly ash only (no Trona) and for reduced fly ash inlet loading due to mechanical collectors which were originally upstream of each CESP. The CESP design collection efficiency is 95% on Units 1 and 2 and 97% on Units 3, 4 and 5.

Trona injection rates can reach as high as about 6,000 lb/hr, depending on unit load and coal sulfur content.

#### **Current Options:**

Assume that current ash collection system in the HESPs and CESPs are adequate for current conditions.

Upgrading the HESPs to improve their performance would make only a minimal change to HESP ash collection (only 0.5 % not currently collected).

Turning the CESPs into primary PJFFs would increase flyash loading to those structures substantially from both their original design and from current conditions. At issue is that it would be very costly to increase the size of the CESP hoppers due to space constraints in the boiler house basement. With the expected flyash and Trona loading, the hoppers would only be capable of approximately 3 hours



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storage volume (using the actual storage volume of approximately 115 CF per hopper and 45 PCF flyash/Trona density.) This is as opposed to the design value of 12 hours storage capacity and 35 PCF (per HESP design) or a value of 8 hours storage time and 45 PCF (standard design values).

Turning the HESP into a PJFF would have minimal impact on the HESP ash collection as only 0.5 % of the fly ash is not currently collected in the HESP. This is for exhausting one boiler unit into one converted HESP. Exhausting two units into one converted HESP would not maintain the hoppers' original design parameters of 12 hours storage and 35 PCF but would be close to standard design parameters of 8 hours storage and 45 PCF. Exhausting two units into one converted HESP would also require an increased collection pipe size up to the subsystem header. However, there is presently no practical way to route two boiler units into one converted HESP, due to ductwork and equipment layout interferences.

Turning any of the CESP's into polishing baghouses where the HESP remains in service, would make no changes to HESP and only very minor increase to the CESP ash collection systems (excluding any potential future enhancements being made to the current Trona injection system).



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## **4. CONCLUSIONS**

The WorleyParsons' PM<sub>2.5</sub> Emission Reduction Study, based on good engineering judgment, has technically evaluated the control options and recommended the most beneficial control strategies for reducing the PM<sub>2.5</sub> emissions at Mirant's PRGS.

### **4.1 TECHNOLOGY OPTIONS**

#### **4.1.1 ESP Upgrade**

**One Vendor** only proposed to upgrade the HESPs internals adding rigid discharge electrodes, wide (16") collecting plate spacing, and High Frequency Power Supply (HFPS). The CESPs were not addressed and no conversions to PJFF were proposed. This vendor also proposed three options to upgrade each of the HESPs:

- a) Upgrading the ESP internals with a rebuild;
- b) T/R control upgrade; and
- c) Upgrade HESP T/R sets to HFPS.

While upgrading the HESP may be the simplest technology option, ESP performance will, by its very nature, always vary somewhat depending on the flue gas conditions. It is this variation in particulate removal performance that suggests the conversion to a PJFF baghouse as a more stable particulate collector. Baghouses have much more consistent and typically lower particulate emissions, especially for fine particulate.

#### **4.1.2 ESP Conversions to PJFF**

Baghouses (PJFFs) are known to provide excellent results in minimizing particulate emissions, including PM<sub>10</sub> and PM<sub>2.5</sub> emissions – superior to that which can be consistently achieved by even the best ESPs. Variations of this theme accounted for most of the recommendations from the Vendors who responded to the RFP. The variations are as follows:

- Convert the CESPs into PJFF that will serve as the primary particulate collectors with the HESPs removed from service.
- Convert a HESP into a PJFF that will serve as the primary particulate collector for one or more boiler units.
- Convert the CESPs into PJFF that will serve as polishing particulate collectors with the HESP in service.

Each of these three technology options are further discussed in more detail below.



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It should also be noted that any future requirement for Mercury control will be enhanced by the use of a fabric filter for particulate control in place of the current ESPs.

#### **4.1.2.1. CESP Conversions into PJFFs as Primary Collectors**

This variation of converting the CESP's into PJFFs as the primary collector (removing the HESP from the gas path) was proposed by one Vendor who listed a number of advantages to this approach. However, this configuration could cause an issue with the current CESP fly ash handling system. The original CESP's hoppers and fly ash conveying piping were designed for only a small percentage of the fly ash produced by the boilers (with most of the fly ash in the original design captured by the mechanical collectors that originally preceded the CESP). Those mechanical collectors no longer exist and the total material flow has increased significantly since the original CESP design due to the introduction of Trona for SO<sub>2</sub> removal. Correspondingly, the still original CESP fly ash hoppers, which would be retained in the CESP to PJFF conversion, are very small and would not provide sufficient storage capacity when receiving the full Trona and fly ash loadings. To install the larger hoppers and the larger fly ash piping would require space that does not exist. The hoppers and fly ash piping are currently at the basement level so there is no space below them; and the CESP is located beneath the existing stacks, so that raising the entire PJFF is also not an option.

#### **4.1.2.2. HESP conversions to PJFFs**

None of the prospective Vendors chose to bid this option due to the complexity of the ductwork modifications required to convert the hot-side ductwork to cold-side to enable the use of a conventional PJFF. However, at the request of Mirant and the City of Alexandria, WorleyParsons has investigated the possibility of doing this conversion at the PRGS site.

- The HESP casings are approximately 2.5 times the size of the CESP casings and the conversion of one HESP to a PJFF could possibly handle up to three units. This conversion would also require redirecting the gas flow from the economizer back through the airheater prior to entering a converted PJFF. WorleyParsons has investigated the potential to convert a HESP into a PJFF, including the feasibility to reroute the ductwork. We have concluded the following based on this analysis.
  - The required duct routing is feasible for a single unit, but not feasible for multiple units in the extremely congested boilerhouse.
  - New ductwork that would be required for multiple units would put additional loads on the existing building structure which is not acceptable.

#### **4.1.2.3. CESP Conversions to PJFF as Polishing Collectors**

Four of the Vendors who responded to the RFP recommended some version of converting the existing CESP's to polishing baghouses. This solution is considered to have the best capability to minimize particulate matter and PM<sub>2.5</sub> emissions from the PRGS boilers. The different Vendors





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proposed different configurations that could produce air to cloth ratios in the range of 4 to 6 (lower being better) and felt that they could offer bag life guarantees up to 4 years. To have this technology work, it would be necessary to keep the HESPs in service – with or without upgrades to the HESPs.

The fly ash handling issues associated with a CESP conversion to PJFF as the primary particulate collector are eliminated by still having the majority of the fly ash captured in the HESPs where the hoppers and fly ash collection piping are designed to handle that load.

#### 4.2 PJFF FILTER BAG OPTIONS

A wide variety of fabric filter materials exist for Fabric Filter (FF) installations. Standard filters are typically made from woven fiberglass or synthetics. Specialty bags potentially provide additional emissions control and can withstand unique operating conditions such as high temperature or acidity. Some types of bags and/or fabric filter designs potentially provide enhanced PM<sub>2.5</sub> control and may be appropriately considered for application to the PRGS boilers. Fabric filter enhancements that may reduce PM<sub>2.5</sub> emissions include utilization of intrinsically coated (IC) fabric bags, microdenier fiber fabrics, and membrane bags. It should be noted that bags with smaller pore size have a higher pressure drop associated with them and can constrain flue gas flow. These are described further below.

*Intrinsically Coated Bags:* As the name indicates, IC bags use fabric made of coated fibers. The coating is typically Teflon® or a similar fluoropolymer material. Besides improving bag durability, the coating reduces the pore size between the fibers, which improves particulate removal efficiency, especially for smaller particles.

*Microdenier Fiber Fabric Bags:* Special laboratory tests have found enhanced PM<sub>2.5</sub> particle efficiency with a special composite PPS felt filter bag material. This material consists of a 0.9 denier PPS fiber needled onto the filtering surface of a larger denier (2.7 or 7.0) PPS base fabric. The microdenier fiber reduces the pore size between the fibers, which improves smaller particle removal efficiency.

*Membrane Bags:* Membrane bags have a fluoropolymer or similar coating applied to the surface rather than to the individual fibers. Membrane bags contain smaller pore sizes than IC bags and, consequently, provide theoretically higher control efficiency for very small particles. The coating also inhibits filter cake formation. This latter effect generally results in an overall reduction in pressure drop and increase in bag life relative to standard woven bag materials. Reduced filter cake accumulation can also reduce the control effectiveness of other systems, such as alkali injection FGD system, that rely on the filter cake for increased reagent-gas contact.



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A summary of the filter bag materials proposed by each of the vendors is shown below:

	Filter Bag Material	Life expectancy, Months
Vendor A (Trona Upgrade)	NA	-
Vendor B (Agglomerator)	NA	-
Vendor C (Primary PJFF)	18 OPSY PPS Felt	36
Vendor D (Polishing PJFF)	18 OPSY PPS Felt	36
Vendor E (Polishing PJFF)	18 OPSY PPS Felt	24
Vendor F (Polishing PJFF)	16 OPSY PPS Micro-denier Felt	48
Vendor G (HESP Upgrades)	NA	-

It is the opinion of WorleyParsons that any one of the PJFF filter bag materials being offered will achieve the required PM<sub>2.5</sub> reduction targets. The micro-denier felt has shown superior fine particle efficiency in laboratory tests and may be viable in this application, but may result in unacceptable resistance to gas flow. This filter bag material can be supplied by any of the PJFF vendors.

## 4.3 COST ESTIMATES

### 4.3.1 Total Installed Costs

The estimated total installed costs (±30%) of each technology are summarized below:

Technology	Total Cost (April 2010\$)
<b>ESP UPGRADE</b>	
Units 3, 4, & 5 HESP Full Upgrade Units 1 & 2 HESP controls upgrade	\$ 27.0 M
<b>ESP CONVERSION TO PJFF</b>	
Units 3, 4, & 5 CESP Conversion into PJFFs as Primary Particulate Collectors, eliminating the HESP and ductwork Units 1 & 2 HESP controls upgrade	\$ 38.6 M
Unit 4 HESP Conversion to PJFF as Primary Particulate Collector Units 1, 2, 3 & 5 HESP controls upgrade	\$ 27.3 M
Units 3,4,5 CESP Conversion to PJFFs as Polishing Baghouses Units 1 & 2 HESP controls upgrade	\$ 31.1 M

For all four of the above cases, the total cost figure includes approximately \$1.2 million for Unit 1 & 2 HESP controls upgrade. In the case of Unit 4 HESP conversion to PJFF, the total cost figure also includes an additional approximately \$1.2 million for Unit 3 & 5 HESP controls upgrade.



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In each case, due to costs, all five units could not receive the same technology. Therefore, emphasis was placed on putting the best technology on the base-loaded units 3, 4 and 5. Peaking units 1 and 2 were recommended to only receive control upgrades for their HESPs. The exception is for the HESP conversion to PJFF where only one unit could be converted and all the remaining units were recommended for only the controls upgrades for their HESPs.

#### **4.3.2 Operating Costs**

Operating cost estimates for each technology are not included. They are beyond the scope of this report.

#### **4.4 RECOMMENDATION**

Based on WorleyParsons review of all potential PM<sub>2.5</sub> Emissions Reduction technologies that were recommended from the Agreement, from brainstorming sessions, from canvassing our own in-house AQC specialists, from literature and internet searches and from RFP responses from leading AQC vendors and contractors, we have the following technology recommendations which are expected to be within the available project funding:

- For the base-loaded units (Units 3, 4, and 5), WorleyParsons recommends conversion of the CESP to PJFFs (polishing baghouses). Current existing ID fans will be able to accommodate the PJFF pressure drop with modifications to the existing system as listed in 3.3.1. It is believed that this conversion provides the best opportunity for PM<sub>2.5</sub> reductions from these units. Additionally, it should also be noted that each PJFF polishing baghouse could also serve as the basis of a mercury capture system in the future. Due to estimated costs being very close to project funding limits, it is recommended that the CESP conversion be bid for two (2) of the three base loaded units with an option to include the third unit. Any base-load unit that does not receive a PJFF would receive HESP upgrades similar to Units 1 & 2, described below, as funding allows.
- For the cycling units (Units 1 and 2), conversion of the CESP to PJFFs would remain the preferred technology; however, financial limitations appear to require a different solution. Therefore, for these cycling units, WorleyParsons recommends as a minimum the upgrading of the HESPs to the next generation of microprocessor controls. If sufficient funding is available, we would recommend other enhancements to the HESPs which could have a combination effect when added to the controls upgrade. While not as effective as the PJFF polishing baghouses, improved particulate performance can be achieved with the increases in applied power that the new power supplies can provide.



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## **5. ATTACHMENTS**

### **5.1 PM<sub>2.5</sub> EMISSIONS REDUCTION TECHNOLOGY SCREENING DOCUMENT**





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CONTROLS ALREADY SCREENED & REMOVED FROM CONSIDERATION:									
CONTROL		SCREENING PARAMETERS						COMMENTS	
		Final Selection Screening							
		Detailed Screening							
		Coarse Screening							
Description	Feasible	Estimated Level of Reduction in Dust Control (Low, High, Medium, Low)	Estimated Cost (\$/unit of Installation)	Schedule Constraints	Operation Issues	Maintenance Issues	Advantages	Disadvantages	Relative Importance Ranking (1 - Highest)
9. Polishing baghouse(s) serving combined stacks.	Yes	High/Low	> \$32 M	12 Mos - 36 Mos		New Electric Feed			
10. Install baghouse or other technologies in the current housings for the hot-side precipitators on units C1, C2, C3, C4 and C5, taking into account the cost of retrofitting such baghouses on these boilers and any impacts to the structural integrity of the boilers and the facility.	No	High/High	\$1M-\$32M (Over 200 bagging - \$6,000-\$14,000 each, four new bagging - \$12,430,000 total)	12 Mos - 36 Mos	Multiple Commitments Needed		Reduced gas flow along with high cloth area results in very low velocity and a-to-d cloth ratio	Requires hot to cold conversion. Feasible duct routing within building was not found without imposing excessive duct loads onto existing building supports and foundations.	
2. Improving the performance and reliability of existing hot- and/or cold-side precipitators. Supercharging; Resectionalization	Yes	Low/Low	\$1M-\$5M	0 - 12 Mos		New Electric Feed		Benefit not deemed to be significant	
4. Improving the performance and reliability of existing hot- and/or cold-side precipitators - Increased collection area and/or residence time.	Yes	Medium/Low	\$5M-\$32M (\$5,000,000 for wet extra field with insurance coverage)	12 Mos - 36 Mos				Tight arrangement of site and ESPs do not allow expansion. Benefit not deemed to be significant.	
11. Remove more SO <sub>2</sub> (to reduce potential condensables) - Enhance SO <sub>2</sub> removal by on-site milling of Trona.	Yes	Low/Med	\$1M-\$5M (\$5M - \$2M based on SO <sub>2</sub> footprint's on-site processing)	0 - 12 Mos		High Wear Item	Could reduce Trona usage (by half when milling).	Milling test at PRGS did not have a significant advantage	
10. ESP Performance upgrade Hot to Cold conversion on HESPs	Yes	Low/Zero	\$5M-\$32M (\$11,490,000)	12 Mos - 36 Mos			Reduced gas flow and HESP area results in high SCA.	Gas duct routing within building is not feasible without placing additional loads onto building steel and foundations.	
3. Improving the performance and reliability of existing hot- and/or cold-side precipitators - Gas Conditioning.	Yes	Low/Low	\$1M-\$5M (\$400,000 - \$1,518,000 total)	0 - 12 Mos					
5. Commercially available technologies - COHPAC™ (Compact Hybrid Particulate Collector)	Yes	High/Low	\$5M-\$32M (\$1,750,000 for COHPAC™, \$7,225,500 for COHPAC™ + 2)	12 Mos - 36 Mos			1) Higher filtration rates (8 ft/min with similar SS as the conventional PUFF) 2) Significant Capital cost savings over ESP enhancement or replacements 3) Ability to remove mercury removal with PAC system 4) Smaller physical stacks needed compared to a full size retrofitted baghouse (10 ft) 5) Reduced outage time	1) Filter PMS 2 7 other filter bag failure was reported in ESP Big Brown Station and Plant Gaston. Higher strength bag materials required. 7.0 denier Dupont and Tergon and Tergon 7 were used. Higher cost. 2) Bag to bag wear was reported in Plant Gaston. Replacement bags were installed between the bags to reduce the problem. 3) For mercury removal, fluid control system (pneumatic) was built. But the bag house cleaning frequency is 1.5 pulses per hour to maintain long term bag life.	
6. Commercially available technologies - Advanced Hybrid Filter™, ELEX Hybrid Filter	Yes	Med/Low	\$5M-\$32M	12 Mos - 36 Mos			1) Capable of using the old ESP casing and foundation.		
7. Commercially available technologies - Max Electrostatic Fabric Filter™ (ESFF)	Yes	High/Low	\$5M-\$32M	12 Mos - 36 Mos			1) 50-60% reduction in stack particulate matter fabric filter compared to conventional PUFF 2) Capabilities of mercury removal (50% - 85% without PAC) and compatible with SO <sub>2</sub> and mercury control systems 3) Low lifetime operation no noise 4) Smaller footprint when operating at higher air to cloth ratio than the conventional PUFF 5) Ability to remove > 90% of the PM <sub>2.5</sub>	Vendor not responsive.	





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## 5.2 PM<sub>2.5</sub> EMISSIONS REDUCTION EPC COST ESTIMATES

### ESTIMATE BASIS

#### Estimate:

The estimate is a conceptual type with an accuracy of +/- 30 percent.

#### Mechanical:

- Budgetary vendor quote provided costs for converting Unit 3, 4, and 5 CESP to a PJFF and for the full upgrades to the HESPs – including material and labor costs.
- Upgrading of a HESP to a PJFF was estimated by WorleyParsons.
- An allowance was used for the controller upgrades to HESPs.
- Other costs were included with vendor data, were estimated by WorleyParsons or are allowances.

#### BOP Costs:

- Compressor foundations are based on preliminary sizes and quantities.
- Piping and duct modification costs are based on preliminary engineering quantity information.
- Asbestos abatement is based on preliminary calculated quantities using average rates for the metropolitan DC area.
- Insulation costs are based on preliminary engineering quantity information.
- Other costs were included as allowances.

#### Other Costs:

Other Costs include Engineering and Procurement Services, Construction and Start-up Oversight, and are based on preliminary information.

#### Contingency:

Contingency is developed using the following categories:

- Contingency (Quoted Items) @ 10.0 percent
- Contingency (Services) @ 10.0 percent
- Contingency (Construction) @ 20.0 percent



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ITEM NO.	DESCRIPTION	QUANTITY	UNIT	TOTAL MAN-HOURS	MATERIAL COST	LABOR COST	TOTAL COST
<b>#1 ESP UPGRADE (Units 3, 4, &amp; 5 HESP Full Upgrade - Units 1 &amp; 2 HESP Controls Upgrade)</b>							
<b>Mechanical</b>							
1	A. Replacing the existing weighted wire type discharge electrodes with ELEXRS Rigid Discharge Electrodes. B. Add Switch Mode Power Supply, a high frequency power supply. C. Modifying existing precipitator design with wide (16") collecting plate spacing.	1	ls		99,916	7,761,600	10,859,000
2	Key Interlock system	Incl. w/ above					
3	Physical flow model study	Incl. w/ above					
4	General HESP upgrade to next generation of microprocessor controls (Units 1 & 2)	1	ls		500,000	500,000	1,000,000
	<b>Subtotal - Mechanical</b>				99,916	8,261,600	11,159,000
<b>Structural / Civil</b>							
1	Collecting electrode support system and all mounting and alignment hardware	Incl. w/ Mech 1					
2	New high voltage discharge electrode system support, mounting, alignment, and stabilization hardware, including new coffin boxes to accommodate larger footprint insulators	Incl. w/ Mech 1					
3	New support Insulators - two / discharge electrode frame per ESP	Incl. w/ Mech 1					
4	New solenoid gravity impact rappers and mounting hardware for the existing inlet perforated plates	Incl. w/ Mech 1					
5	New internal anti-sneak baffles	Incl. w/ Mech 1					
	<b>Subtotal - Structural / Civil</b>						
<b>Electrical and I &amp; C</b>							
1	Fourteen (14) new NWL Switch Mode Power Supplies (SMPS) (per ESP) arranged as shown on the proposal drawings, with local display panel.	Incl. w/ Mech 1					
2	Dual-outlet High Voltage SMPS ground switches, in enclosures with windows.	Incl. w/ Mech 1					
3	High voltage DC bus conductor, carbon steel bust duct, and through bushing insulator systems.	Incl. w/ Mech 1					
4	New GRC Rapper controls	Incl. w/ Mech 1					
5	New PCAMS system with NT Interface	Incl. w/ Mech 1					
6	New collecting system solenoid gravity impact rappers, mounting hardware including guide tubes, and quick disconnects for wiring.	Incl. w/ Mech 1					
7	New discharge electrode system solenoid gravity impact rappers, mounting hardware including guide tubes, and quick disconnects for wiring.	Incl. w/ Mech 1					
	<b>Subtotal - Electrical and I &amp; C</b>						
<b>BOP Costs</b>							
1	Electrical Distribution Changes to Units 1 & 2 HESP (ALLOWANCE)	1	LS	1,400	150,000	149,400	299,400
2	New 480 v, 3 phase power --- Not Req'd	0					
3	New transformers --- Not Req'd	0					
4	Low voltage wiring - Power cables, conduit, raceways-units 3-4-5 (ALLOWANCE)	1	LS	1,848	128,760	197,100	325,800
5	Start-up or commissioning (3 units - 21 days ea) (2 units - 7 days ea)	1	ls	1,078		136,900	135,900
	<b>Subtotal - BOP Costs</b>			4,326	278,760	483,400	762,100
	<b>Sub Total Construction</b>			104,242	8,540,300	11,642,400	20,182,700
	<b>GC Premium @ 4%</b>						807,300
	<b>Total Construction</b>						20,990,000
<b>Other Costs</b>							
	Engineering & Procurement (Incl Trips)	1	ls				2,100,000
	Construction & Start-up Oversight	1	ls				300,000
	Owners Costs						excluded
	<b>Subtotal Other Costs</b>						2,400,000
	<b>Total (less Contingencies)</b>						23,504,300
	Contingency (Quoted Items)	10%					826,200
	Contingency (Services)	10%					240,000
	Contingency (Construction)	20%					2,384,000
	<b>Total Present day costs (April 2010 Dollars)</b>						26,955,000

**MIRANT POTOMAC RIVER, LLC – POTOMAC RIVER GENERATING STATION  
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CLIENT: MIRANT POTOMAC RIVER LLC		ESTIMATED: RN	DATE: 8-Apr-10	SUMMARY			
PROJECT: POTOMAC RIVER GENERATING STATION		CHECKED:	DATE:	x	C/S/A		
DESCRIPTION: PM 2.5 Emissions Reduction Study		APPROVED:	DATE:	x	MECHANICAL		
		REVISED:	DATE:	x	PIPING		
				x	ELECTRICAL		
				x	I/C		
CONCEPTUAL ESTIMATE - accuracy +/- 30 %							
ITEM NO.	DESCRIPTION	QUANTITY	UNIT	TOTAL MAN-HOURS	MATERIAL COST	LABOR COST	TOTAL COST
<b>#2 ESP CONVERSION TO PJFF (Units 3, 4, and 5 CESP Conversion as Primary PM Collector - Units 1 &amp; 2 HESP Controls Upgrade)</b>							
<b>Mechanical</b>							
1	General HESP upgrade to next generation of microprocessor controls (Units 1 & 2)	1	ls	-	500,000	500,000	1,000,000
2	Convert existing CESP to PJFF (Units 3, 4 & 5) (incl. demolition of internals)	1	ls	84,364	8,700,000	9,000,000	17,700,000
3	Air Compressors, incl. w/ above costs	1	ls	-	-	-	-
4	Dampers, incl. w/ above costs	1	ls	-	-	-	-
5	Flow model study from economizer outlet to stack breaching	1	ls	-	50,000	-	50,000
6	Trona Injection System modification base on flow model test results.	1	ls	-	150,000	-	150,000
7	CFD for trona system revised flow modeling	1	ls	-	50,000	-	50,000
8	Compressed Air System for PJFF, included w/2 (install only)	1	ls	280	-	29,900	29,900
	Subtotal - Mechanical			84,644	9,450,000	9,529,900	18,979,900
<b>Structural / Civil</b>							
1	Remove/modify ductworks between economizer to air heater -- Incl w/ Mech 2 Above	1	ls	-	-	-	-
2	New ductwork from air heater to inlet nozzle of cold side ESP -- Incl w/ Mech 2 Above	1	ls	-	-	-	-
3	New inlet/outlet plenums for PJFF -- Incl w/ Mech 2 Above	1	ls	-	-	-	-
	Subtotal - Structural / Civil			-	-	-	-
<b>Electrical and I &amp; C</b>							
1	Electrical Switch Gear -- Incl w/ Mech 1 & 2 Above	1	ls	-	-	-	-
2	Instruments -- Incl w/ Mech 1 & 2 Above	1	ls	-	-	-	-
	Subtotal - Electrical and I & C			-	-	-	-
<b>BOP Costs</b>							
1	Ash handling system modification - units 1 & 2, (Not Req'd)	0	ls	-	-	-	-
2	Ash handling system modification - units 3 - 5	1	ls	19,048	2,000,000	2,032,000	4,032,000
3	Hopper modification ( Not Feasible )	0	ls	-	-	-	-
4	Steel modification ( Not Feasible )	0	ls	-	-	-	-
5	Re-assign electrical power from HESP to PJFF	0	ls	-	-	-	-
6	Re-assign air piping material and installation, 402 L.F., 4" CS, Sch 40,	402	lf	424	23,900	45,300	69,200
7	New foundations - for air compressors	3	ea	68	2,400	7,200	9,600
8	New distribution switch gear	1	ls	3,500	382,500	373,400	755,900
9	Repair duct walls to pre-HESP conditions	1	LS	3,809	350,000	406,400	756,400
10	Start-up or commissioning (3 units - 21 days ea) (2 units - 7 days ea)	1	ls	1,078	-	136,900	136,900
11	Asbestos abatement - est. erree by WP Engrg. - Sub Contr. (incl. any lead paint)	7428	SF	-	557,100	-	557,100
12	New duct insulation	2921	SF	1,983	18,200	211,600	229,800
13	Insulation - replace abated areas	7428	SF	7,565	69,500	807,100	876,600
14	Dampers (ALLOWANCE)	6	LS	1,260	300,000	134,400	434,400
15	Electrical modifications for Fly Ash [1] Not Req'd)	1	LS	-	-	-	-
16	Electrical Distribution Changes to Units 1 & 2 HESP (ALLOWANCE)	1	LS	1,400	150,000	149,400	299,400
17	Electrical Distribution Changes to Units 3, 4 & 5 (ALLOWANCE)	1	LS	2,100	225,000	224,000	449,000
18	Pre-cooling of filter bags during start-up (ALLOWANCE)	1	LS	-	75,000	-	75,000
19	In-duct silencer modifications (1 per fan - 6 total)	6	ea	8,288	103,200	1,160,040	1,263,300
20	Turning vanes at base of stack	1	LS	2,928	52,000	409,920	462,000
	Subtotal - BOP Costs			53,450	4,308,800	6,097,660	10,406,600
	Sub Total Construction			138,094	13,758,800	15,627,560	29,386,500
	GC Premium @ 4%						1,175,500
	Total Construction						30,562,000
<b>Other Costs</b>							
	Engineering & Procurement (incl Trips)	1	ls				2,500,000
	Construction & Start-up Oversight	1	ls				300,000
	Owners Costs						excluded
	Subtotal Other Costs						2,800,000
	Total (less Contingencies)						33,362,000
	Contingency (Quoted Items)	10%					945,000
	Contingency (Services)	10%					280,000
	Contingency (Construction)	20%					3,987,000
	Total Present day costs (April 2010 Dollars)						38,574,000



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## MIRANT POTOMAC RIVER, LLC – POTOMAC RIVER GENERATING STATION PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY

CLIENT: MIRANT POTOMAC RIVER LLC		ESTIMATED	RN	DATE	8-Apr-10	SUMMARY	
PROJECT: POTOMAC RIVER GENERATING STATION		CHECKED		DATE		C/SIA	
DESCRIPTION: Particulate Emissions Reduction Study		APPROVED		DATE		MECHANICAL	
		REVISED		DATE		PIPING	
						ELECTRICAL	
						I/C	
CONCEPTUAL ESTIMATE - accuracy +/- 30 %							
ITEM NO.	DESCRIPTION	QUANTITY	UNIT	TOTAL MAN-HOURS	MATERIAL COST	LABOR COST	TOTAL COST
<b>#3 ESP CONVERSION TO PJFF (Unit 4 Conversion as Primary PM Collector - Units 1, 2, 3 &amp; 5 HESP Controls Upgrade)</b>							
1	Mechanical Convert (1) HESP to Baghouse (includes engineering and material) - Remove the ESP roof and internals. [Note WP labor - ALLOWANCE]	1	ls	70,304	4,500,000	7,500,000	12,000,000
2	Convert (1) HESP to Baghouse (includes engineering and material) - Sectionalize the ESP into 4 chambers with inlet and outlet gas dampers.	1	ls	-	-	-	-
3	Convert (1) HESP to Baghouse (includes engineering and material) - Reuse existing ESP hoppers and support structure.	1	ls	-	-	-	-
4	Convert (1) HESP to Baghouse (includes engineering and material) - Install a tube sheet for supporting the filter bags and cages.	1	ls	-	-	-	-
5	Convert (1) HESP to Baghouse (includes engineering and material) - Extend existing casing walls to accommodate a clean air plenum and a roof hatch.	1	ls	-	-	-	-
6	Convert (1) HESP to Baghouse (includes engineering and material) - Add roof weather enclosure with monorail.	1	ls	-	-	-	-
7	Convert (1) HESP to Baghouse (includes engineering and material) - Modify the ESP inlet and outlet plenum for gas entry below the bags.	1	ls	-	-	-	-
8	Compressed air systems for 1 Baghouse units (scfm at 70 to 100 psig per Baghouse unit). Total of 2 compressors/dryers/receivers (1 operating + 1 spare).	1	ls	1,072	526,000	114,400	641,000
9	General HESP upgrade to next generation of microprocessor controls (Units 1, 2, 3 & 5)	1	ls	-	1,000,000	1,000,000	2,000,000
Subtotal - Mechanical				71,376	6,026,000	8,614,400	14,641,000
<b>Structural / Civil</b>							
1	New Duct work, duct reinforcing steel, & support steel	1	ls	13,755	431,400	1,467,400	1,898,600
2	Demolition of existing non-usable ductwork.	1	ls	5,670	-	604,900	604,900
3	Demolition of concrete (Elev 83'-0")	12	cy	302	-	32,300	32,300
4	Demolition of existing Cold ESP (Allowance)	1	ls	5,600	20,000	597,400	617,400
5	Install new expansion joints (8 various sizes)	1	ls	591	111,900	63,000	174,900
6	New duct insulation	1	ls	-	609,000	-	609,000
Subtotal - Structural / Civil				25,918	1,172,300	2,765,000	3,937,300
<b>Electrical and I &amp; C</b>							
1	PLC, instrumentation and controls. Incl w/ Mech 1.	1	ls	-	-	-	-
2	Hoppers electric heaters for 1/3 of height. Incl w/ Mech 1.	1	ls	-	-	-	-
3	Hopper ash level indicators. Incl w/ Mech 1.	1	ls	-	-	-	-
Subtotal - Electrical and I & C				-	-	-	-
<b>BOP Costs</b>							
1	Electrical Distribution Charges to Units 1, 2, 3 & 5 HESP (ALLOWANCE)	1	LS	2,800	300,000	298,700	598,700
2	Electrical updates - for compressors, including MCCs, conduit, wiring, and terminations	1	ls	536	25,000	57,200	82,200
3	Compressed air piping material and installation, 268 LF, 4" CS, Sch 40, per WP engg.	268	lf	568	31,800	60,400	92,200
4	New foundations - for air compressors	2	ea	90	3,300	9,600	12,900
5	Transient analysis for Unit 4 (ALLOWANCE)	1	LS	-	150,000	-	150,000
6	Transient mitigation for Unit 4 (ALLOWANCE)	1	LS	-	80,000	-	80,000
7	Upgrade IO lens (N/A)	1	LS	-	-	-	-
8	All heat insulation, girts and lagging - PJFF	1903	sf	1,292	11,900	137,600	149,700
9	Access facilities to PJFF roof (10' stairs) (ALLOWANCE)	1	LS	385	50,000	41,100	91,100
10	Pre-coating of filter bags during start-up (ALLOWANCE)	1	LS	-	25,000	-	25,000
11	Asbestos abatement - est. area by WP Engrg. - Sub Contr. (incl. any lead paint)	6190	SF	-	464,300	-	464,300
12	Dampers (NONE)	0	LS	-	-	-	-
13	Start-up or commissioning (1 unit - 21 days ea) (4 units - 7 days ea)	1	ls	666	-	87,100	87,100
Subtotal - BOP Costs				6,355	1,141,300	691,900	1,835,200
Sub Total Construction				103,650	8,340,200	12,071,300	20,411,500
GC Premium @ 4%				-	-	-	816,000
Total Construction				-	-	-	21,227,500
<b>Other Costs</b>							
Engineering & Procurement (incl Trips)				1	ls	-	2,100,000
Construction & Start-up Oversight				1	ls	-	300,000
Owners Costs				-	-	-	excluded
Subtotal Other Costs				-	-	-	2,400,000
Total (less Contingencies)				-	-	-	23,636,000
Contingency (Quoted Items)				10%	-	-	603,000
Contingency (Services)				10%	-	-	240,000
Contingency (Construction)				20%	-	-	2,643,000
Total Present day costs (April 2010 Dollars)				-	-	-	27,322,000

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# WorleyParsons

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## MIRANT POTOMAC RIVER, LLC – POTOMAC RIVER GENERATING STATION PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY

CLIENT: MIRANT POTOMAC RIVER LLC		ESTIMATED: RN	DATE: 8-Apr-10	SUMMARY			
PROJECT: POTOMAC RIVER GENERATING STATION		CHECKED:	DATE:	x C/S/A			
DESCRIPTION: Particulate Emissions Reduction Study		APPROVED:	DATE:	x MECHANICAL			
		REVISED:	DATE:	x PIPING			
				x ELECTRICAL			
				x I/C			
CONCEPTUAL ESTIMATE - accuracy +/- 30 %							
ITEM NO.	DESCRIPTION	QUANTITY	UNIT	TOTAL MAN-HOURS	MATERIAL COST	LABOR COST	TOTAL COST
<b>#4 ESP CONVERSION TO PJFF (Units 3, 4 &amp; 5 Conversion as Primary PM Collector - Units 1 &amp; 2 HESP Controls Upgrade)</b>							
<b>Mechanical</b>							
1	Convert existing CESP to PJFF (Units 3, 4 & 5) (incl. demolition of internals)	1	ls	84,364	8,700,000	9,000,000	17,700,000
2	General HESP upgrade to next generation of microprocessor controls Units 1 & 2	1	ls	-	500,000	500,000	1,000,000
3	Compressed Air System for PJFF, included w/1 (install only)	1	ls	280	-	29,900	29,900
4	Piping material and installation, see BOP costs.	-	-	-	-	-	-
5	Demolition of existing CESP Internals (Units 3 - 5) -- incl above.	-	-	-	-	-	-
Subtotal - Mechanical				84,644	9,200,000	9,529,900	18,729,900
<b>Structural / Civil</b>							
1	Outlet Duct Modification - new PJFF to outlet plenum to D Fan -- with Mechanical costs above.	-	-	-	-	-	-
Subtotal - Structural / Civil				-	-	-	-
<b>Electrical and I &amp; C</b>							
1	Low Voltage Wiring -- swgr. + wiring for air compr., and other misc. -- see BOP costs.	-	ls	-	-	-	-
Subtotal - Electrical and I & C				-	-	-	-
<b>BOP Costs</b>							
1	Electrical Distribution Changes to Units 1 & 2 HESP (ALLOWANCE)	1	LS	1,400	150,000	149,400	299,400
2	Electrical Distribution Changes to Units 3, 4 & 5 CESP -- (ALLOWANCE)	1	LS	2,100	225,000	224,000	449,000
3	ID fan update for Units 3, 4 & 5 CESP (NOT APPLICABLE)	0	LS	-	-	-	-
4	Electrical upgrades for ID Fan (NOT APPLICABLE)	0	LS	-	-	-	-
5	New foundations - for air compressors	3	EA	68	2,400	7,200	9,600
6	Piping material and installation, 402 LF, 4" CS, Sch 40, per WP engng.	402	LF	424	23,900	45,300	69,200
7	Fly Ash system modifications (NOT APPLICABLE)	0	LS	-	-	-	-
8	Low voltage wiring - Power cables, conduit, raceways (ALLOWANCE)	1	LS	2,940	150,000	313,600	463,600
9	Asbestos abatement - est. pres by WP Engrg. - Sub Contr. (incl. any lead paint)	7428	SF	-	557,100	-	557,100
10	New duct insulation	2284	SF	1,551	14,200	165,400	179,600
11	Insulation - replace abated areas	7428	SF	7,565	69,500	807,100	876,600
12	Pre-coating of filter bags (units 3-4-5) during start-up (ALLOWANCE)	1	LS	-	75,000	-	75,000
13	Start-up or commissioning (3 units - 21 days ea) (2 units - 7 days ea)	1	ls	1,078	-	136,900	136,900
14	In-duct silencers	6	ea	8,286	103,200	1,160,100	1,263,300
15	Turning vanes at base of Unit 4 stack	1	LS	2,928	52,000	410,000	462,000
Subtotal - BOP Costs				26,340	1,422,300	3,419,000	4,841,300
Sub Total Construction				112,984	10,622,300	12,948,900	23,571,200
GC Premium @ 4%							943,000
Total Construction							24,514,200
<b>Other Costs</b>							
Engineering & Procurement (incl Trips)		1	ls				2,200,000
Construction & Start-up Oversight		1	ls				300,000
Owners Costs							excluded
Subtotal Other Costs							2,500,000
Total (less Contingencies)							27,014,200
Contingency (Quoted Items)		10%					920,000
Contingency (Services)		10%					250,000
Contingency (Construction)		20%					2,874,000
Total Present day costs (April 2010 Dollars)							31,060,000

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**MIRANT POTOMAC RIVER, LLC – POTOMAC RIVER GENERATING STATION  
PHASE II – PM<sub>2.5</sub> EMISSIONS REDUCTION STUDY**

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**6. REFERENCES**

"EPA Air Pollution Control Cost Manual", EPA/452/B-02-001, Sixth Edition, United States Environmental Protection Agency, January 2002.

"Guidelines for Upgrading Electrostatic Precipitator Performance, Volume 2: Electrostatic Precipitator Upgrade Options - Final Report", TR-113582-V2, EPRI, December 1999.

"Status of Integrated Emission Control Process Development, Airborne and ReACT Process Technical Review", Topical Report 1010338, EPRI, November 2005

"Advanced Electrostatic Precipitator (ESP) Power Supplies Update, The State-of-the-Art of High-Frequency Power Supplies", Interim Report 1010361, EPRI, March 2006

<http://www.epa.gov/>

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## *City of Alexandria, Virginia*

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### MEMORANDUM

**DATE:** MAY 28, 2010

**TO:** HONORABLE MAYOR AND MEMBERS OF CITY COUNCIL

**FROM:** WILLIAM J. SKRABAK, DIRECTOR, OFFICE OF ENVIRONMENTAL QUALITY, T&ES

**SUBJECT:** UPDATE ON THE JULY 2008 CITY/ MIRANT SETTLEMENT AGREEMENT AND RECOMMENDATIONS FROM THE MIRANT COMMUNITY MONITORING GROUP (MCMG)

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The purpose of this memorandum is to update the City Council on the current status of the July 2008 City/Mirant Settlement Agreement and inform Council of the recommendations made by the MCMG at its last meeting on May 13, 2010. The meeting was co-chaired by Councilwoman Del Pepper and Councilmember Paul Smedberg. The objectives of this meeting were to:

1. Review the Engineer WorleyParsons's draft Phase II report regarding controls on fine particulate (PM2.5) from the stacks;
2. Review progress of the Phase I projects that were previously approved by City Council; and
3. Update the group members and attendees on recent regulatory developments and the recent Mirant/ RRI Energy merger.

#### **Draft Phase II Report by the Engineer WorleyParsons**

WoorleyParson (Project Engineer) presented the draft Phase II report to the MCMG. The City, Mirant and Virginia DEQ officially now have 45 days (starting April 30, 2010) to comment on this draft before the Engineer finalizes it within the following 60 days.

- The report recommends installation of polishing baghouses on boilers # 3, 4, and 5. This will be achieved by retrofitting existing cold side electrostatic precipitators with new baghouses. The report also recommends upgrades to the existing hot electrostatic precipitators for boilers # 1 and 2. **The Engineer's budgetary estimate for the Phase II project is \$31.1 million and this includes \$4.1 million in contingencies. Since the budget cap for the Phase II project is \$32 million, and due to uncertainties inherently associated with retrofit projects, it is not certain at the present time if the baghouse conversion could be done on two or three**

**boilers until the firm bids are received, and contracts signed with appropriate terms and conditions.**

City staff had previously argued in front of the State Air Pollution Control Board for the use of baghouses for PM2.5 emissions control at this facility. Since this project involves retrofitting an existing facility, there were significant technical challenges that needed to be overcome to insure that baghouses option was feasible. MCMG members expressed concerns regarding the length of time on the Phase II project. Again, the additional time was needed to address numerous technical challenges of retrofitting a baghouse into the existing shell of the cold precipitator without compromising the plant's structural integrity and safety as well as not exceeding the budget cap of \$32 million.

### **Progress on the Phase I Projects**

As you may recall, Council authorized moving forward with the five projects targeting fugitive dust under Phase I in November 2009 which included a dust suppression system, a street sweeper, an ash loader, drip pans, and wind screens. The dust suppression system, and street sweeper has been ordered and delivery is expected this summer. The new ash loader has been installed and currently being operated (with temporary power supply).

With respect to the remaining two projects, the installation of the drip pans was put on hold because of requirement of a permit modification by VDEQ. With respect to the wind screens project, the projected cost has increased significantly by \$405,000 from the initial estimates and is now at \$1.02 million. This is primarily due to poor soil conditions at this site, resulting in a more extensive foundation for the poles at significant additional cost.

In total, the installation of these five projects approved by Council is presently estimated to cost \$2.07-2.19 million. The budget for the Phase I is \$2 million.

### **Discussion**

In light of the Engineer's budgetary estimate of \$31.1 M for Phase II being so close to the \$32 million available for this phase, and the increased costs of Phase I projects, staff recommended for consideration by the MCMG to defer the installation of the wind screens and the drip pans until the cost for the Phase II project has been determined more accurately through the bidding process. This enables maximum flexibility in allocating the resources to projects to meet the overall goal of reducing emissions. Of particular concern is that by committing up to \$1.42 M for the wind screens and drip pans projects now, the City could preclude the use of those funds for Phase II, if needed, to achieve a third baghouse (e.g., in the event the Phase II project including the three baghouses is \$33 million).

**Staff confirmed that, in the event that the cost of the preferred option (i.e., conversion of the cold electrostatic precipitator to polishing baghouse on boilers #3, 4, 5 and hot electrostatic precipitator controller upgrades on boilers #1,2) exceed the Phase II budget, staff will reconvene the MCMG.** Staff has previously discussed with Mirant on the flexibility of using Phase I budget on the Phase II project if it became necessary and Mirant would not have

a problem with this option if the City decides to exercise it. This was re-confirmed by Debra Raggio of Mirant at the MCMG meeting.

Staff also discussed the two recent Notice of Violations (NOVs) issued by Virginia Department of Environmental Quality to Mirant. One deals with an opacity violation happened on February 26, 2010 and the other is related to the alleged high readings of the particulate continuous emissions monitor (PM CEM).

Mirant representative discussed the recent merger between Mirant and RRI Energy and confirmed that the City/Mirant agreement remains unaffected by the merger. MCMG members also expressed concerns with respect to the interest accumulated in the Escrow Account. Staff indicated that it would have the City Attorney's Office review this in consultation with the Office of Management and Budget.

### **MCMG Recommendations**

After a thorough discussion, the MCMG voted and recommended the following actions for consideration by the City Council at its June 22 legislative session:

- City Council support the conclusion by the Engineer Worley Parsons that the baghouse is the preferred technology for stack fine particulate (PM<sub>2.5</sub>) emissions control, and that the City/Mirant proceed with steps to install it on as many boilers as possible within the Phase II project budget.
- Should the final report on the Phase II Project be significantly different than the current draft version under consideration by the MCMG and City Council (e.g., different control technologies for boilers # 3, 4, and 5), staff hold another meeting with MCMG to decide on a new course of action.
- Based on the Engineer's budgetary cost estimate for the Phase II project of \$32 million and the revised and more accurate installed cost for the wind screens of \$1.02 million, the installation of the wind screens and the drip pans (two Phase I projects previously approved by City Council) be deferred until the cost for the phase II project will have been determined accurately.

Cc: MCMG Members  
James K. Hartmann, City Manager  
Michele Evans, Deputy City Manager  
Mark Jinks, Deputy City Manager  
Richard J. Baier, P.E., Director, T&ES  
Christopher Spera, Deputy City Attorney  
Lalit Sharma, P.E., Division Chief, OEQ, T&ES  
Khoa Tran, Sr. Air Pollution Control Specialist, OEQ, T&ES



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6-22-10

# **City/Mirant Settlement Agreement - Council's Receipt and Consideration of Phase II Project Report**

**Council Legislative Session**

**June 22, 2010**



**City of Alexandria**

# AGREEMENT SUMMARY

- Mirant to spend \$34 M on Pollution Controls
  - Capital improvements including engineering study
  - Includes particulate controls for fugitive emissions (Phase I - \$2 million) and stack (Phase II - \$32 million)
- Mirant received a two-stack permit from VA
  - Operate up to 5 boilers
  - Receive dispersion credit and proceed with the \$35 M stack-merge project
  - Stringent Limits
  - Install PM and CO CEMS in 12 months



# Progress

- Stack merge project completed
- Escrow account of \$34 M established
- PM & CO CEMS installed
- PM<sub>2.5</sub> ambient monitor installed on roof of Riverton Condominium in August 2009
- WorleyParsons selected as the Project Engineer
- EPSCO International hired as City Engineer



# Progress on Phase I

- Phase I engineering study completed in April 2009 with five fugitive control options recommended and approved by Council in November 2009
  - Ash loading dust suppression system – ordered, delivery expected this summer
  - Street sweeper – ordered, delivery this summer
  - Mirant New ash loader installation – installed and operational with temporary power source
  - Drip pans – required a permit modification which will be applied for at the same time as Phase II project
  - Wind screens – revised cost is \$1.02 million



## Progress on Phase II

- Phase II is focused on stack PM<sub>2.5</sub> emissions control technology
- Phase II engineering study completed April 2010
  - Screened 25 technologies
  - Obtained budgetary proposals from six vendors and prepared budget estimates for four most promising options



# Progress on Phase II

- Phase II engineering study completed in April 2010 (continued)
  - Carried out testing of existing ID fans to determine if they are capable of accommodating future baghouse
  - Conducted “Transient Analysis” to evaluate potential implosion of the boiler system with future baghouse
  - Performed Computational Fluid Dynamic modeling to evaluate opportunities for reducing pressure loss in existing boiler exhaust duct
  - Verified plant existing electrical system to ensure adequate capacity for future baghouse installation



# Progress on Phase II

- Phase II engineering study completed in April 2010 (continued)
  - Recommended option - Retrofitting cold electric precipitators (ESP) with polishing baghouses for units #3,4,5 and upgrade of hot ESP for units #1,2
  - Budgetary cost for this option is estimated at \$31.1 million, including \$4.1 million in contingencies
  - Actual number of baghouse conversions can only be known after the contract is signed



## Progress on Phase II

- MCMG, in its May 13 meeting, reviewed the draft Phase II report and recommended that Council:
  - Support the conclusions and recommendations in the draft Phase II report which
    - Selects baghouse as the preferred technology
    - Recommends that baghouse conversion of the cold ESP be implemented on boilers #3, 4 and 5 and hot ESP control upgrade be carried out on boilers #1 and 2
  - Ask staff to reconvene the MCMG to decide on new course of action if the final report is significantly different than the present draft report
  - Defer the installation of the wind screens and drip pans (Phase I projects) until the Phase II cost will have been determined accurately





# Next Steps

## ● In the near term

- City, Mirant, and VDEQ had 45 days to review this draft Phase II report (deadline June 17, 2010)
  - Comments received were sent to Council and Mayor
- The Engineer then has 60 days to revise and prepare the final report (deadline around August 6, 2010)
- Board/ VDEQ to approve the preferred technology
  - Subsequently, VDEQ must issue a permit prior to construction
- The Engineer prepares bid package



# Next Steps

- Upon project completion
  - Stack test using EPA methods
    - Include filterable and condensible  $PM_{2.5}$
  - Final limits lower of stack test or NAAQS compliant modeling
  - Final limits included in a revised permit
  - Mirant required to maintain and operate controls continuously



## Conclusions and Recommendations

- Staff agrees with the conclusions and recommendations of the Engineer's draft Phase II report
- Staff also concurs with the recommendations by the MCMG on May 13, 2010
- Staff recommends that Council endorse MCMG recommendations

