AP-42 Section Number: 1.3

Reference Number: 65

Title: Field Chemical Emissions Monitoring Project, Site 112 Emissions Report, Preliminary Draft

EPRI Report

February 1994

Oil #2

EPRI

EPR1E-10106/R016C374.T

CARNOT

65

FIELD CHEMICAL EMISSIONS MONITORING PROJECT SITE 112 EMISSIONS REPORT

PRELIMINARY DRAFT

Prepared For:

ELECTRIC POWER RESEARCH INSTITUTE
Palo Alto, California

Prepared By:

CARNOT
Tustin, California

FEBRUARY 24, 1994

EPRI
Electric Power
Research Institute *Leadership in Science and Technology*

December 22, 1993

Mr. William H. Maxwell, P.E. (MD13)
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Dear Mr. Maxwell:

In response to the Clean Air Act Amendments of 1990, the Electric Power Research Institute (EPRI) initiated the PISCES (Power Plant Integrated Systems: Chemical Emissions Studies) program to better characterize the source, distribution, and fate of trace elements from utility fossil-fuel-fired power plants. As part of the PISCES program, the Field Chemical Emissions Monitoring (FCEM) program has sampled extensively at a number of utility sites, encompassing a range of fuels, boiler configurations, and particulate, SO_2, and NO_x control technologies. EPRI is actively pursuing additional FCEM sampling programs, with 29 sites either completed or planned.

This site report presents a preliminary summary of data gathered during a sampling program conducted at one of the FCEM sampling programs - Site 112. Site 112 consists of a residual oil-fired boiler with an electrostatic precipitator (ESP). Site 112 re-injects the collected ESP ash into the furnace to improve carbon burn-out.

The Site 112 sampling and analytical plan included some differences from the standard sampling and analytical plans at other FCEM sites. Specifically, the California Air Regulatory Board (CARB) methods were used to sample for the volatile organic compounds (VOCs) and the polycyclic aromatic hydrocarbons (PAHs). In the multi-metals trains, the filter and associated rinses were combined with the impinger fractions in order to obtain lower detection limits - thus only total metal concentrations are available, instead of differentiating between particulate and vapor phase concentrations.

The Site 112 sampling and analytical plan also included a mercury comparison study. In general, Hg levels in fuel oil tend to be one to two orders of magnitude less than coal. The expected Hg concentration in flue gas is near or below the detection limit using the conventional multi-metals train, thus Hg can be difficult to accurately quantify - especially at oil-fired power plants. Along with the multi-metals train, two developmental techniques were also evaluated - the Nick Bloom/Frontier Geoscience's solid sorbent Hg speciation

train and an activated carbon trap with analysis using INAA by Dr. Ilhan Olmez of the Massachusetts Institue of Technology. Both of these alternative methods are able to achieve lower detection limits, and therefore have the potential to better quantify Hg emissions at oil-fired plants. The results of the Hg evaluation study were inconclusive. All three methods obtained results that appeared to be suspect. EPRI recommends that EPA consider the experimental nature of these alternative techniques when using the Hg results.

Similar to the Group 1 FCEM sites, some sampling or analytical difficulties may have occurred with the VOCs. While the QA/QC data appeared to be acceptable, the measured VOCs at the ESP outlet were higher than at the ESP inlet. EPRI is continuing to review the Site 112 data. As additional data from other sites are collected and evaluated, EPRI may conduct verification tests at this site. If this is done, the new data will be made available to the Environmental Protection Agency (EPA).

The primary objective of this report is to transmit the preliminary results from Site 112 to the EPA for use in evaluating select trace chemical emissions from fossil-fuel-fired steam generating plants. **It should be noted that the results presented in this report are considered PRELIMINARY.** In addition to the raw data in the Appendix, the report provides an assessment of the trace metals material balances, discusses the data quality, identifies suspect data, and offers possible explanations for the questionable data. This report does not compare the results from Site 112 with the results from previous utility sites. Generic conclusions and recommendations were not drawn concerning the effectiveness of the electrostatic precipitator as a potential control technology for particulate phase trace metals; however, removal efficiencies were calculated where possible. Nor does this site report attempt to address the environmental and health risk impacts associated with the trace chemical emissions.

EPRI hopes that this site report is of assistance to the EPA in evaluating utility trace chemical emissions as well as the associated health risk impacts.

Sincerely,

Paul Chu
Manager, Toxic Substances Characterization
Environment Division

TABLE OF CONTENTS

SECTION			PAGE
1.0	INTRODUCTION		1
	1.1	BACKGROUND AND OBJECTIVES	1
	1.2	SAMPLING AND ANALYSIS PROTOCOL	3
	1.3	QUALITY ASSURANCE/QUALITY CONTROL	3
	1.4	DATA QUALITY	4
	1.5	REPORT ORGANIZATION	5
2.0	SITE DESCRIPTION		6
	2.1	FACILITY INFORMATION	6
	2.2	PARTICULATE CONTROL	6
	2.3	ASH REMOVAL FACILITIES	6
	2.4	SAMPLING LOCATIONS	9
	2.5	PROCESS OPERATION DURING TESTING	10
3.0	RESULTS		12
	3.1	SAMPLING SCHEDULE	12
	3.2	DATA TREATMENT	16
		3.2.1 Blank Corrections	16
		3.2.2 Average Concentrations	16
		3.2.3 Summation of Multiple Train Fractions	17
		3.2.4 Method Detection Limit and Reporting Limit	17
		3.2.5 Assignment of Bias and Uncertainty Estimates	18
	3.3	OIL	18
	3.4	ESP INLET GAS	20
	3.5	ESP OUTLET GAS	20
	3.6	EMISSION FACTORS	25
	3.7	ESP PERFORMANCE	25
4.0	OTHER SPECIES DETECTED DURING METHOD EVALUATION TESTS		29
	4.1	CHROMIUM	29
	4.2	MERCURY SPECIATION TESTS	31
5.0	DATA EVALUATION		35
	5.1	PROCESS OPERATION	35
	5.2	SAMPLE COLLECTION	37
	5.3	EVALUATION OF MEASUREMENT DATA QUALITY	38
	5.4	ANALYTICAL QUALITY CONTROL RESULTS	40
		5.4.1 Metals	53
		5.4.2 Anions	55
		5.4.3 Polycyclic Aromatic Hydrocarbons	56

TABLE OF CONTENTS (continued)

PAGE

5.4.4 Formaldehyde 57
5.4.5 Benzene and Toluene 58
5.4.6 Particulate 59
5.4.7 Method Evaluation Tests 59
5.5 STACK SAMPLING QUALITY CONTROL RESULTS 61
5.6 MATERIAL BALANCE RESULTS 62

6.0 EXAMPLE CALCULATIONS 66
6.1 STREAM FLOW RATES 66
6.2 MEANS AND CONFIDENCE INTERVALS FOR STREAM CONCENTRATIONS 67
6.3 UNIT ENERGY EMISSION FACTORS 71

7.0 GLOSSARY 72

APPENDICES

A SAMPLING AND ANALYTICAL SUMMARY A-1

B FCEM SITE 112 INDIVIDUAL STREAM B-1

C DATA NOT USED IN CALCULATIONS C-1

D PROCESS STREAM FLOW RATES AND CALCULATION PROCEDURES . . D-1

E PROCESS OPERATION E-1

F UNCERTAINTY ANALYSIS F-1

G QUALITY ASSURANCE AND QUALITY CONTROL DATA G-1

H ANALYTICAL AND BLANK CORRECTION DATA H-1

LIST OF TABLES

TABLE		PAGE
1-1	FCEM SUBSTANCES OF INTEREST	2
2-1	UNIT CONFIGURATION	7
2-2	PROCESS STREAM ANALYSES PERFORMED	11
3-1	FUEL OIL ANALYSIS	19
3-2	ESP INLET GAS COMPOSITION DATA	21
3-3	ESP OUTLET GAS COMPOSITION DATA	23
3-4	ESP OUTLET GAS EMISSION FACTORS	26
3-5	SUMMARY OF ESP REMOVAL EFFICIENCIES	28
4-1	ESP INLET AND OUTLET CONCENTRATIONS OF TOTAL AND HEXAVALENT CHROMIUM EPA RECIRCULATION TRAIN METHOD EVALUATION TESTS	30
4-2	MERCURY RESULTS USING THREE EVALUATION TECHNIQUES	32
5-1	SUMMARY OF UNIT OPERATION	36
5-2	TYPES OF QUALITY CONTROL SAMPLES	39
5-3	TYPES OF QUALITY CONTROL DATA REPORTED	41
5-4	SUMMARY OF PRECISION AND ACCURACY ESTIMATES	42
5-5	EXIT STREAMS	62
5-6	MATERIAL BALANCES	64

LIST OF FIGURES

FIGURE		PAGE
2-1	PROCESS FLOW DIAGRAM	8
3-1	SAMPLING SCHEDULE FOR WEEK 1	13
3-2	SAMPLING SCHEDULE FOR WEEK 2	14
3-3	SAMPLING SCHEDULE FOR WEEK 3	15

SECTION 1.0

INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

This report summarizes data gathered by Carnot at a power plant designated Site 112 for a program sponsored by the Electric Power Research Institute (EPRI) and the host utility. The objective of the Field Chemical Emissions Monitoring Project (FCEM) sponsored by EPRI is to measure the concentrations of selected inorganic and organic substances in the process and discharge streams of power plants. These data are being used to determine the fate and control of these substances.

The primary objectives of this report are to provide information on fuel composition and stack emissions and to evaluate these data according to the criteria outlined below. The information is presented in a format suitable for the U.S. Environmental Protection Agency (EPA) to use to study emissions from fossil fuel fired power plants, as mandated by the Clean Air Act Amendments (CAAA) of 1990. This report summarizes fuel and stack gas concentration data measured during the operation of a tangentially fired boiler firing residual oil. Emissions were controlled by an electrostatic precipitator. Sampling was conducted during July and August 1992.

Table 1-1 lists the substances of interest to the FCEM project. The target analyte list and additional evaluation tests for chromium and mercury speciation were chosen for study at Site 112. Carnot conducted the testing and has prepared this report using the following procedures to evaluate the data:

- The type and quantity of quality assurance samples were reviewed to determine the confidence that can be placed in the results; and
- The QA/QC results were compared with data quality objectives to evaluate precision and accuracy.

Results are presented for each substance by individual run and as an averaged total. To represent data variability, the 95% confidence interval about the mean is also presented. The confidence interval incorporates the combined process, sampling, and analytical variabilities.

TABLE 1-1
FCEM SUBSTANCES OF INTEREST
SITE 112

Elements	Organic Compounds
Arsenic	Benzene
Barium	Toluene
Beryllium	Formaldehyde
Cadmium	Naphthalene
Chlorine (as chloride)	Acenaphthylene
Chromium	Acenaphthene
Cobalt	Fluorene
Copper	Phenanthrene
Fluorine (as fluoride)	Anthracene
Lead	Fluoranthene
Manganese	Pyrene
Mercury	Benz(a)anthracene
Molybdenum	Chrysene
Nickel	Benzo(b)fluoranthene
Phosphorus	Benzo(k)fluoranthene
Selenium	Benzo(a)pyrene
Vanadium	Indeno (1,2,3-cd)pyrene
	Dibenzo(a,h)anthracene
	Benzo(g,h,i)perylene
	2-Methylnaphthalene
	7,12-Dimethylbenz(a)anthracene
	3-Methylcholanthrene

Additional Substances

Total and hexavalent chromium by the EPA recirculation method*
Hg(0), Hg(II) and methyl mercury by the Nick Bloom/Brooks Rand solid sorbent methodology
Total mercury by MIT activated carbon cartridge/neutron activation methodology

* Determination of Hexavalent Chromium Emission from stationary sources, Method Manual for Compliance with the BIF Regulations EPA/530-SW-91-010.

1.2 SAMPLING AND ANALYSIS PROTOCOL

The sampling and analysis protocol for Site 112 is described in Appendix A. The FCEM program has attempted to employ standard sampling and analytical procedures when possible. The methods used are comparable to those used at other FCEM sites with the following exceptions:

- Benzene and toluene samples were collected in tedlar bags according to California Air Resources Board (CARB) methodology rather than using VOST sampling.
- Exhaust gas metals were determined as the total per sample train rather than differentiating between particulate and vapor phase metals.
- PAHs were collected and analyzed according to CARB methodology. These samples were analyzed using isotope dilution methodology by high resolution gas chromatography/low resolution mass spectrometry with selected ion monitoring (HRGC/LRMS-SIM)
- Fuel oil samples were analyzed for metals by INAA where possible and by ICP-AES analysis to complete the analysis of target metal species.

1.3 QUALITY ASSURANCE/QUALITY CONTROL

The completeness of the quality assurance data was reviewed to judge whether the quality of the measurement data could be evaluated with the available information. In general, the results of the QC checks available for Site 112 indicate that the sample results are well characterized. An evaluation of the accuracy, precision, and uncertainty of the data, even if only qualitative, is considered to be an important part of the data evaluation. A full discussion of each of these components of data quality can be found in Section 5.0.

Standard QA/QC checks for this type of sampling program involve the use of: 1) duplicate field samples and lab analyses, matrix spike and lab control duplicates and replicate tests to determine precision; 2) matrix spikes, surrogate spikes, and laboratory control samples to determine accuracy; and 3) field blanks, trip blanks, method blanks, and reagent blanks to determine if any of the samples were contaminated during collection or analysis. Most of these standard QA/QC checks were used on samples from Site 112. Some QA/QC checks do not apply to some types of analyses, for example, surrogate spikes do not apply to metals and anion analysis. The absence of any of these "standard" quality control checks from the Site 112 report does not necessarily reflect poorly on the quality of the data but does limit the ability to measure the various components of measurement error.

1.4 DATA QUALITY

The available QA/QC results were compared to the data quality objectives presented in Section 5.0. QA/QC results outside the data quality objectives are noted and discussed, other quality assurance values are evaluated, and the potential effect on data quality is noted. The detailed information presented in Section 5.0 shows that the data quality objectives were met with the following exceptions:

- The benzene and toluene values at the ESP inlet are lower than the outlet values. This indicates a concern for a possible sampling problem.

- Formaldehyde concentrations may be biased high. An accurate assessment of the overall method blank level could not be determined. Both field and trip blanks had formaldehyde levels similar to the samples. This method allows field blank levels to be subtracted from the result, but because the levels were high, the lower reagent blank level was used for blank corrections.

- Chromium concentrations measured in the ESP outlet gas with the multimetals train were contaminated by the teflon-coated stainless steel in-stack filter holder. Total chromium measurements from the EPA chromium recirculation train were substituted. The ESP inlet gas samples were not contaminated because a glass filter holder was used.

- There are concerns with the mercury concentrations measured at the ESP inlet and outlet using the multimetals drain. The reporting limit achieved was higher than needed to quantify mercury in all sample fractions. Mercury concentrations of the ESP inlet and outlet gas collected and measured by techniques that are under evaluation provide alternate mercury values. The values obtained have the advantage that they are below the detection limit of the reference method, but less quality assurance information is available. Both alternate methods are developmental; this was their first evaluation at an oil fired site.

- Manganese concentrations in the ESP outlet gas may be biased high. Manganese concentrations at the ESP inlet and outlet are similar. It is likely that the ESP outlet concentrations are biased high because ESP removal of manganese should be similar to other particulate metals. It is possible that a small amount of manganese from the potassium permanganate impinger may have contaminated the other impingers. High field blank levels relative to the sample values support this conclusion.

- Molybdenum concentrations at the ESP outlet may be biased high. There were high field blank levels relative to sample values.

1.5 REPORT ORGANIZATION

Section 2.0 of this report briefly describes the plant, the electrostatic precipitator, and the sample locations. Section 3.0 discusses the results of the chemical analysis of the oil and flue gas streams. Section 4.0 discusses the results of the chromium and mercury speciation tests. Section 5.0 presents QA/QC and engineering evaluations of the data. Section 6.0 presents example calculations, and a glossary of terms is provided in Section 7.0. The appendices contain information on sampling and analytical methods, stream concentrations, sampling data, process operation, error propagation equations, and detailed QA/QC data.

SECTION 2.0

SITE DESCRIPTION

This section presents a description of the test site, designated Site 112, and the sampling locations at this site.

2.1 FACILITY INFORMATION

Testing was performed at Site 112 which began operation in 1968. The unit is a tangentially-fired Combustion Engineering (CE) boiler with a maximum rated capacity of 387 MW gross. This balanced draft unit was originally designed to burn coal, but currently fires a 1% sulfur residual fuel oil. It was retrofitted with dual Buell/ENVIROTECH wire-and-plate electrostatic precipitators in 1978. The unit operates under a particulate limit of 0.1 lb/MMBtu. Char from the ESP hoppers is reinjected below the bottom row of burners. The configuration of the unit is summarized in Table 2-1. Figure 2-1 presents a process flow diagram of Site 112.

2.2 PARTICULATE CONTROL

Site 112 uses dual electrostatic precipitators for particulate control. Two ducts distribute the flue gas evenly to the north and south electrostatic precipitators. Each ESP has eight fields and a collection area of 206,640 ft^2 for a specific collection area of 189 ft^2/1,000 acfm. The particulate matter collected in the ESP hoppers is reinjected into the furnace to burn any remaining carbon.

2.3 ASH REMOVAL FACILITIES

Furnace hopper ash (bottom ash) consists of the larger and heavier ash that settles in the furnace hoppers. This ash in the furnace hoppers is manually removed on a weekly basis. It is ultimately disposed of in a landfill.

Some fly ash that is trapped in the ESP hoppers is sluiced on an as needed basis to clear pluggage. The fly ash sluice is treated and dewatered at the waste water treatment plant. City water is used for sluicing. A rear pass (superheater, reheater and economizer) ash sluice is also conducted as needed. The rear pass ash is sluiced with city water and treated at the waste water treatment plant.

TABLE 2-1
SITE 112 CONFIGURATION

Maximum Gross Electrical Output (MW):	387
Particulate Emission Limits (lb/10^6 Btu):	0.10
Air Pollution Control:	Electrostatic Precipitators
Boiler Type:	Tangentially-fired
Fuel Oil Additive:	Magnesium Oxide Slurry
Fuel Type:	Residual Oil
Fuel Sulfur Content: (%)[a]	0.85
Fuel Ash Content: (%)[a]	0.03
Fuel Heating Value: (Btu/lb)[a]	18,580
Furnace Hopper Ash Disposal:	Landfill
Fly Ash Disposal: [b]	Wastewater Treatment Plant
Fly Ash Sluice Water Source:	City Water
Rear Pass Ash Disposal[b]:	Wastewater Treatment Plant
Rear Pass Ash Sluice Water:	City Water
Cooling Water System:	Single Pass
Cooling Water Source:	Sea Water

(a) Average values measured during sampling
(b) Not sampled

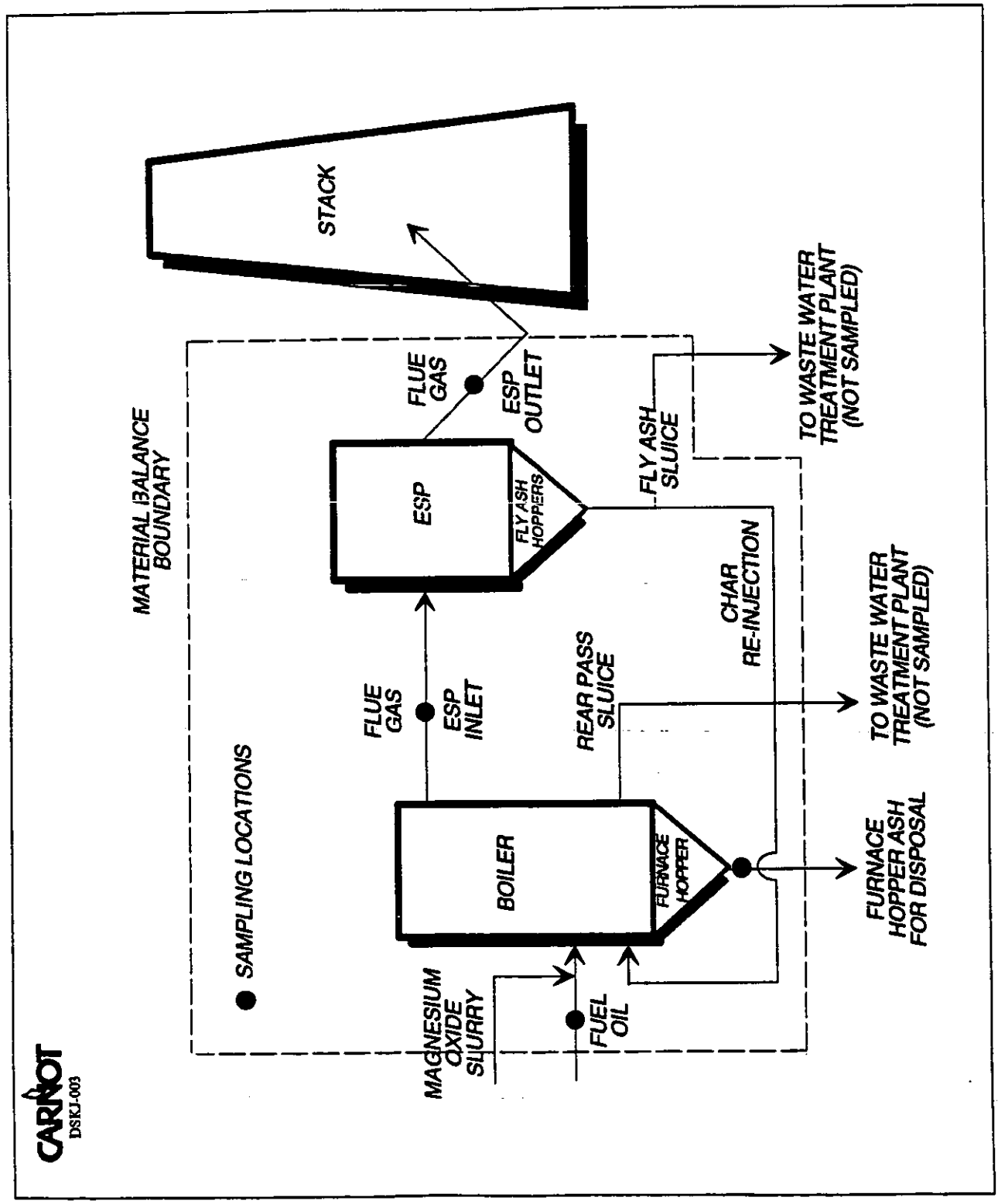


Figure 2-1. Process Flow Diagram of Site 112

2.4 SAMPLING LOCATIONS

Samples were collected at the four sampling locations identified in Figure 2-1. Fuel oil was the only feed stream sampled. One internal stream, the inlet gas to the ESP, was sampled. Two discharge streams were sampled: the ESP outlet exhaust gas and the furnace hopper ash.

In February 1992, sampling of a partial boiler wash was conducted. These results are located in Appendix B and are used for mass balance purposes.

A brief description of each sampling location follows:

- Fuel oil samples were collected by plant personnel three times a day during flue gas emissions sampling. These samples were composited for analysis to correspond with flue gas emissions tests. The fuel oil samples that were collected did not contain the magnesium oxide slurry. The magnesium oxide additive was analyzed for trace metals, however, the contribution was not significant. These results are presented in Appendix B.

- Flue gas entering the electrostatic precipitators was sampled at the twelve available tests ports on the two ESP inlet ducts. Six vertical ports were available per duct. A total of 84 points were sampled for each isokinetic test. A horizontal port was installed on the ESP inlet location to allow use of the hexavalent chromium recirculation train.

- Flue gas exiting the electrostatic precipitator was sampled at the eight available test ports on the two ESP outlet ducts. Four ports were available per duct. A total of 88 points were sampled for isokinetic tests. There were no accessible ports on the stack. The ESP outlet ports are positioned at an angle so a horizontal port was installed for hexavalent chromium sampling with the EPA recirculation train.

- Furnace hopper ash was dumped from the furnace hoppers into a bin four times for the test program. The furnace hoppers were dumped once before the start of the program, once after metals tests were performed, once after the chromium and mercury speciation tests were performed, and once after the retest for Semi-Volatile organic species. Grab samples from various depths in the bin were removed and composited. The furnace hopper ash dumped before the start of the test program was not used for any calculations or analyses in this program.

- A partial boiler wash was sampled prior to this test program. The boiler wash sampling consisted of three phases (1) a soda ash wash, (2) a water wash, and (3) the furnace hopper ash. In addition, composite fuel oil samples and magnesium oxide samples were collected and analyzed. The areas downstream of the economizer could not be sampled. These areas include the air preheaters, duct

work to the precipitators, the precipitators, the ID fans, the breaching to the stack and the stack.

The procedures for collecting, pretreating, and analyzing the samples are discussed in Appendix A. Table 2-2 presents an overview of the types of analyses performed on these streams.

2.5 PROCESS OPERATION DURING TESTING

Tests were conducted at nominal full load, with the exception of Test 7 (one of the mercury speciation tests), which was conducted at 50% load due to one ID fan being out of service.

Average load during testing was 365 MW gross, with a range of 355 to 374 MW. Maximum achievable load was limited throughout the program due to ID fan capacity limits. With this limitation, the average load was 94% of the rated capacity of 387 MW.

During the tests, the fuel and air systems were operated in manual control which is normal operation for this unit. The ID fans were operated at maximum capacity, and the FD fans were controlled to maintain a safe negative furnace pressure value. Excess oxygen values (measured by boiler instrumentation on a wet basis at the economizer exit) averaged 2.0% for the north duct and 1.8% for the south duct. Flue gas recirculation fans and auxiliary burner air dampers were adjusted by boiler operators to achieve target steam temperatures, and tended to vary from day to day.

ESP operation was documented daily. Power levels (no power factor assumed) averaged 136 kVA for the north ESP and 77 kVA for the south ESP. One to four of sixteen ESP sections were out of service for each test.

Appendix E contains process operation data.

TABLE 2-2
PROCESS STREAM ANALYSES PERFORMED

Stream	Metals[a]	Anions[b] and anion precursors	Semi Volatile[c] Organics	Volatile[d] Organics	Particulate	Total[e] and Hexavalent Chromium Evaluation	Mercury[f] Evaluation	Composition[g]
Oil	✓	✓					✓	✓
ESP Inlet Gas	✓	✓	✓	✓	✓	✓		
ESP Outlet Gas	✓	✓	✓	✓	✓	✓	✓	
Furnace Hopper Ash	✓	✓	✓				✓	
Boiler Wash	✓	✓	✓					

(a) = "Metals" include the target species: arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, phosphorus, selenium and vanadium.

(b) = Anions include the target analytes: chloride and fluoride.

(c) = Semi-Volatile Organics are nineteen PAH species.

(d) = Volatile Organics are benzene, toluene, and formaldehyde.

(e) = Total and hexavalent chromium evaluation using EPA recirculation train, single point isokinetic test.

(f) = Mercury evaluation was simultaneous single point sampling for mercury by Nick Bloom/Brooks Rand methodology, MIT carbon cartridge/ INAA methodology and an EPA multimetals train analyzed specifically for mercury.

(g) = Composition of fuel oil analysis is carbon, hydrogen, nitrogen, sulfur, oxygen (by difference), moisture, ash, and higher heating value.

SECTION 3.0

RESULTS

This section summarizes the data collected at Site 112. Because the focus of this report is on exhaust gas emissions, only oil characterization data and gas stream data are presented here in detail. Sampling, preparation and analytical methods are summarized in Appendix A. Detailed data can be found in Appendices B and C.

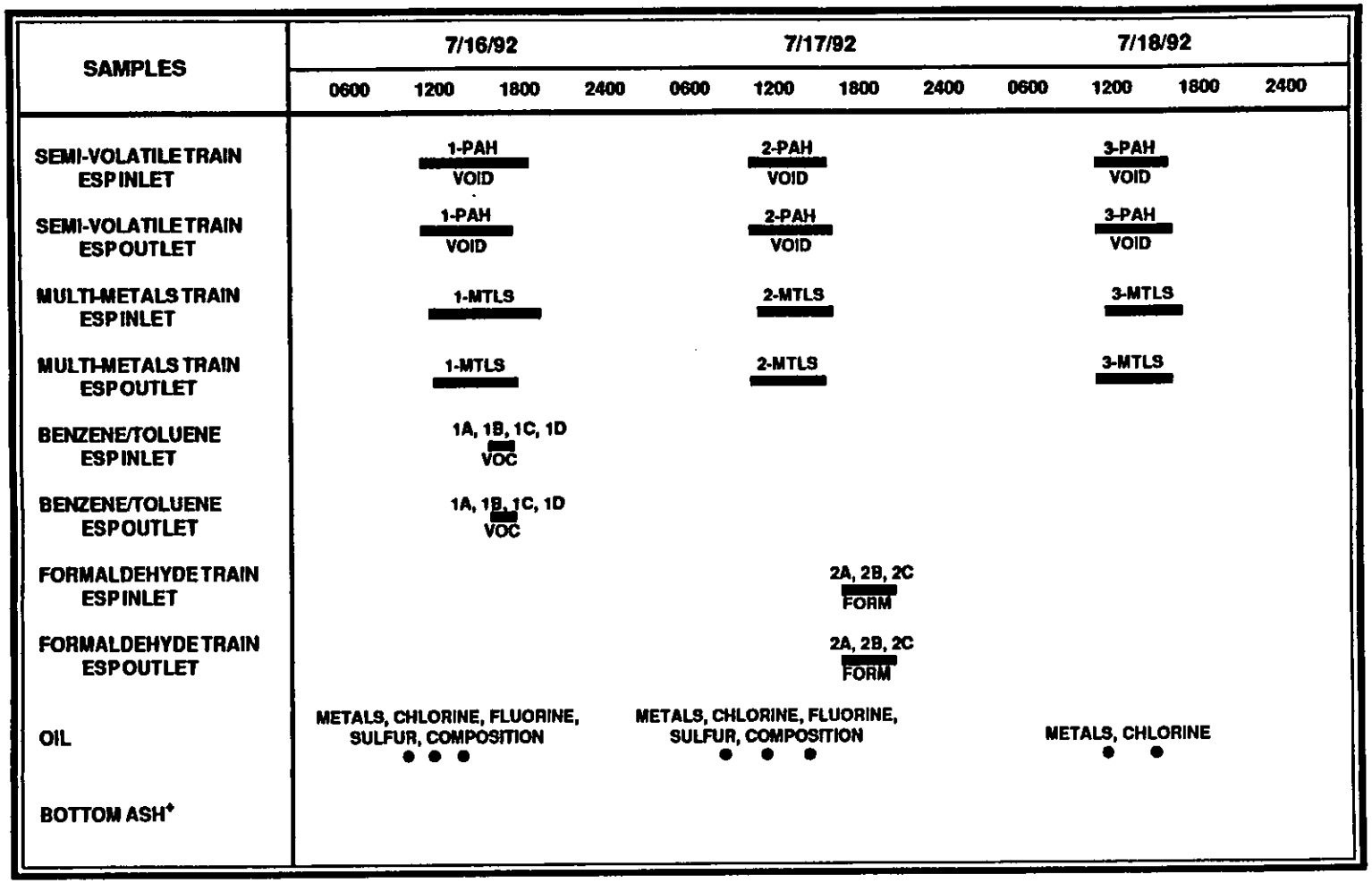
3.1 SAMPLING SCHEDULE

Sampling at Site 112 was performed in July and August 1992.

Figures 3-1 and 3-2 present the sampling schedule for the first two weeks of testing which includes testing for the FCEM tests and the chromium and mercury speciation tests. Figure 3-3 presents the sampling schedule for the semi-volatile tests that were repeated in the third week. Test numbers have been assigned sequentially and all tests conducted simultaneously have the same number. Additional designators indicate the sample train type and sampling location.

Five types of sampling trains were used to collect flue gas samples for the FCEM species of interest from the north and south sides of the ESP inlet and ESP outlet ducts. These trains were: multimetals trains, semi-volatile organics trains, particulate/anion trains, tedlar bag samples for benzene and toluene, and formaldehyde trains. Each multimetals, semi-volatile, and particulate/anion sample required a full traverse of both the north and south ducts. Particulate samples were collected by EPA Method 17 (in stack filter) at the ESP outlet location, and by EPA Method 5 at the ESP inlet location. Formaldehyde samples and tedlar bag samples for benzene and toluene were collected at a single point. ESP inlet sampling and ESP outlet sampling were conducted simultaneously for all trains. Semi-volatile trains were run in July 1992, but had to be repeated in August 1992 because of a laboratory error which brought the samples to dryness during extraction and destroyed the samples.

For the total and hexavalent chromium tests the EPA recirculation train was run simultaneously at a single point at the ESP inlet and ESP outlet. For the mercury tests, three trains were run simultaneously at a single ESP outlet point: 1) the Nick Bloom/Brooks Rand solid sorbent method that speciates Hg(II), methyl mercury and elemental mercury by collection on KCl/soda lime and iodated carbon cartridges, 2) MIT's activated carbon cartridge method, and 3) a multimetals train that was analyzed specifically for mercury. The results of two mercury tests (Runs 5 and 6) by activated carbon collection were invalidated by MIT because

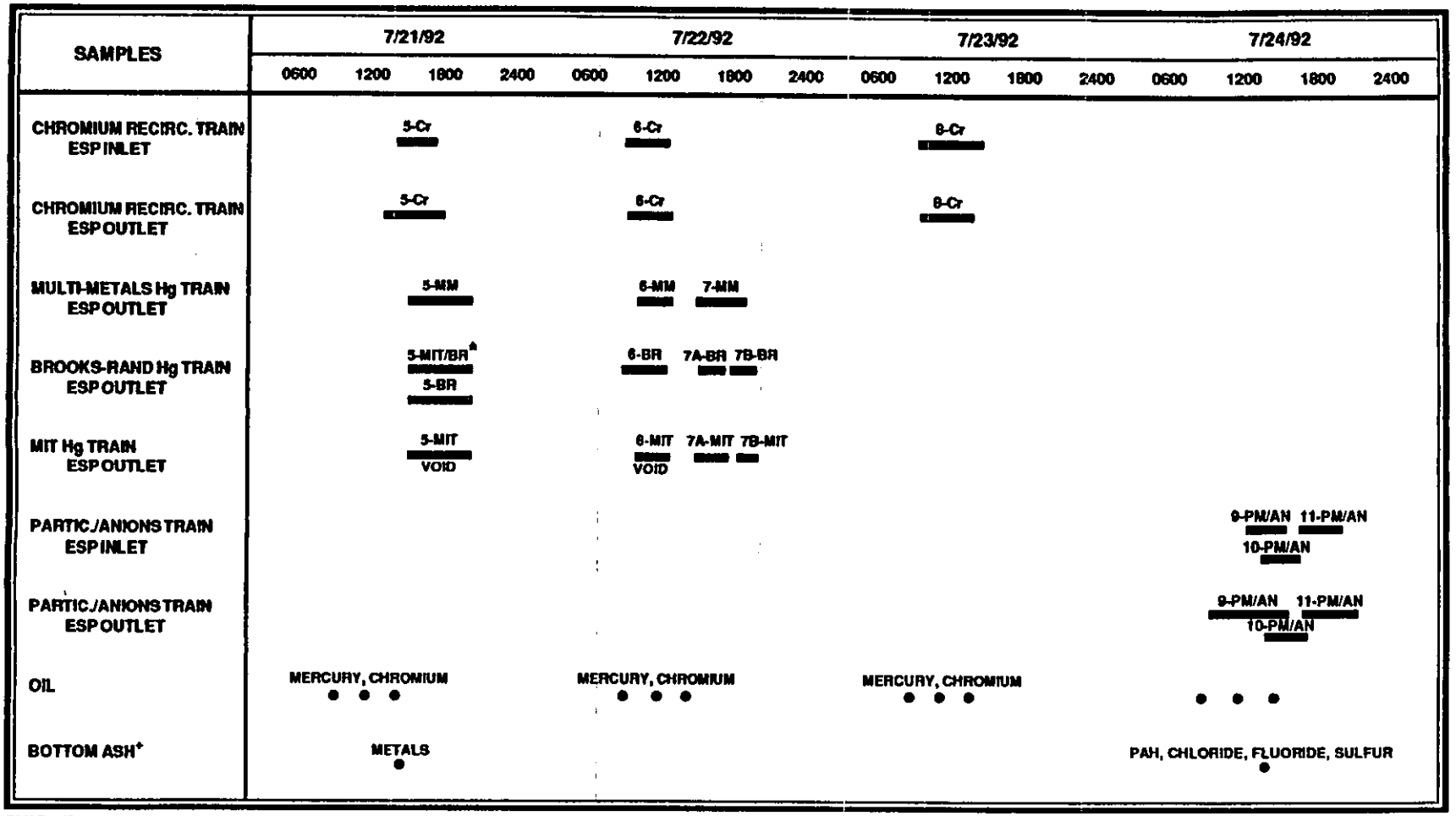


PMAB-042

NOTES:

- ● DENOTES GRAB SAMPLE TIMES
- ▬ CONTINUOUS SAMPLING
- 1 INDICATES RUN NUMBER
- \+ BOTTOM ASH DUMPED BEFORE SAMPLING PROGRAM, BUT NOT COLLECTED OR ANALYZED
  OIL GRAB SAMPLES FOR 7/16, 7/17 AND 7/18 COMPOSITED INTO A DAILY COMPOSITE SAMPLE BEFORE ANALYSIS
  METALS INCLUDE PHOSPHORUS

Figure 3-1. Sampling Schedule for Site 112 Week 1



PMAB-043

NOTES:

- ● DENOTES GRAB SAMPLE TIMES
- ▬ CONTINUOUS SAMPLING
- 1 INDICATES RUN NUMBER
- \+ 7/24/92 BOTTOM ASH SAMPLE COLLECTED AT APPROXIMATELY 1400, EXACT TIME NOT RECORDED
- * ISOKINETIC COMBINATION TRAIN

OIL GRAB SAMPLES FOR 7/21, 7/22, 7/23 COMPOSITED INTO A SINGLE SAMPLE FOR ANALYSIS OF Hg AND Cr FOR EVALUATION TESTS
METALS INCLUDES PHOSPHORUS

Figure 3-2. Sampling Schedule for Site 112 Week 2

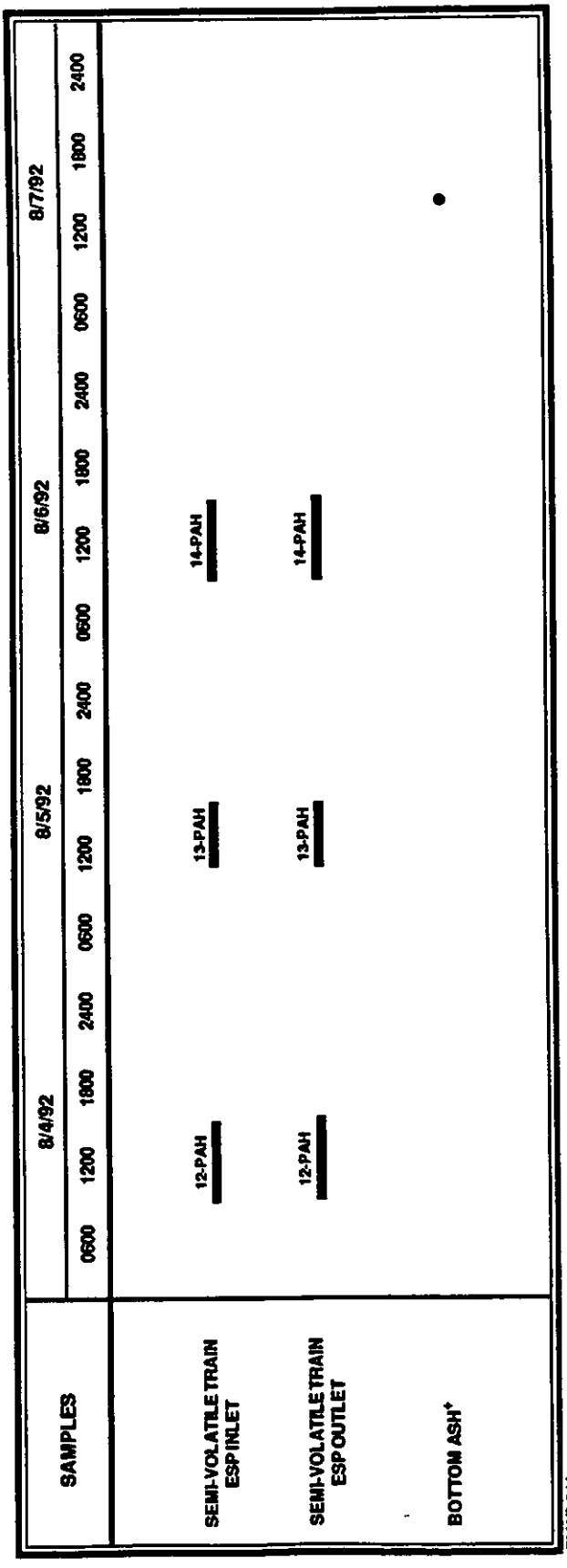


Figure 3-3. Sampling Schedule for Site 112 Week 3

of difficulties keeping the carbon packed properly during sampling.

A composite sample of fuel oil collected during the mercury tests was also analyzed for total mercury by Brooks Round, by MIT, and by a contract laboratory using CVAAS.

3.2 DATA TREATMENT

Several conventions were developed for treating the test data and developing average concentrations of substances in the oil and flue gas streams. The conventions used in this report are consistent with the FCEM data treatment procedures.

3.2.1 Blank Corrections

The individual run measurements were corrected for the reagent blank analysis when it was available and when it is allowed by the reference method. If a reagent blank was not analyzed or was considered nonrepresentative, the measurement was corrected for a laboratory blank. The laboratory blank is not exposed to field conditions and contains only the chemicals needed for analysis so it is expected to be lower than reagent blank. Generally, field blank analyses are used to provide information on sample collection conditions but not to correct the results. When the blank correction is equal to or greater than 50% of the uncorrected measurement, the concentration is flagged with a "B." When the blank correction results in a value less than the reporting limit, the concentration is presented as detected at the reporting limit. Appendix H presents blank correction data, and an example of how the blank correction contribution is calculated.

3.2.2 Average Concentrations

The following criteria were used to average data from the individual runs.

- When all values are above the reporting limit, the mean arithmetic concentration is calculated using the reported quantities.

- For results that include values both above and below the reporting limit, one-half of the reporting limit is used for values below the reporting limit to calculate the mean. For example:

Analytical Values	Calculation	Mean Value
10,12,ND(8)	(10+12+[8/2])/3	8.7

By our convention, the calculated mean cannot be smaller that the largest reporting limit value. In the following example, the calculated mean is 2.8. This is less than the largest reporting limit, so the reported mean becomes ND(4).

Analytical Values	Mean Value
5,ND(4), ND(3)	ND(4)

- When all analytical results are less than the reporting limit, the presented value is the largest reporting limit value expressed as ND (the largest reporting limit value).

3.2.3 Summation of Multiple Train Fractions

Some sample trains, such as the anions, are analyzed in multiple fractions. If all fractions were detected, the total emissions were reported as the sum of the measurements. If all fractions were not detected, total emissions were reported as not detect, less than the sum of the reporting limits of the fractions. If one or more, but not all fractions were not detected, the total is reported as the sum of the detected values and one-half of the reporting limit for the non-detected values.

3.2.4 Method Detection Limit and Reporting Limit

The method detection limit (MDL) is defined by 40 CFR 136, Appendix B - Definition and Procedure for the Determination of the Method Detection Limit - Revision 1. It states, "The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte." The MDL is determined by seven replicate analyses of an analyte in a given matrix at one to five times the estimated MDL. It is calculated as:

$$MDL = 3.143\ S$$

where:

S is the standard deviation of the replicate analyses, and

3.143 is the student "t" value corresponding to seven replicates with n-1 degrees of freedom at the 99% confidence level.

Additional criteria are imposed by the procedure for calculating subsequent method reporting limits. In practice, the method detection limit can be impacted by variability in performing the analytical procedure, the sample matrix and the analyte concentration of the sample. Because the method detection limit may not completely specify the confidence an analytical laboratory has in reporting a result, a laboratory typically presents a reporting limit or quantitation limit. The numerical difference between the method detection limit as defined by the CFR and a laboratory's reporting limit varies for different types of analyses and sample matrices but generally varies from the MDL value to approximately three times greater than the

MDL. The values presented in this report are all based on individual laboratories' stated reporting limits.

3.2.5 Assignment of Bias and Uncertainty Estimates

In calculating uncertainties that are presented in this report, procedures were followed that have been previously established for FCEM data treatment. This procedure involved calculating an overall uncertainty for each result using standard statistical techniques and known measurement biases. An error propagation analysis was performed on calculated results to determine the contribution of process, sampling and analytical variability, and measurement bias, to the overall uncertainty in the result.

Example calculations and bias and uncertainty estimates are presented in Appendix F.

3.3 OIL

This section presents the analytical results for the oil samples. Complete results are presented in Appendix B for all samples. Appendix A presents the analytical methodology. Table 3-1 presents the fuel metals results from the composited oil samples corresponding to the multimetals train sampling times (Runs 1, 2 and 3), chlorine results (Runs 1, 2 and 3), and fluorine, sulfur, and fuel composition results (Runs 1 and 2). Table 3-1 also presents the mean value and the uncertainty in the results calculated at the 95% confidence interval about the mean. The confidence interval is the range about the mean in which the true mean lies within a given probability. For example, it is 95% certain that the true mean beryllium concentration in the oil is between 0.043 and 0.077 μg/g. The confidence interval calculation is discussed in Section 6.0.

Measurements of the analyte concentrations in fuel oil reported here were made using what Carnot considered to be the most applicable method. The method chosen was an accepted analytical method for the sample matrix, had an acceptably low reporting limit and demonstrated acceptable precision and accuracy.

Instrumental neutron activation analysis (INAA) was used for the determination of arsenic, barium, chromium, cobalt, manganese, mercury, molybdenum, selenium, vanadium and chlorine. Inductively coupled plasma atomic emission spectroscopy (ICP-AES) was used for the determination of beryllium, cadmium, copper, lead, nickel and phosphorus. INAA analysis was used where possible because the results exhibit good precision and low reporting limits for most elements. Additionally INAA analysis involves few handling procedures and no wet chemical digestions. This eliminates most analytical difficulties associated with contamination or volatilization of some elements. Appendix G contains an analysis of NIST fuel oil standard 1634B by INAA and ICP-AES, GFAAS or CVAAS. Arsenic, mercury and selenium were quantitated more accurately by INAA because of INAA's lower reporting limit. Chlorine results by INAA were used instead of chlorine results obtained by ASTM D-808 because of the better

TABLE 3-1
FUEL OIL ANALYSIS SITE 112

Parameter	Run 1	Run 2	Run 3	Mean	95% C.I.
Date	7/16/92	7/17/92	7/18/92	(Runs 1,2,3 only)	
Fuel Flow, lb/hr[1]	180,000	182,000	187,000	184,000	9,000
Ash, %	0.01	0.05	NA	0.03	0.25
Sulfur, %[2]	0.86	0.84	NA	0.85	0.14
HHV, Btu/lb[2]	18,620	18,544	NA	18,582	483
Metals, µg/g					
Arsenic	0.059	0.070	NA	0.065	0.070
Barium	1.1	1.2	1.6	1.3	0.66
Beryllium	0.053	0.066	0.062	0.060	0.017
Cadmium	0.010@	0.015@	0.014@	0.013	0.007
Chromium	0.23	0.28	0.20	0.24	0.10
Cobalt	1.3	1.5	3.0	1.9	2.3
Copper	0.64	0.63	0.62	0.63	0.04
Lead	0.40@	0.36@	0.40@	0.39	0.06
Manganese	0.32	0.38	0.31	0.34	0.10
Mercury	0.0028	0.0043	0.011	0.0060	0.0108
Molybdenum	0.13	0.15	0.12	0.13	0.04
Nickel	39.9	41.9	39.9	40.6	3.5
Selenium	0.056	0.044	NA	0.050	0.077
Vanadium	24	33	24	27	13
Anion Precursors, µg/g					
Chlorine, µg/g	30	34	25	30	11
Fluorine, µg/g[2]	ND(10)	ND(10)	NA	ND(10)	NC
Phosphorus, µg/g	17@	16@	12@	15	6.6

@ Species detected at less than five times the reporting limit
NA - not analyzed
NC - not calculated
ND( ) - species not detected at the reporting limit
(1) Fuel flow rate by plant instrumentation, readings have an assumed accuracy of ±5%.
(2) Fluorine, sulfur and compositional analysis performed in duplicate only from 7/16/92 and 7/17/92 samples. Results of the ultimate analysis are in Appendix B.
INAA used for determination of arsenic, barium, chromium, cobalt, manganese, mercury, molybdenum, selenium, vanadium and chlorine. Arsenic and selenium were determined by INAA on runs 1 and 2 only.
ICP-AES used for determination of beryllium, cadmium, copper, lead, nickel and phosphorus.

precision exhibited by INAA analysis.

Fluorine concentrations were measured using an ion selective electrode. Sulfur concentrations were measured by LECO SC-132. Carbon, hydrogen and nitrogen were measured with a LECO CHN/600 analyzer. The higher heating value of the fuel was measured by calorimetry by ASTM D-240-87. The fuel ash content was measured gravimetrically by using ASTM D-482.

3.4 ESP INLET GAS

Table 3-2 summarizes the concentration measurements made on flue gas entering the electrostatic precipitators. Additional data are presented in Appendix B. For the metals results, the probe and nozzle rinse, filter, and nitric acid/hydrogen peroxide impinger catch were all combined before analysis; therefore, the data represent the total (particulate plus vapor phase) concentration in the ESP inlet gas. The components of the train were combined after digestion to lower the reporting limits. Mercury results were obtained by analyzing the permanganate impinger solution and an aliquot from the front half and nitric acid/hydrogen peroxide impinger solution. These results were added together to provide the total mercury concentration. Anion results represent the sum of analyses of each sample train portion.

The total concentrations from each run were averaged according to the convention outlined previously to obtain an overall mean concentration and the uncertainty at the 95% confidence interval. The uncertainty in isokinetic tests involves a 14% bias because of the non-axial flow at this location. Appendix F contains detailed descriptions of bias estimates and uncertainty calculations.

3.5 ESP OUTLET GAS

Table 3-3 summarizes the concentrations of the species in the flue gas emitted from the electrostatic precipitators.

The analytical procedure for the multimetals trains was modified by combining the particulate and vapor phases for analysis as described previously for the ESP inlet gas.

Emission results that need further explanation because of sampling or blank level problems include manganese, molybdenum, nickel and chromium. It is possible that small amounts of manganese from the potassium permanganate impinger in the multi metals train contaminated the acid impingers of the train on some samples. ESP removal efficiency for manganese was poor compared to other similar particulate phase metals, and field blank manganese levels were high. Molybdenum concentrations may be biased high also because field blank levels are high relative to sample values. Chromium concentrations were obtained using the EPA recirculation train because the multi metals train results appear contaminated from the

TABLE 3-2
ESP INLET GAS COMPOSITION DATA AT SITE 112

	Run 1	Run 2	Run 3		Run 9	Run 10	Run 11	Mean	95% C.I.
Gas Stream Flow Rate,[1]									
dscfm	803,500	783,300	839,100		727,100	768,400	732,600		
Nm³/hr	1,272,000	1,240,000	1,329,000		1,151,000	1,217,000	1,160,000		
Substance									
Particulate loading, mg/Nm³					117.4	96.7	94.5	103	35
	Run 1A	Run 1B	Run 1C	Run 1D				Mean	
VOC, µg/Nm³									
Benzene[2]	0.87@	1.12@	0.87@	ND (0.52)				0.78	0.60
Toluene[2]	32.8	16.3	17.9	15.5				20.6	13.2
		Run 2A	Run 2B	Run 2C					
Formaldehyde		26.0	26.8	23.2 B				25.3 F	4.8
Metals, µg/Nm³									
Arsenic	3.9@	6.2@	8.1@					6.1	5.4
Barium	20.5	46.2	17.1					27.9	39.6
Beryllium	2.6	3.0	3.7					3.1	1.4
Cadmium	0.76	0.43@	0.53					0.57	0.42
Chromium	9.8	9.0	12.5					10.4	4.9
Cobalt	47.9	45.1	48.8					47.3	8.5
Copper	33.4	33.0	45.8					37.4	19.1
Lead	9.0@	6.5@	4.7@					6.7 F	5.5
Manganese	27.0	15.3	11.2					17.8	20.5
Mercury	1.12	2.95	1.03					1.70	2.70
Molybdenum	16.2	18.6	18.9					17.9	4.5
Nickel	1370	1390	1440					1400	220
Phosphorus	390	400	467					419	122
Selenium	ND(7.1)	ND(8.9)	ND(9.0)					ND(9.0)	NC
Vanadium	1120	1350	1490					1320	515
Anions, µg/Nm³									
Chloride					3780	3370	2820	3320	1300
Fluoride					1010	530	420	650	730

ND( ) - species not detected at the reporting limit
NC - not calculated
@ Species detected at less than five times the reporting limit
F = field blank greater than 50% of the average uncorrected sample measurement
B indicates that the blank correction was ≥ 50% of the original sample value.

(Continued)

Runs 1A, 1B, 1C and 1D performed during Run 1.
Runs 2A, 2B, and 2C are performed during Run 2.
[1] Flow rate calculated from unit heat rate and F factor. Calculations are contained in Appendix D.
Flow rate for Runs 2 and 3 from metals tests.
[2] The benzene and toluene inlet values are lower than the outlet values (Table 3-4), indicating a possible sampling problem.

TABLE 3-2 (continued)
ESP INLET GAS COMPOSITION DATA AT SITE 112

	Run 12	Run 13	Run 14	Mean	95% C.I.
Gas Stream Flow Rate					
dscfm	687,500	733,300	726,200	755,700	35,900
Nm^3/hr	1,089,000	1,161,000	1,150,000	1,197,000	
Substance					
PAH, $\mu g/Nm^3$					
Naphthalene	0.59@	0.58@	0.58@	0.58	0.087
Fluorene	0.024@	0.018@	0.014@	0.019	0.013
Phenanthrene	0.159	0.120	0.086	0.122	0.092
2-Methylnaphthalene	ND(0.017)	0.034@	0.040@	0.027	0.041

Notes:
ND( ) - species not detected at the reporting limit
@ Species detected at less than five times the reporting limit
Only PAH species that were detected are listed here. Results for PAH target species that were not detected are listed in Appendix B.
Mean and uncertainty for gas flow rate includes all tests for the base series but excludes tests for additional species. Detailed flow rate results for all tests and their mean are in Appendix D.

TABLE 3-3
ESP OUTLET GAS COMPOSITION DATA AT SITE 112

	Run 1	Run 2	Run 3	Run 5	Run 6	Run 8	Run 9	Run 10	Run 11	Mean	95% C.I.
Gas Stream Flow Rate, dscfm	762,400	759,800	739,600	729,000	759,800	774,000	760,700	752,200	764,000		
Nm^3/hr	1,207,000	1,203,000	1,171,000	1,154,100	1,202,900	1,225,000	1,204,000	1,191,000	1,210,000		
Substance											
Particulate loading, mg/Nm^3							20.6	23.0	25.3	23.0	6.9
VOC, $\mu g/Nm^3$	Run 1A	Run 1B	Run 1C	Run 1D						Mean	
Benzene	2.47*	3.90	3.21	2.51*						3.02	1.08
Toluene	183	124	74.8	26.9						102	106
		Run 2A	Run 2B	Run 2C						17.5F	51
Formaldehyde		7.82*B	41.1	3.44*B							
Metals, $\mu g/Nm^3$											
Arsenic	ND(3.0)	ND(0.60)	ND(3.2)							ND(3.2)	NC
Barium	23.4	3.0	14.7							13.7	25.6
Beryllium	0.92	0.30	1.08							0.77	1.0
Cadmium	0.96	0.13*	0.18*							0.42	1.2
Chromium[1]				7.5	3.1	4.2				4.9	5.7
Cobalt	15.6	4.5	18.6							12.9	18.6
Copper	9.0	4.4	11.8							8.4F	9.5
Lead	4.1*	3.0*	3.2*							3.4F	1.5
Manganese	7.8	23.1	26.8							19.2F	25.2
Mercury[2]	0.29@	0.44@	ND(0.41)@							0.31	0.31
Molybdenum	7.1	5.4	10.7							7.8F	6.9
Nickel	468	161	564							398	525
Phosphorus	149	104	174							143	90
Selenium	ND(6.2)	ND(6.2)	ND(3.2)							ND(6.2)	NC
Vanadium	383	112	451							316	449
Anions, $\mu g/Nm^3$											
Chloride							3,241	5,258	5,477	4,659	3,052
Fluoride							1,051	497	253	600	1,014

[1] From outlet chromium recirculation train results performed during method evaluation tests (runs 5, 6 and 8).
[2] One-half of the value reported for Run 3 used to calculate the mean concentration. This is a variation of the FCEM reporting convention.
ND( ) indicates that the concentration was below the reporting limit
* Species detected at less than five times the reporting limit
B indicates that the blank correction was ≥50% of original sample value.
NC - not calculated.
F = Field blank greater than 50% of the average uncorrected sample measurement.
Runs 1A, 1B, 1C and 1D are performed during Run 1.
Runs 2A, 2B, and 2C are performed during Run 2.
Flow rate calculated from unit heat rate and F factor. Calculations are contained in Appendix D.
Flow rate for Runs 2 and 3 from metals tests.

TABLE 3-3 (continued)
ESP OUTLET GAS COMPOSITION DATA AT SITE 112

	Run 12	Run 13	Run 14	Mean	95% C.I.
Gas Stream Flow Rate					
dscfm	754,100	759,900	757,800	757,200	13,300
Nm^3/hr	1,194,000	1,203,000	1,200,000	1,199,000	
Substance					
PAH, $\mu g/Nm^3$					
Naphthalene	0.45@	0.39@	0.42@	0.42	0.10
Fluorene	0.014@	0.007@	0.059	0.027	0.072
Phenanthrene	0.030	0.025@	0.023@	0.026	0.009
2-Methylnaphthalene	.021@	0.018@	.018@	0.019	0.005

Notes:

@ Species detected at less than five times the reporting limit

The PAH results presented are the detected species only. Results for the complete list of PAH target species are in Appendix B.

Mean and uncertainty for the gas flow rate include all data present in this table (Runs 1-3 and 8-14), but exclude flow rates from Run 7 and mercury speciation tests.

Teflon-coated stainless steel in-stack filter holder. The nickel values may also be contaminated by this same problem. In comparison, the inlet multi metals train used a standard borosilicate glass filter holder. Therefore, the inlet chromium and nickel results were not subject to the same potential contamination problems. More detail on these sampling and analytical problems is presented in Section 5.

Uncertainty calculations for this sample location are the same as described for the ESP inlet location.

3.6 EMISSION FACTORS

Table 3-4 presents mean emission factors, expressed as lb/10^{12} Btu for the ESP outlet.

Mean particulate emissions at the ESP outlet were 0.0177 lb/10^{6} Btu. Chloride (3,590 lb/10^{12} Btu) and fluoride (465 lb/10^{12} Btu) have the highest emission factors of the target species. Among the metals, nickel, vanadium and phosphorus had the highest emission factors at 303, 240 and 109 lb/10^{12} Btu, respectively. Emission factors for the other metals ranged from 0.24-14.6 lb/10^{12} Btu.

Of the PAH target species, only naphthalene, fluorene, phenanthrene, and 2-methylnaphthalene were detected. Their emission levels ranged from 0.020-0.322 lb/10^{12} Btu. Other PAH species were not detected in the range of 0.011-0.175 lb/10^{12} Btu.

Toluene had the highest emission value of the volatile organic target species at 79.5 lb/10^{12} Btu. Benzene and formaldehyde emission levels were 2.4 and 13.4 lb/10^{12} Btu, respectively.

3.7 ESP PERFORMANCE

The removal efficiency of the ESP with respect to the target inorganic substances is presented in Table 3-5. Removal efficiency was calculated from the average ESP inlet and outlet concentrations of the element, expressed in lb/10^{12} Btu. The ESP had a particulate removal efficiency of 77%. The most prevalent metals, nickel and vanadium, were removed by the ESP at efficiencies similar to total particulate at 74% and 78%. These tests indicated a calculated removal efficiency of 83% for mercury, however the calculated uncertainty is also high (46% efficiency). The high level of uncertainty should be considered when interpreting these results.

TABLE 3-4
ESP OUTLET GAS EMISSION FACTORS AT SITE 112
(lb/10^{12} Btu unless noted)

Substance	Mean	95% C.I.
Flow, dscfm[4]	757,200	13,300
Oil Flow, Klb/hr[3]	177,000	7,000
Heating Value, Btu/lb	18,582	483
Particulate, lb/10^6 Btu	0.0177	0.0053
Metals:		
Arsenic	ND(2.4)	NC
Barium	10.5	19.6
Beryllium	0.58	0.78
Cadmium	0.33	0.90
Chromium[1]	3.7	4.3
Cobalt	9.8	14
Copper	6.4F	7.2
Lead	2.6F	1.1
Manganese[2]	14.6F	19.1
Mercury	0.24	0.24
Molybdenum[2]	5.9F	5.2
Nickel[2]	303	400
Phosphorus	109	69
Selenium	ND(4.8)	NC
Vanadium	240	340
Anions:		
Chloride	3,590	2410
Fluoride	465	791

(continued)

Notes:

ND( ) indicates that the concentration is below the reporting limit

NC = not calculated

F = Field blank greater than 50% of the average uncorrected sample measurement.

Confidence Interval cannot be calculated when a single highest not detected value is used

(1) Chromium value from the recirculation train. This program represents the first application of the EPA recirculation method to an oil-fired unit. The chromium measurements from the multi-metals trains were contaminated. Chromium at the outlet using the multi-metals train was six times higher at the outlet than the inlet. Contamination of the outlet train was determined as the cause from the Teflon coated stainless steel filter holder. Inlet chromium results were not contaminated because a glass filter holder was used.

(2) Manganese, molybdenum and nickel emissions at the ESP outlet may be biased high.

(3) The oil flow rate is from Runs 1-3, and 8-14 which corresponds to air sampling for the base FCEM program and excludes the speciation tests.

(4) Mean for flue gas flow rate is calculated from all runs except Run 7 at 50% load.

TABLE 3-4 (continued)
ESP OUTLET GAS EMISSION FACTORS AT SITE 112
(lb/10^{12} Btu unless noted)

Substance	Mean	95% C.I.
PAH:		
Naphthalene	0.322+	0.077
Fluorene	0.020	0.053
Phenanthrene	0.020	0.007
2-Methylnaphthalene	0.015	0.004
Volatile Organic Species		
Benzene	2.4	0.86
Toluene	79.5	82.7
Formaldehyde	13.4F	39.3

F = Field blank greater than 50% of the average uncorrected sample measurement.
\+ Napthalene is a suspected degradation product of a common contaminant to the XAD-2 resin used in the sampling train. Laboratory and field blanks contain napthalene at 28% to 82% of the sample values.

TABLE 3-5
SUMMARY OF ESP REMOVAL EFFICIENCIES AT SITE 112

Substance	Removal Efficiency, %	Uncertainty (as % Efficiency)
Total Particulate	77	8
Arsenic[3]	>53	NC
Barium	54	40
Beryllium	77	16
Cadmium	30	49
Chromium	57	18
Cobalt	75	10
Copper[2]	79	18
Lead[1][2]	53	21
Manganese[2],[4]	NC	NC
Mercury	83	46
Molybdenum[2],[7]	60	10
Nickel[8]	74	9
Phosphorus	68	10
Selenium[5]	NC	NC
Vanadium	78	14
Chloride[6]	NC	NC
Fluoride	5	46

Notes:

NC - not calculated.

(1) Field blank was greater than 50% of the average uncorrected sample measurement for ESP inlet samples.

(2) Field blank was greater than 50% of the average uncorrected sample measurement for ESP outlet samples.

(3) Arsenic not detected at ESP outlet, removal efficiency may be greater than the indicated value.

(4) Manganese detected at essentially the same level at the ESP inlet and outlet. Manganese results were 14.5 lb/10^{12} Btu at ESP inlet and 14.6 lb/10^{12} at the ESP outlet. ESP outlet levels are likely to be biased high based on high field blank results.

(5) Selenium not detected at ESP inlet or outlet.

(6) Chloride results were 2513 lb/10^{12} Btu at the ESP inlet and 3593 lb/10^{12} Btu at the ESP outlet. Removal efficiency is reported as 0%.

(7) Molybdenum levels at the ESP outlet may be biased high based on high field blank results.

(8) Nickel levels at the ESP outlet may be biased high due to possible contamination from a Teflon-coated stainless steel filter holder.

Calculation of removal efficiency confidence interval (C.I.) presented in Section 6.

SECTION 4.0

OTHER SPECIES DETECTED DURING METHOD EVALUATION TESTS

This section presents the results of the chromium and mercury speciation tests performed at Site 112.

4.1 CHROMIUM SPECIATION TESTS

Table 4-1 presents the results of the chromium speciation tests using the EPA recirculation train. This test series was considered an evaluation of the methodology because it was not known if the method was applicable to sources with high SO_2 emissions and low chromium emissions. This program represents the first application of this method to an oil-fired unit. The EPA methodology was modified to include periodic additions of potassium hydroxide to maintain the pH above 8.5. Maintaining the pH above this level should prevent the conversion of hexavalent chromium to the trivalent form.

Triplicate tests for hexavalent and total chromium were performed at the ESP inlet and ESP outlet. An isotopically labelled chromium spike, $^{51}Cr^{6+}$, was added to one run (run 8) to assess conversion during sampling. The conversion rate of $^{51}Cr^{6+}$ to $^{51}Cr^{3+}$ was 4% on the inlet sample, 55% on the outlet sample, and 2% on the field blank. There were no noted testing problems to account for the difference in conversion between the inlet and outlet samples. The conversion rate indicates that this methodology may be viable at this type of source with further development. This methodology may be suitable for total chromium determination as well. At the ESP inlet comparable results were obtained between the recirculation train and the multimetals train: chromium emissions at the ESP inlet were 9.1 $\mu g/Nm^3$ using the recirculation train and 10.4 $\mu g/Nm^3$ from the multimetals train. Comparison between the results of the recirculation train and the multimetals train at the ESP outlet was not possible due to a sample recovery error on the ESP outlet multimetals train.

The use of a 5N potassium hydroxide (5N KOH) in the recirculation train presented analytical difficulties. Total chromium results in the 5N KOH fraction were substantially higher than the hexavalent chromium results in the same fraction. According to the EPA methodology, the KOH fraction is filtered shortly after sampling so the KOH-insoluble trivalent chromium should be removed, and the extractable hexavalent chromium should remain in the solution. For this program, the total chromium results in the KOH solution were considered invalid based on previous experience with the ratio of total to hexavalent chromium in this fraction. Instead, hexavalent chromium was considered a better indicator of total chromium in the KOH fraction. Hexavalent chromium was used to calculate total chromium in the KOH fraction. The

TABLE 4-1
ESP INLET AND OUTLET CONCENTRATIONS OF TOTAL AND HEXAVALENT CHROMIUM EPA RECIRCULATION TRAIN METHOD EVALUATION TESTS SITE 112

Substance	Concentration, $\mu g/Nm^3$ Run 5	Run 6	Run 8	Mean	95% C.I.	% Conversion* of $^{51}Cr^{6+}$ to $^{51}Cr^{3+}$
ESP Inlet						
Total Chromium	9.3	8.8	9.3	9.1	1.5	
Hexavalent Chromium	1.24	ND(0.46)	ND(1.15)	ND(1.15)	NC	4
ESP Outlet						
Total Chromium	7.5	3.1	4.2	4.9	5.7	
Hexavalent Chromium	ND(0.48)	ND(0.61)	ND(1.07)	ND(1.07)	NC	55

* Run 8 only by radiochemical analysis
ND( ) species not detected.
NC - not calculated.
Note: This represents the first application of the EPA recirculation train to an oil-fired unit.

substituted value was added to the total chromium values from the other fractions to obtain a total chromium result for the whole train. The 5N KOH reagent blank indicated high levels of Cr^{6+} relative to the samples, however this blank was considered non-representative of the reagents used during this test series and was not subtracted from the sample values. Additional QA information for the chromium speciation tests is presented in Section 5.4.7.

4.2 MERCURY SPECIATION TESTS

Mercury emissions were first sampled with a multimetals train during a full traverse of the ESP inlet and outlet ducts, then again with a series of mercury speciation tests.

This test series measured ESP outlet mercury emissions data at a single point using three techniques:

1) A multimetals train that was analyzed specifically for mercury.

2) The Brooks Rand/Frontier Geosciences solid sorbent methodology using KCl/soda lime and iodated carbon traps for methyl mercury, mercury(II), and elemental mercury (Hg(0)).

3) The MIT activated carbon cartridge methodology for total mercury.

The Brooks Rand/Frontier Geosciences solid sorbent methodology and the MIT activated carbon cartridge methodology are experimental techniques. This program represents the first application of these techniques to an oil-fired unit. The Brooks Rand/Frontier Geosciences method was chosen for its potential to speciate mercury as methyl mercury, Hg(II) and Hg(0). The MIT method was chosen because of the low reporting limits afforded by INAA analysis.

In addition, a composite fuel oil sample was analyzed by Frontier Geosciences using CVAFS, by MIT using INAA and by a contract laboratory using CVAAS. Table 4-2 presents the results of the flue gas tests and the associated fuel analyses. Mercury concentration data from earlier multimetals tests at the ESP inlet and outlet, and fuel analyses are included for comparison. Mass balance data is included for reference.

Runs 5 and 6 of the MIT activated carbon method were invalidated by MIT due to sampling problems. Because this was an initial set up of the equipment, the carbon cartridges for these two runs became less tightly packed than was required for adequate absorption of mercury. The average total mercury concentration for the remaining two tests was 1.85 $\mu g/Nm^3$.

Mercury(II) and methyl mercury (species such as CH_3HgCl) concentrations were determined by dissolving the KCl-impregnated traps in an acetic acid/HCl mixture, followed by aqueous ethylation, separation by gas chromatography, and detection by CVAFS. Mercury(II) was detected as diethyl mercury and methyl mercury as methyl ethyl mercury. Subsequent

PRELIMINARY

TABLE 4-2
MERCURY RESULTS USING THREE EVALUATION TECHNIQUES, SITE 112

STREAM/SPECIES	Run 5	Run 6	Run 7A	Run 7B	Mean	95% C.I.
Flue Gas ESP Outlet, $\mu g/Nm^3$:						
Brooks Rand						
Hg(II)	ND(0.021)	ND(0.021)	ND(0.021)	ND(0.021)	ND(0.021)	NC
Hg(0)	ND(0.021)	ND(0.021)	ND(0.021)	ND(0.021)	ND(0.021)	NC
Methyl Mercury	0.015	0.003	0.015	0.013	0.012	0.009
Mercury, total[1]	0.036	0.025	0.036	0.034	0.033	0.009
MIT	void	void	1.97	1.73	1.85	1.54
Simultaneous Multimetals (Hg only)[2]	0.44	ND(1.12)	0.41		0.47	0.28
Fuel Oil, ug/g:						
Composite from Runs 5, 6, 7						
Brooks Rand (CVAFS)	0.0009					
MIT(INAA)	0.015					
CVAAS	ND(0.02)					

Multimetals, Runs 1, 2, 3:[3]	Run 1	Run 2	Run 3	Mean	95% C.I.
Flue Gas, ESP Inlet	1.12	2.95	1.03	1.7	2.7
Flue Gas, ESP Outlet	0.29	0.44	ND(0.41)	0.31	0.31
Fuel Oil, ug/g:					
MIT(INAA)	0.0028	0.0043	0.011	0.0060	0.0108
CVAAS	0.08	ND(0.02)	ND(0.02)	0.033	NC

Notes:

(1) The Brooks Rand total mercury was calculated as the sum of the Hg(II), Hg(0), and methyl mercury values. Non-detected values were used at one-half the reported value. The average mercury results from the multimetals tests used non-detect values at one-half the reporting limit.

(2) The simultaneous multimetals train was a separate train analyzed for mercury only. Mercury was also analyzed from the multimetals trains conducted during Runs 1, 2, and 3. Run 7 was performed at half load.
MIT data not available for Runs 5 and 6. Sampling problems caused the activated carbon cartridges to be less tightly packed than is required for adequate mercury absorption on the carbon.

(3) The multimetals tests during Runs 1,2,3 were full traverses of both the ESP inlet and outlet ducts. The mercury speciation tests during Runs 5,6,7 were conducted at a single point in the ESP outlet.

ND( ) - not detected at the reporting limit.
NC - not calculated

DO NOT CITE OR QUOTE

investigation by Fontier Geosciences has revealed that the method produces invalid results for methyl mercury; therefore, methyl mercury results are not reported in this report. Frontier Geosciences discovered that there is a reaction among acetate, sulfite, and Hg(II) that occurs during dissolution of the soda lime traps. This reaction has been shown to produce methyl mercury. Therefore the methyl mercury that was detected can be attributed in whole or in part to the Hg(II) collected in the KCl/soda lime traps. This report combines the results for methyl mercury and Hg(II) as a sum, termed oxidized mercury. The Brooks Rand/Frontier Geosciences method showed mean values for oxidized mercury and elemental mercury at 0.022 $\mu g/Nm_3$ and ND(0.021) $\mu g/Nm^3$, respectively.

The mean total mercury concentration shown by the simultaneous multimetals method was 0.47 $\mu g/Nm^3$. Mercury analysis by CVAAS has a higher reporting limit than INAA or CVAFS analysis.

The composite fuel sample results for total mercury were as follows:

MIT/INAA - 0.015 $\mu g/g$
Frontier Geosciences/CVAFS - 0.0009 $\mu g/g$
CVAAS - ND(0.02) $\mu g/g$

Due to the high reporting limits, CVAAS was not suitable for the determination of mercury in fuel oil. The results obtained from INAA and CVAFS analyses do not appear comparable to each other, yet both techniques offer a lower reporting limit than the conventional CVAAS procedure. The procedures for determining mercury in fuel oil by INAA and CVAFS are currently under development and are being evaluated by EPRI.

Data for mercury concentrations determined from the full traverse multi-metals tests (Runs 1,2,3) and the fuel collected during these tests is presented in Table 4-2 for comparison.

Table 4-3 presents a mass balance for the mercury speciation results and for the results of the full traverse multimetals tests. These mass balances were constructed with the fuel as the input stream and the flue gas at the ESP outlet as the only output stream. Other output streams were insignificant in the calculation of the mercury mass balance.

Additional mercury concentration data from Runs 1, 2 and 3 (from a full traverse) and the fuel collected during these tests is presented for comparison.

TABLE 4-3
MERCURY MASS BALANCE RESULTS
SITE 112

Mercury Speciation Tests	Average Emission Factors, lb/10^{12} Btu		Balance (Outlet/fuel)	Uncertainty,
	Fuel Oil	ESP Outlet	% Closure	% Closure
Brooks Rand ESP Outlet/Brooks Rand Fuel	0.048	0.03	63	5
MIT Esp Outlet/MIT Fuel	0.81	0.40	49	3
Sim. Multimetals/MIT Fuel	0.81	1.92	237	22
Primary Mass Balance				
Multimetals/MIT Fuel[1] (Runs 1,2,3)	0.32	0.24	73	37

Notes:

(1) These data represent the emissions from triplicate multimetals tests at the ESP outlet and the fuel oil collected during this period (Runs 1,2,3). The mercury speciation tests were conducted later in the program (Runs 5,6,7).

(2) These uncertainties do not include an uncertainty in the fuel oil analysis. An uncertainty in the fuel oil analysis could not be determined because only one sample was analyzed.

SECTION 5.0

DATA EVALUATION

Several procedures can be used to evaluate the information developed during a field sampling program. In the case of Site 112, three methods were used to evaluate data quality. First, the process data were examined to determine if the unit operated at normal, steady-state conditions during the sampling periods. Second, the QA/QC protocol for sampling and analytical procedures used at Site 112 (i.e. equipment calibration and leak checks, duplicates, blanks, spikes, standards, etc.) was evaluated. Site 112 QA/QC data were compared with FCEM project objectives. Data quality was evaluated using QA/QC measurements that assess bias, accuracy and precision, such as blank measurement, matrix spike recoveries, surrogate recoveries, replicate runs and laboratory control duplicates. Third, material balances were calculated around the boiler/ESP system. Material balances involve the summation and comparison of mass flow rates in several streams often sampled and analyzed by different methods. Closure within an acceptable range can be used as an indicator of accurate results for streams that contribute significantly to the overall inlet or outlet mass rates, such as the fuel oil and ESP outlet streams.

5.1 PROCESS OPERATION

Process operating data were examined to ensure that operation was stable during sampling periods. Measurements were available from control room instrumentation. Process operating data was collected at least two times a day except for July 23, when process data was collected once. Table 5-1 shows the key unit operating parameters and conditions. The coefficient of variation (CV) was calculated for each parameter to evaluate process variability over the three week test program.

Steady boiler operation was observed during the test program as indicated by the low CVs for the load, fuel flow and economizer exit oxygen levels. A graphical summary of load, fuel flow, economizer exit oxygen levels and ESP power levels is presented in Appendix E. The unit operated between 92 and 96% of full load. The maximum achievable load was limited by ID fan capacity limits. A mercury evaluation test (Run 7) was conducted at half load. ESP performance was normal, although the number of operating sections and ESP power levels fluctuated from day to day. Between one and four of sixteen ESP sections were out of service for each test. South side ESP power levels were lower than north side ESP power levels..

TABLE 5-1
SUMMARY OF UNIT OPERATION
SITE 112

Date	7/16/92	7/17/92	7/18/92	7/21/92	7/22/92	7/23/92	7/24/92	8/4/92	8/5/92	8/6/92	Mean	CV
Unit load, MW gross	362	366	366	365	367	360	364	355	374	371	365	1.5%
Steam flow, 10^6 lb/hr	2.45	2.46	2.47	2.45	2.5	2.4	2.46	2.37	2.27	2.30	2.41	3.2%
Fuel flow, lb/hr	180,000	182,000	NA	NA	182,000	192,000	178,000	160,000	167,000	166,000	177,000	5.6%
O_2, % N/S (economizer exit)	2.1/1.6	2.1/1.6	2.1/1.6	1.9/1.6	1.9/1.6	2.1/1.8	1.8/1.7	OOS/2.2	1.7/1.8	1.9/2.0	2.0/1.8	7.5%/12%
Opacity, %: 6-min. avg.	4	4	5	6	4	4	7	6	7	7	5	25%
ESP power, kVA**												
North	139	141	128	143	–	140	167	107	126	--	136	13%
South	73	104	72	103	–	79	73	57	55	–	77	23%
No. ESP sections in service (of 8): N/S	8/6	6/7	6/8	6/6	–	7/8	7/8	7/7	7/7	7/7	7/7	–

* Opacity readings are for south duct only for Tests 1-8 -- north duct opacity meter was out of service.
** kVA for ESP calculated with no power factor assumed.
Data for 7/22/92 from Test 6 only. Test 7 was a mercury evaluation test conducted at 50% load (187 MW). Detail is contained in Appendix E.
Fuel flow from plant instrumentation. Variability in fuel flow measurement is generally ±5% from expected fuel usage of a given load.
The coefficient of variation (CV) is the standard deviation divided by the mean.
NA: not available

5.2 SAMPLE COLLECTION

Several factors indicate the acceptable collection of gas samples. Key components of the sampling equipment -- pitot tubes, thermocouples, dry gas meters, and sampling nozzles were calibrated before use in the field. Dry gas meter calibrations were checked at the end of sampling. These and additional periodic equipment calibrations are on file at Carnot. The methods used to collect metals, particulate/anions and PAH samples were comparable to those used at other FCEM sites. The sampling runs were well documented, and these flue gas samples were collected at rates between 90 and 100% isokinetic. Typical flue gas conditions were 6-8% oxygen, 9 to 11% moisture, 330 to 350°F and flow rates of approximately 750,000 dscfm. These values are typical for an oil-fired utility boiler of this size.

Sufficient data were collected using standard sampling and analysis methods to ensure acceptable data completeness and the comparability of measurements. Major differences from other FCEM program were that benzene and toluene samples were collected according to CARB Method 410A in tedlar bags and formaldehyde samples were collected non-isokinetically according to CARB Method 430 in midget impingers containing 2,4-dinitrophenylhydrazine.

Flue gas entering the electrostatic precipitators was sampled at the twelve available test ports on the two ESP inlet ducts. Six vertical ports were available per duct. A total of 84 points were sampled for each isokinetic test. A horizontal port was installed on the ESP inlet location to allow use of the hexavalent chromium recirculation train. This sampling location did not meet EPA Method 1 requirements for minimum distances from flow disturbances. Three-dimensional velocity testing indicated that the location did not meet EPA Method 1, Section 2.5 criteria of ≤ 20 degrees resultant angle and ≤ 10 degrees standard deviation. The resultant angle was 10.2 degrees which met EPA Method 1 criteria, but the standard deviation was 11.9 degrees. The high standard deviation at this location reflects the high level of flow velocity stratification; twenty of eighty-four points did not have measurable velocity levels. Some modifications were made to the sampling procedures because of duct obstructions or air in-leakage into the duct. These are described in Appendix A.

Flue gas exiting the electrostatic precipitator was sampled at the eight available test ports on the two ESP outlet ducts. Four ports were available per duct. A total of 88 points were sampled for isokinetic tests. There were no accessible ports on the stack. The ESP outlet ports are positioned at an angle, so a horizontal port was installed for hexavalent chromium sampling with the EPA recirculation train. This sample location does not meet the EPA Method 1 criteria for minimum distances from flow disturbances, but does meet the resultant angle and standard deviation criteria. Three-dimensional velocity measurements indicated a resultant angle of 13.6 degrees with a standard deviation of 6.8 degrees. Some modifications were made to the sampling procedures because of duct obstructions and to maintain the in-stack filter used at this location at stack temperature.

There is a concern that there were sampling problems with benzene and toluene because the ESP inlet levels were lower than the ESP outlet levels.

Oil samples are considered to be representative of the oil fired during the flue gas sampling. Each oil sample analyzed was a composite of oil samples collected to bracket flue gas sampling periods.

Calculated exhaust gas flow rates were used for this site. The flow rates for this site are calculated from the unit heat rate and F-factor as:

Flow rate (dscfm) = (Gross MW - 12 MW aux power) * 9,776 Btu/net kw-hr * 9,000 dscf/10^6 Btu * 20.9/(20.9-%O_2) * hr/60 min * 1,000 kw/MW

This calculation was used because both pitot measurements and calculations based on the metered fuel flow rate were subject to higher levels of uncertainty than the average heat rate. The average heat rate of 9,776 Btu/net-kw-hr is within 3-4% of the actual heat rate at full load. The heat rate is calculated routinely at the facility from continuously monitored parameters. The average heat rate used for flow rate calculations was considered the current average value calculated during the test program.

On average, the pitot traverse flow rate results were 13.7% higher than the heat rate based flow rate results. This level of difference is typical for S-type traverses with flow angles of 10 to 15 degrees, and provides an indicator that using the heat rate method was appropriate. The phenomenon of positive biases in flow measurements obtained with S-type pitot tubes is documented in the reference "Flow and Gas Sampling Manual" by TRW prepared for the Industrial Environmental Research Lab in July 1976. According to this reference, S-type measurements have exhibited a positive bias of up to 15%.

Details on sample collection are contained in Appendix A (sampling and analytical summary). Process stream flow rates and conditions during testing are presented in Appendix D.

5.3 EVALUATION OF MEASUREMENT DATA QUALITY

An evaluation of the quality of the measurement data is based on quality control data obtained experimentally during sampling and analysis. Generally, the type of quality control information obtained that pertains to measurement precision, accuracy, and blank effects, is determined using various types of replicate, spiked, and blank samples. The specific characteristics evaluated depend on the type of quality control checks performed. For example, blanks may be prepared at different stages in the sampling and analysis process to isolate the source of a blank effect. Similarly, replicate samples may be generated at different stages to isolate and measure sources of variability. The QA/QC measures commonly used as part of the FCEM data assessment protocol, and the characteristic information obtained, are summarized in Table 5-2. The absence of any of these types of quality control checks from the data reports does not necessarily reflect poorly on the quality of the data, but does limit the ability to measure the various components of measurement error.

TABLE 5-2
TYPES OF QUALITY CONTROL SAMPLES

QC Activity	Characteristic Measured
Precision	
Replicate samples collected over time under the same conditions	Total variability, including process or temporal, sampling and analytical.
Duplicate field samples collected simultaneously	Sampling plus analytical variability at the actual sample concentrations.
Duplicate analyses of a single sample	Analytical variability at the actual sample concentrations.
Matrix- or media-spiked duplicates	Sampling plus analytical variability at an established concentration.
Laboratory control sample duplicates	Analytical variability in the absence of sample matrix effects
Surrogate-spiked sample sets	Analytical variability in the sample matrix but at an established concentration.
Accuracy	
Matrix-spiked samples	Analyte recovery in the sample matrix, indicating possible matrix interferences and other effects. In a single sample, includes both random error (imprecision) and systematic error (bias)
Media-spiked samples	Same as matrix-spiked samples. Used where a matrix-spiked sample is not feasible, such as certain stack sampling methods.
Surrogate-spiked samples	Analyte recovery in the sample matrix, to the extent that the surrogate compounds are chemically similar to the compounds of interest. Primarily used as an indicator of analytical efficacy.
Laboratory control standards (LCS)	Analyte recovery in the absence of actual sample matrix effects. Used as an indicator of analytical control.
Standard Reference Material	Analyte recovery in a matrix similar to the actual samples
Blank Effects	
Field Blank	Total sampling plus analytical blank effect, including sampling equipment and reagents, sample transport and storage, and analytical reagents and equipment.
Trip Blank	Blank effects arising from sample transport and storage. Typically used only for volatile organic compound analyses.
Method Blank	Blank effects inherent in analytical method, including laboratory reagents and equipment.
Reagent Blank or Field Reagent Blank	Blank effects from reagents used during sampling and analysis.

As shown in the table, different QC checks provide different types of information pertaining to the sources of inaccuracy, imprecision, or blank effects. As part of the FCEM project, measurement precision and accuracy are typically estimated from QC indicators that cover as much of the total sampling and analytical process as feasible. Precision and accuracy measurements are based primarily on the actual sample matrix. The precision and accuracy estimates obtained experimentally during the test programs are compared with data quality objectives (DQOs) established for the FCEM project.

These DQOs are not intended to be used as validation criteria, but they can be used as empirical estimates of the precision and accuracy that are expected from existing reference measurement methods. Although analytical precision and accuracy are relatively easy to quantify and control, sampling precision and accuracy are unique to each site and each sample matrix. Data that do not meet these objectives are not necessarily unacceptable. Rather, the intent is to document the precision and accuracy actually obtained; the objectives serve as benchmarks for comparison. The effects of not meeting the objectives should be considered in light of the intended use of the data.

5.4 ANALYTICAL QUALITY CONTROL RESULTS

Table 5-3 summarizes the types of quality control data reported for Site 112. The results of these analyses are summarized in Appendices G and H. Table 5-4 presents a summary of precision and accuracy measurements. Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of the sampling procedure.

Based on the quality control data evaluated, the majority of the results met the project objectives. No accuracy data were evaluated for the following analyses:

- Brooks Rand and MIT mercury speciation tests
- Fuel composition and fluorine

Duplicate, spiked and laboratory standards are typically performed with these analyses and there was no reason to conclude that the data reported were unacceptable. However, not enough information was available to unequivocally validate the data.

TABLE 5-3
TYPES OF QUALITY CONTROL DATA REPORTED
SITE 112

	Precision					Accuracy				Blank			
Analysis	Replicate Runs	Duplicate Field Samples	Duplicate Laboratory Analysis	Matrix or Media Spiked Duplicate	Laboratory Control Sample Duplicate	Matrix or Media Spike	Surrogate Spike	Laboratory Control Sample	Standard Reference Material	Field Blank	Trip Blank	Laboratory Method Blank	Reagent Blank (Field)
ESP Inlet and Outlet Gas													
Metals	✓		✓		✓	✓		✓		✓		✓	✓
Particulate	✓												✓
Particulate Size Distribution	✓												✓
Anions	✓		✓			✓		✓					✓
Polycyclic Aromatic Hydrocarbons	✓		✓	✓		✓	✓			✓		✓	
Volatile Organic Compounds	✓		✓			✓							
Formaldehyde	✓		✓	✓		✓		✓		✓	✓	✓	
Total and Hexavalent Chromium by EPA Recirculation Train	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓
Mercury Evaluation:													
Multi-metals	✓		✓			✓		✓				✓	✓
Brooks Rand	✓		✓										
MIT	✓								✓			✓	
Fuel Oil													
Metals by ICP-AES, GFAAS and CVAAS	✓		✓			✓		✓	✓			✓	
Metals by INAA	✓								✓				
Chlorine													
Fluorine													
Sulfur													
Ultimate and Heating Value								✓					
Bottom Ash													
Metals by ICP-AES, GFAAS and CVAAS			✓			✓		✓				✓	
Chloride			✓			✓		✓				✓	
Fluoride			✓			✓		✓				✓	
Sulfur													
Polycyclic Aromatic Hydrocarbons			✓				✓					✓	

TABLE 5-4
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
Site 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Metals in ESP Outlet Gas	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Arsenic		10% RPD	75-125%	NC	MSA
Barium		10% RPD	75-125%	3% RPD	3%
Beryllium		10% RPD	75-125%	2% RPD	64%
Cadmium		10% RPD	75-125%	4% RPD	69%
Chromium		10% RPD	75-125%	NC	NM
Cobalt		10% RPD	75-125%	2% RPD	41%
Copper		10% RPD	75-125%	2% RPD	49%
Lead		10% RPD	75-125%	23% RPD	NM
Manganese		10% RPD	75-125%	2% RPD	52%
Mercury		10% RPD	75-125%	16% RPD	103%
Molybdenum		10% RPD	75-125%	3% RPD	48%
Nickel		10% RPD	75-125%	2% RPD	48%
Phosphorus		10% RPD	75-125%	9% RPD	114%
Selenium		10% RPD	75-125%	NC	NP
Vanadium		10% RPD	75-125%	5% RPD	NM
Mercury from Separate Multi-metal train		10% RPD	75-125%	12% RPD	94%
ESP Inlet Metals					
Arsenic		10% RPD	75-125%	See Outlet Gas	MSA
Barium		10% RPD	75-125%		14%
Beryllium		10% RPD	75-125%		108%
Cadmium		10% RPD	75-125%		84%
Chromium		10% RPD	75-125%		80%
Cobalt		10% RPD	75-125%		75%
Copper		10% RPD	75-125%		83%
Lead		10% RPD	75-125%		21%
Manganese		10% RPD	75-125%		81%
Mercury		10% RPD	75-125%		103%
Molybdenum		10% RPD	75-125%		83%
Nickel		10% RPD	75-125%		81%
Phosphorus		10% RPD	75-125%		NP
Selenium		10% RPD	75-125%		NP
Vanadium		10% RPD	75-125%		101%

(continued)

Precision for metals was measured as duplicate analyses and replicate runs. Replicate runs results are contained in Appendix F.
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy for metals was assessed by post-digestion and pre-digestion laboratory spikes. This table is based on post-digestion laboratory spikes except for mercury. Additional information is contained in Appendix H.

RPD = Relative Percent Difference.
NA = Not available.
NC = Not calculated; analyte reported as not detected in two or more runs.
NM = Not meaningful, spike level was too low to measure accurately.
MSA = Sample analysis performed by method of standard additions.
NP = Not performed.
Chromium not used at Outlet; see chromium evaluation test results.

PRELIMINARY

DO NOT CITE OR QUOTE

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
PAH in ESP Outlet Gas (detected species)	Precision - Matrix Spike Duplicate Accuracy - Pre-extraction Surrogate Spikes				
Naphthalene		50% RPD	50-150%	NP	52%
Fluorene		50% RPD	50-150%	0.0% RPD	73%
Phenanthrene		50% RPD	50-150%	4% RPD	86%
2-Methylnaphthalene		50% RPD	50-150%	NP	NA
PAH in Inlet Gas (detected species)	Precision - Duplicate Analysis Accuracy - Pre-extraction Surrogate Spikes				
Naphthalene		50% RPD	50-150%	NP	62%
Fluorene		50% RPD	50-150%	0.0% RPD	82%
Phenanthrene		50% RPD	50-150%	4% RPD	93%
2-Methylnaphthalene		50% RPD	50-150%	NP	NA
Anions in ESP Outlet Gas	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Chloride		15% RPD	80-120%	See Inlet Gas	64-98%
Fluoride		15% RPD	80-120%		94-137%
Sulfate		15% RPD	80-120%		96-124%
Anions in ESP Inlet Gas	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Chloride		15% RPD	80-120%	10% RPD	See Outlet Gas
Fluoride		15% RPD	80-120%	36% RPD	
Sulfate		15% RPD	80-120%	4% RPD	

(continued)

Precision for PAH analyses also determined by replicate runs (Appendix F)
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy for PAH analyses also determined by pre-sampling surrogate spikes (field spikes) and blank matrix spikes.
Precision for Anions also determined by replicate runs (Appendix F)
Accuracy for Anions determined from spike recovery in each sample train fraction. Results presented here are the range of spike recoveries reported.
RPD = Relative Percent Difference.
NA = Not Available, method of internal standardization was used.
NP = Not Performed
NC = Not Calculated: analyte reported as not detected in two or more runs.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Formaldehyde in ESP Outlet Gas	Precision - Replicate Runs Accuracy - Spiked Samples	10% RPD	60-140%	0.3% RPD	160%
Formaldehyde in ESP Inlet	Precision - Replicate Runs Accuracy - Spiked Samples	10% RPD	60-140%	2% RPD	208%
Benzene and Toluene in ESP Outlet Gas	Precision - Replicate Runs Accuracy - Spiked Samples				
Benzene		20% RPD	70-130%	42% RPD	97%
Toluene		20% RPD	70-130%	2% RPD	101%
Benzene and Toluene in ESP Inlet Gas	Precision - Replicate Runs Accuracy - Spiked Samples				
Benzene		20% RPD	70-130%	8% to RPD	See Outlet Gas
Toluene		20% RPD	70-130%	17% to RPD	

(continued)

Precision for Formaldehyde also assessed by replicate runs and multiple pre- and post- test reagent blanks (Appendices E and F).
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy for Formaldehyde determined from field spikes. A trip spike indicated 118% recovery.
Precision for Benzene and Toluene also determined by replicate runs (Appendix F).
Benzene and toluene spike performed on ESP outlet gas sample only. Flue gas should not be substantially different at ESP inlet.
RPD = Relative Percent Difference.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Particulate, ESP Outlet Gas	Precision - Replicate Runs Accuracy - NBS Traceable Weights				
Particulate		20% CV	95-105%	10.3% CV	95-105%
Particulate, ESP Inlet Gas	Precision - Replicate Runs Accuracy - NBS Traceable Weights				
Particulate		20% CV	95-105%	12.2% CV	95-105%

(continued)

Precision for Particulate tests includes EPA allowable variance of 0.5 mg for duplicate weights.
Measured Precision for Particulate Size distribution tests expressed an average for all collection stages.
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy of 95-105% assumes maximum EPA allowable variance of 0.5 mg and 10 mg sample size. Actual use of NBS traceable weights requires 99-101% accuracy.
CV = Coefficient of variation. Duplicate analyses were not available.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Mercury Evaluation Tests, ESP Outlet Gas					
Brooks Rand	Precision - Replicate Runs Accuracy - NA				
Hg (total)		20% CV	70-130%	17% CV	NA
Hg (II)		20% CV	70-130%	NC	NA
Hg (0)		20% CV	70-130%	NC	NA
Methylmercury		20% CV	70-130%	49% CV	NA
MIT	Precision - Replicate Runs Accuracy - NA				
Hg (total)		20% CV	70-130%	9% RPD	NA
ESP Outlet, Chromium Recirculation Train Evaluation	Precision - Replicate Runs Accuracy - spiked samples % Conversion - $^{51}Cr^{6+}$ to $^{51}Cr^{3+}$ (Run 8 only)				
Hexavalent chromium		20% CV	75-125%	42% CV	102%
Total chromium		20% CV	75-125%	46% CV	99%
				Conversion:	55%
ESP Inlet, Chromium Recirculation Train Evaluation	Precision - Replicate Runs Accuracy - spiked samples % Conversion - $^{51}Cr^{6+}$ to $^{51}Cr^{3}$ (Run 8 only)				
Hexavalent chromium		20% CV	80-120%	37% CV	102%
Total chromium		20% CV	80-120%	3% CV	99%
				Conversion:	4%

(continued)

NA: not available.
NC: not calculated, analyte reported as not detected.
Precision for Cr and Cr^{6+} also assessed from duplicate analyses and duplicate spike analyses.
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy for total chromium in filtrant (filtered solids) only.
Accuracy for hexavalent chromium also assessed using EPA audit spike on one-half of KOH solution on runs 5-IN and 5-OUT. Results were 117% and 107% recovery.
CV = Coefficient of variation. Duplicate analyses were not available.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Metals in Oil by ICP-AES	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Beryllium		10% RPD	75-125%	2% RPD	84%
Cadmium		10% RPD	75-125%	0.2% RPD	82%
Copper		10% RPD	75-125%	0.2% RPD	80%
Lead		10% RPD	75-125%	4% RPD	80%
Nickel		10% RPD	75-125%	2% RPD	NM
Phosphorus		10% RPD	75-125%	29% RPD	107%
Metals and Cl in Oil by INAA	Precision - Replicate Runs Accuracy - Standard Reference Material NIST 1634b				
Arsenic		20% CV	75-125%	17% CV	125%
Barium		20% CV	75-125%	15% CV	288%
Cobalt		20% CV	75-125%	37% CV	113%
Chromium		20% CV	75-125%	12% CV	106%
Manganese		20% CV	75-125%	9% CV	78%
Mercury		20% CV	75-125%	55% CV	135%
Molybdenum		20% CV	75-125%	8% CV	NA
Selenium		20% CV	75-125%	24% CV	78%
Vanadium		20% CV	75-125%	15% CV	88%
Chloride		20% CV	75-125%	10% CV	NA
Mercury in Oil by CVAFS (Brooks Rand)	Precision - NA Accuracy - Matrix Spike	10% RPD	75-125%	NA	99.4%
Fluorine and Sulfur in Fuel Oil	Precision - Replicate Runs Accuracy - Laboratory Control Sample for Sulfur				
Fluorine		20% CV	80-120%	NC	NA
Sulfur		20% CV	90-100%	2% CV	100.2

(continued)

Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.

NA = Not available
NC = Not calculated, analyte reported as not detected
NM = Not meaningful, spike level too low. Accuracy based on NIST 1634b is 87%.
RPD = Relative Percent Difference
CV = Coefficient of variation. Duplicate analyses were not available.

Metals analyses by ICP-AES presented here are those used in the final calculations. Additional metals data is presented in Appendices C, G, and H. Precision also determined by replicate runs.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Metals in Furnace Hopper Ash	Precision - Duplicate Analysis Accuracy - Spiked Laboratory Method Blanks				
Arsenic		10% RPD	75-125%	9% RPD	106%
Barium		10% RPD	75-125%	9% RPD	96%
Beryllium		10% RPD	75-125%	1% RPD	111%
Cadmium		10% RPD	75-125%	30% RPD	102%
Chromium		10% RPD	75-125%	32% RPD	101%
Cobalt		10% RPD	75-125%	17% RPD	90%
Copper		10% RPD	75-125%	41% RPD	93%
Lead		10% RPD	75-125%	20% RPD	97%
Manganese		10% RPD	75-125%	1% RPD	100%
Mercury		10% RPD	75-125%	NC	106%
Molybdenum		10% RPD	75-125%	4% RPD	95%
Nickel		10% RPD	75-125%	2% RPD	99%
Selenium		10% RPD	75-125%	NC	113%
Phosphorus		10% RPD	75-125%	NA	90%
Vanadium		10% RPD	75-125%	3% RPD	93%
Anions in Furnace Hopper Ash	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Chloride		20% RPD	80-120%	NC	109%
Fluoride		20% RPD	80-120%	NC	65%
Sulfur		20% RPD	80-120%	NA	NA

NA = Not available
NC = Not calculated, sample value was not detected.
RPD = Relative Percent Difference.

Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.

Metals spike recovery data not available for metals in ash. The spike level was too low relative to the concentration of metals in the ash. Accuracy reflects recovery of spiked laboratory method blanks.

TABLE 5-4 (cont'd)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 112

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
PAH in Furnace Hopper Ash (detected species)	Precision - Duplicate Analysis Accuracy - Pre-Extraction Surrogate Spikes				
Fluorene		50% RPD	50-150%	0% RPD	90%
Phenanthrene		50% RPD	50-150%	16% RPD	98%
Anthracene		50% RPD	50-150%	50% RPD	66%
Fluoranthene		50% RPD	50-150%	8% RPD	135%
Pyrene		50% RPD	50-150%	10% RPD	100%
2-Methylnaphthalene		50% RPD	50-150%	27% RPD	NA

RPD = Relative Percent Difference.
NA = Not Available.
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.

The following potential problems were highlighted by the quality control data:

- Formaldehyde results may be biased high because an accurate assessment of the overall method blank level could not be determined. Because both field and trip blanks had formaldehyde levels similar to the samples the more conservative approach of correcting for the laboratory reagent blank was used.

- The sample matrix prevented accurate analysis of acenaphthylene and anthracene in the ESP inlet samples and acenaphthylene, anthracene and benzo(a)pyrene in the ESP outlet samples. Reported values can be interpreted as biased low or as having a lower than normal reporting limit. In these cases where these PAH could not be accurately quantitated, the deuterated standard recovery was uniformly less than 20%, and the species were not detected in the samples. "Recovery corrections," that is adjusting the reported value based on low or high surrogate recovery were not performed. In addition to the PAH species discussed above, other internal standard recoveries were lower than acceptable (<50%) for some tests. Results were recovery corrected in these cases. The overall emissions values are not considered to be impacted by these isolated low recovery results.

- Blank corrections to ESP inlet and outlet lead results are significant at 42% and 40%, respectively, of the original uncorrected value. The cause of high blank levels were in the laboratory digestion step of the procedure.

- Napthalene is a suspected degradation product of a common contaminant to the XAD-2 resin used in the PAH sampling train. (Thomson, R.D., Foster, M.G., "Degradation of XAD-2 Resin in Dry Storage and Its Impact On PAH Analysis," AWMA 1991.) Laboratory and field blanks contain napthalene at 28% to 82% of the sample values.

- Post digestion spike recoveries for metals are low on ESP outlet samples because the spiking level was not sufficiently greater than the sample values. A spike that is significantly higher than the sample value is needed to obtain meaningful results. Spiked blanks and spiked inlet samples do not indicate an overall low bias to the metals measurements or problems unique to the sample matrix.

- Metals that may have a low bias based on spike recoveries for ESP inlet and outlet samples are lead and barium.

- Total chromium results in the 5N KOH fraction of the chromium recirculation train were substantially higher than the amount of hexavalent chromium measured in this fraction and are considered invalid. According to the EPA methodology, the KOH fraction is filtered shortly after sampling so the KOH-insoluble trivalent

chromium should be removed, and the extractable hexavalent chromium should remain in solution. There is not sufficient information to support the total chromium values obtained in this sample fraction since spike analyses were performed only for hexavalent chromium in this sample fraction. Analytical difficulties with total chromium analysis in strongly caustic solutions are suspected based on previous experience with the ratio of total to hexavalent chromium in this sample fraction. For this test series, the hexavalent chromium measurement was considered a better indicator of total chromium in this sample fraction.

- Metals reported at significant concentrations in the field blank compared to the ESP outlet samples were copper, lead, manganese and molybdenum.

- The accuracy of the INAA analysis for metals in fuel oil needed to be determined. Fuel oil standard 1634b was analyzed by INAA and by conventional techniques (ICP-AES, GFAAS or CVAAS). The results of the comparison are presented in Appendix G. In general, the INAA technique was reproducible and accurate. INAA results were used where possible.

The following potential problems were determined by evaluation of the data with respect to ESP performance and mass balance considerations:

- ESP inlet and outlet benzene and toluene measurements may be biased low.

- ESP outlet chromium measurement from the multimetals trains are biased high. These data were not used. Total chromium results from the EPA recirculation train provide a better chromium emissions estimate.

- ESP outlet manganese and molybdenum measurements from the multimetals trains may be biased high. Field blank levels of these species are similar to some samples.

An additional concern in that the total amount of trace species contributed by the furnace hopper ash and the boiler wash is more uncertain than the exhaust gas or fuel sample measurements. As discussed previously, the furnace hopper ash flow rate was highly variable and the boiler wash results are considered low because large amounts of the wash were not sampled.

Definition of Quality Assurance Terms

Presented below is a general discussion of considerations to be used when evaluating data and definitions of terms used to describe quality assurance indicators.

Precision is a measure of the reproducibility of laboratory analyses of the same sample. It is expressed in terms of distribution or scatter of the data, and traditionally calculated as the standard deviation or coefficient of variation (CV, standard deviation divided by the mean). For duplicate analysis, precision is expressed as the relative percent difference (RPD).

$$RPD = \frac{x_1 - x_2}{\bar{x}} \times 100$$

Accuracy is a measure of the degree of conformity of a value generated by a specific procedure to the assumed or accepted true value; it includes both precision and bias. Bias is the persistent positive or negative deviation of the method average value from the assumed or accepted true value.

The efficacy of the analytical procedure for a given sample matrix is quantified by the analysis of spiked samples containing target or indicator analytes or other quality assurance measures, as necessary. However, all spikes, unless made to the flowing stream ahead of the sampling, produce only estimates of recovery of the analyte through all of the measurement steps occurring after the addition of the spike. A good spike recovery tells little about the true value of the sample before spiking.

Representativeness expresses the degree to which sampling data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. The representativeness criterion is based on making certain that sampling locations are properly selected and that a sufficient number of samples are collected.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sampling data should be comparable with other measurement data for similar samples collected under similar conditions. This goal is achieved using standard techniques to collect and analyze representative samples and by reporting analytical results in appropriate units. Data sets can be compared with confidence when the precision and accuracy are known.

Completeness is an expression of the number of valid measurements obtained compared with the number planned for a given study. The goal is to generate a sufficient amount of valid data.

A discussion of the overall measurement precision, accuracy, and blank effects is presented below for each measurement type. Complete QA/QC data is presented in Appendix G. Appendix H presents analytical and blank correction data. Table H-12 contains a summary of blank correction contributions to the sample values.

5.4.1 Metals

Precision

The precision of metals analyses of flue gas samples can be estimated by the results of duplicate laboratory analyses. The precision data on duplicate analyses of an outlet sample were compared to the data quality objective (DQO) of 10% RPD. The only metal exceeding 10% RPD was lead at 23% RPD. Arsenic and selenium were not detected so precision was not calculated for these species.

Precision for flue gas metals was also calculated based on replicate runs. This measure of precision should be more variable than duplicate analyses due to the added variability in process operation and sampling. The precision data on replicate runs were compared to a typical objective of 20% CV.

The metals results at the ESP outlet did not meet the 20% CV objective except for lead at 17% CV. The coefficient of variation for all ESP outlet metals ranged from 17-110%. This indicates that the outlet results were subject to greater variability than expected.

The range of CV values for ESP inlet metals was 3-64%. The following metals did not meet the DQO for replicate runs: arsenic, barium, cadmium, lead, manganese and mercury.

Precision of fuel oil metal results analyses was calculated from laboratory duplicate analyses and from the results of three oil samples. Metals analyzed by ICP-AES (Be, Cd, Cu, Pb, Ni, P) all met the precision objective of 10% RPD except for phosphorus at 29% RPD. Precision for metals analyzed by INAA was acceptable at <20% CV except cobalt and mercury.

Precision of metals analyses in ash samples is estimated from duplicate laboratory analysis of one ash sample. Only cadmium, chromium and copper exceeded the 20% RPD precision guideline.

In general, the precision data obtained for all metals analyses indicates that the laboratory analyses were of acceptable quality. Some variability on the ESP outlet and inlet gas samples may be due to blank effects as discussed below.

Accuracy

The accuracy of metals analyses in flue gas was estimated from spiked samples. A spike recovery objective of 75-125% is specified by the multi-metals method. One inlet and one outlet sample was spiked after digestion and before analysis. Typically, if the recovery is not within ± 25% of nominal, the laboratory attempted to analyze the sample using either an alternate instrumental technique or by the method of standard additions (MSA).

Spike recoveries for ESP outlet samples ranged from 41-114% recovery, excluding barium that had 3% recovery. The spike recovery on ESP outlet samples was lower than objectives, however, in this case low recovery does not indicate a potential low bias to the analytical results. Low metals recoveries were caused by adding a low spike level of the analyte to the samples. In many cases this low spike level was indistinguishable from the metal content of the samples.

The spike recoveries of the ESP inlet samples are acceptable, except for barium (14%) and lead (21%). These samples were spiked at the correct level so accurate spike recovery results could be generated. The ESP inlet samples are the same sample type as the ESP outlet gas samples so it can be concluded that spike recoveries are acceptable for flue gas samples, with only barium and lead results demonstrating analytical difficulties.

Additionally, a pre-digestion spike was added to a blank sample to demonstrate that there were no gains or losses of metals in the analytical procedure. Pre-digestion spike recoveries were acceptable for all metals except selenium (39%).

The accuracy of metals analysis in fuel oil was estimated from spiked samples for ICP-AES analysis and from standard reference material NIST 1634b (metals in fuel oil) analysis for INAA. The NIST 1634b has certified values for only a select number of metals. The ICP-AES spike recoveries ranged from 80-107%. Nickel was spiked at too low a level to obtain meaningful results. INAA results on NIST 1634b ranged from 78-125% for all metals except mercury and barium. Mercury results were 0.0014 μg/g or 135% of the uncertified recommended NIST value of ND$<$0.001 μg/g. Barium was 288% of the uncertified recommended value, however, similar results were obtained by ICP-AES analysis for this element.

The accuracy of metals in ash was not estimated in the sample matrix. Spiked laboratory method blanks were evaluated and were acceptable at 90-113%.

Blank Effects

Field blank metals levels were greater than 50% of the uncorrected sample value for lead in ESP inlet samples, and lead, copper, manganese and molybdenum in the ESP outlet samples. Lead laboratory preparation blanks were at similar levels indicating a fairly uniform background lead level for all samples. Manganese and molybdenum reagent blank levels were low relative to sample values. Manganese and molybdenum results therefore appear to be biased high due to field handling rather than laboratory preparation. Though not to the same degree, copper results also indicate that the results were impacted by field rather than laboratory handling.ESP outlet chromium samples from the multimetals train were invalidated because of field contamination from the in-stack filter holder. Other blank levels are not significant compared to sample levels.

Blank levels on laboratory blanks performed during the fuel analysis by ICP-AES and CVAAS were below 20% of the sample value except for mercury. The blank correction to the fuel mercury values by CVAAS was 69% of the original value.

Blank levels on laboratory blanks performed during the ash analysis by ICP-AES were uniformly low and were not subtracted from the results.

Conclusions

Flue gas sample blank effects have the most impact on the interpretation of manganese and molybdenum ESP outlet sample results. These results are considered to be biased high. Other flue gas metals analyses are considered acceptable and within the variability of the sampling and analytical methods.

5.4.2 Anions

Precision

ESP inlet and outlet samples indicated acceptable precision of < 15% RPD for chloride and sulfate. Laboratory precision was not calculated for fluoride since it was not detected in either replicate.

Replicate runs indicated acceptable precision of less than 20% CV for chloride and sulfate. Fluoride did not meet the DQO at 68% CV for outlet samples and 48% CV for inlet samples.

Precision in oil samples for chlorine and sulfur were estimated from replicate runs. Both anion precursors showed acceptable precision at 15% CV for chlorine and 2% CV for sulfur. Fluorine was not detected in the fuel oil. Precision could not be calculated for anions in the ash because chloride and fluoride were below the detection limit, and the sulfur result was from a single analysis.

Accuracy

The accuracy of anion analyses in ESP inlet and outlet samples was estimated from spiked samples. The anion train involved three matrices: solids extracted with water, a sodium bicarbonate/sodium carbonate impinger solution and a 3% peroxide solution. A spiked sample analysis was performed for each anion. Recovery results were: chloride 64-98%, fluoride 94-137%, sulfate 96-124%. Although some values are out of the range of 80-120% set as the objective, there were no apparent analytical difficulties. Not meeting the QA/QC objective did not invalidate the results.

Accuracy for sulfur in fuel was estimated from replicate laboratory control samples. The average recovery was 100.2%. Accuracy estimates for other anion precursors in fuel were not

reported, however, laboratory check samples are routinely verified during these analyses. The furnace hopper ash sample was spiked and the recovery was 109% for chloride and 65% for fluoride.

Blank Effects

No blank effects were noted for exhaust gas, fuel or ash samples. Blank values were below the detection limit for all sample matrices.

Conclusion

It should be noted that although there are no apparent analytical difficulties, chloride concentrations in the ESP inlet and outlet exhaust gas are approximately two times higher than is possible from the chlorine content of the fuel.

5.4.3 Polycyclic Aromatic Hydrocarbons

Precision

Four PAH species were detected in the ESP inlet and outlet gas (naphthalene, fluorene, phenanthrene and 2-methylnaphthalene). A DQO of 50% RPD was set for PAH samples because of the high relative uncertainties in the analysis of extremely trace species. Measured laboratory precision of matrix spike duplicates met the 50% DQO for both fluorene and phenanthrene. A matrix spike for 2-methylnapthalene was not performed. Matrix spike duplicate analysis results for Napthalene were not available.

The measured precision for replicate runs met the 50% DQO except for 2-methylnapthalene at the ESP inlet at 60% CV and fluorene at the ESP outlet at 107% CV.

Precision for PAH species for the ash sample was obtained by a duplicate analysis of the sample. Six PAH species were detected in the ash: fluorene, phenanthrene, anthracene, fluoranthene, pyrene and 2-methylnaphthalene. Precision on the duplicate analysis of these species was 0-50% RPD.

Additional precision data for PAH analysis can be derived from evaluation of duplicate matrix spikes and duplicate analysis of standards. Matrix spikes for PAH are spiked resin media spiked with native and deuterated PAH species and not spiked samples. These samples also demonstrated acceptable precision.

Accuracy

The accuracy of the PAH analyses is assessed by the recovery of labelled surrogate compounds added to each sample before extraction. Acceptable recovery of the surrogate is 50-150%. The recovery for all detected PAH species was acceptable, ranging from 52-93%. As

discussed previously, surrogate recoveries were low for three PAH species that were not detected: acenaphthylene, anthracene, and benzo(a)pyrene. Recoveries of these species in field blanks and laboratory matrix blanks show no pattern of analysis problems. The low recoveries for these PAH species indicate that these species may not be accurately quantified in some of the samples. The field spikes added before sampling were all acceptable and ranged from 63-81% recovery. PAH surrogate recovery from ash samples was acceptable.

Blank Effects

Laboratory and field blanks contain naphthalene at 28% to 82% of the sample values. Naphthalene is a suspected degradation product of a common contaminant to the XAD-2 resin used in the sampling train. Typically all samples using this resin are biased high; however, it is difficult to evaluate the extent of the high bias. Field blank levels of phenanthrene were approximately 15% of the sample values. No other laboratory or field related blank levels were noted.

Conclusion

PAH analysis is acceptable, except for analysis of acenaphthylene, anthracene and benzo(a)pyrene, however, no estimate of measurement bias can be concluded from these results.

5.4.4 Formaldehyde

Precision

Duplicate analyses of ESP inlet and ESP outlet formaldehyde samples indicated acceptable precision at less than 10% RPD.

ESP outlet replicate runs had precision of 118% CV, which failed to meet the 20% CV objective. The outlet test results were highly variable at 3.44, 7.82, and 41.1 $\mu g/Nm^3$. ESP inlet replicate runs had acceptable precision at 8% CV.

Accuracy

Accuracy was estimated from field spikes. A field spike is a formaldehyde spiked vial of DNPH solution that is connected to the sampling equipment, leak checked and recovered. It is therefore exposed to the ambient air and field conditions in a similar manner to the sample. Spike recovery was 160% at the outlet and 208% at the inlet. These recoveries exceed the method specification of 60-140% recovery. Recovery from a trip spike (spiked DNPH vial that is never opened) was 118%. There is a high bias to all spike results.

Blank Effects

Formaldehyde field blank levels were at the same concentration or higher than sample values. Field blanks are collected in the same manner as described for the field spikes. Because there was no consistent and traceable contribution of formaldehyde, these blank levels were not subtracted from the results. Laboratory reagent blank levels were low and were subtracted from the results. The average blank correction from the laboratory reagent blank was 30% on inlet samples and 46% on outlet samples.

Conclusion

Formaldehyde samples are considered to be biased high because: (1) spike recovery and field blank levels are uniformly higher than expected and (2) the ESP outlet gas samples were variable with one run that was seven times higher than the average of the remaining two runs.

5.4.5 Benzene and Toluene

Precision

Duplicate analyses of benzene indicated acceptable precision for ESP inlet samples at 2% RPD. ESP outlet duplicates failed to meet the DQO with 43% RPD. The ESP outlet samples were low (near reporting limit) ranging from 2.5 to 3.9 $\mu g/Nm^3$. Toluene duplicate analyses yielded acceptable precision at <20% RPD.

Precision of benzene measurements as assessed by replicate runs was 22% CV for ESP outlet samples and 47% CV for ESP inlet samples. Replicate runs indicated precision for toluene of 65% CV at the ESP outlet and 39% CV at the ESP inlet.

Accuracy

Analytical accuracy for the benzene and toluene samples was estimated from a spiked sample. After analysis a known volume of one outlet sample was spiked with a known volume of a benzene and toluene standard gas. This spike was used to measure potential matrix effects and assess the accuracy of the analysis. Recovery of benzene was 97% and recovery of toluene was 101%.

Blank Effects

Laboratory blank levels were below the detection limit for benzene and toluene analysis. Field blank levels were not evaluated.

Conclusions

The analysis of benzene at the ESP outlet appear accurate and consistent. ESP outlet toluene values are highly variable. The benzene and toluene inlet results are lower than the outlet results, causing concern that there may have been a sampling problem.

5.4.6 Particulate

Precision

Measured precision for particulate samples was 7% RPDM for ESP outlet samples and 9% RPDM for ESP inlet samples.

Accuracy

EPA Method 5 procedures for gravimetric analysis were used. These procedures generally have laboratory accuracy of 95-105% and overall accuracy of 85%-115%.

Blank Effects

Acetone reagent blanks were subtracted from the front-half particulate catch of the particulate tests. Blank correction contributions were not significant and averaged less than 1% for the particulate tests.

Conclusion

Particulate tests met standard criteria for acceptability.

5.4.7 Method Evaluation Tests

Mercury Evaluation (Brooks Rand and MIT)

Precision

Both mercury evaluation techniques had measured precision for total mercury of $<20\%$ CV for replicate runs. Methyl mercury measurements by the Brooks Rand methodology had a calculated precision of 49% CV. It should be noted that methyl mercury was the only mercury compound detected above the detection limit with the Brooks Rand train.

Accuracy

No accuracy data was reported for the flue gas samples by Brooks Rand or MIT. However, both laboratories routinely perform analyses of standard reference materials and spiked samples.

Brooks Rand reported accuracy of the mercury concentration in fuel oil by the analysis of a matrix spike. Recovery was calculated at 99.4%.

MIT determined accuracy of mercury in fuel oil by analyzing NIST Standard Reference Material 1634b Recovery was calculated at 135%. The mercury value of SRM 1634b is an uncertified informational value of <0.001 μg/g.

Blank Effects

Both Brooks Rand and MIT reported data that was blank corrected. Brooks Rand performed multiple reagent blanks and proofed laboratory glassware as additional method blanks. MIT performs a blank analysis on the lot of activated carbon used in the sample cartridge. The blank correction is then calculated from the mass of carbon used in each test cartridge.

Chromium Evaluation Tests

Precision

Precision results were acceptable considering the developmental nature of this sampling procedure. Precision for hexavalent chromium was 42% CV for the ESP outlet samples and 37% CV for the ESP inlet samples. Precision for total chromium was 46% CV for the ESP outlet samples and 3% CV for the ESP inlet samples.

Accuracy

Analytical accuracy for hexavalent chromium was estimated by analyzing samples spiked in the laboratory and by analyzing a sample spiked in the field with an EPA audit sample. Hexavalent chromium recovery of the laboratory spiked samples averaged 102%. Hexavalent chromium recovery of the EPA audit sample was 117% on an inlet sample and 107% on an outlet sample.

Analytical accuracy for total chromium analysis was estimated from spiked samples. Spike results averaged 99% recovery. Because total chromium is expected to be found in the filtered solids and acid rinse of the train, spikes were performed on the solid fraction, but not the potassium hydroxide fraction. The analytical accuracy of total chromium measurements in 5N potassium hydroxide was not evaluated during this test series.

An additional check of the overall accuracy of the hexavalent chromium recirculation train was made using labelled Cr^{6+} during one sampling run. Conversion of the labelled Cr^{6+} was 55% on the outlet sample and 4% on the inlet sample.

Blank Effects

There were difficulties identifying representative blank levels in reagents during this test series because two laboratories and multiple lots of reagent were used. Some variation in measured blank levels is likely to be due to analytical difficulties with the 5N KOH matrix. Hexavalent chromium was detected in the 5N potassium hydroxide reagent blank solution but at higher levels than in most samples. The blank was considered non-representative and was not subtracted from the sample values.

Total chromium was detected in the 5N potassium hydroxide reagent blank at 20-60% of the sample values. High total chromium in the 5N potassium hydroxide followed the trend of detecting more total chromium in this sample fraction than is considered possible using this sample train. Total chromium values from this sample fraction were not used.

Total chromium levels in the reagent blanks representing the filtered solids and nitric acid impinger solution and rinse were low at 0.6 μg/train. The blank correction contribution in the filtered solids ranged from 2-16%. The nitric acid impinger solution and rinses were also corrected for this reagent blank. The average blank correction was 46%.

Field blank levels of total and hexavalent chromium were not detected but at higher reporting limits than the samples. Conversion of Cr^{6+} to Cr^{3+} in the field blank was 2%.

Conclusions

Total and hexavalent chromium emissions from an oil-fired unit were evaluated using the EPA recirculation train. This data can be considered representative of the use of this train under these conditions.

5.5 STACK SAMPLING QUALITY CONTROL RESULTS

Sampling quality control was well documented in this program. It included calibration sheets for most of the equipment used, including the gas meters, portable O_2 meters and CEM calibration. Also on file are calibrations for temperature indicators and pitot assemblies. Gas meters are calibrated before and after sampling and can differ no more than 3% from the original meter calibration. The sampling data were evaluated and comments were made on the sampling data sheets about the sampling locations, techniques used, and specific tests comments. In general, a methodical and conservative approach was employed to collect the samples according to the specifications.

The precision of the sampling can be estimated by comparing results for various parameters of the replicate samples, notably velocity, moisture content, and gas composition. These were fairly constant for each sample location. Comparisons of measured flow rate at each

location to calculated flow rates from the unit heat rate and F-factor were made. Average measured flow rates were 14% higher than the calculated values.

The accuracy of the sampling is usually assumed from the calibration and proper operation of the equipment and from historical validation of the methods. Field blanks were used to assess any biases that may be caused by contamination of the equipment, location, or operator errors. Field blank values were not subtracted from tests results. Field blanks were performed for all tests except the particulate/anions train. Reagent blanks were collected for all tests except PAH tests where laboratory reagent blanks are used.

5.6 MATERIAL BALANCE RESULTS

At Site 112, four key streams were used to define the material balance: fuel oil, furnace hopper ash, partial sampling of an off-line boiler wash, and ESP outlet exhaust gas. Because of the low ash content on oil fuel (0.01-0.03% vs. 5-15% for coal), the time frame for removal of solids for the boiler is longer than the duration of the sampling program. Table 5-5 lists all of the possible streams for solid removal from the boiler, along with information on whether or not they were sampled.

TABLE 5-5
EXIT STREAMS FROM SITE 112

Stream	Operational Time Frame	Sampling Time Frame
ESP exhaust gas	Continuous	Four to six hours
Furnace hopper ash	Batch dump as needed, every one to three weeks.	One 5-day sample and two 3-day samples collected.
Off-line boiler cleaning	Every scheduled unit outage, typically several months to over a year apart.	Monitored part of a boiler cleaning in February 1992 following 14 months of operation.
Rear pass ash	Batch dump as needed, every one to six weeks.	Not sampled
Water sluice of ESP hoppers and ash lines	Every one to three weeks, as needed.	Not sampled

Stream flow rates and concentrations, and the bias and precision errors associated with those measurements, were entered into a statistical error propagation model to estimate the overall material balance closure. A detailed discussion of this statistical error propagation analysis is presented in Section 5.0.

Closure is defined as the ratio of output to input mass. A 100% closure indicates perfect agreement of the measured input and output mass flow rates. Closures of 70-130% have been set as a goal for the FCEM project. This range reflects the typical level of analytical uncertainty. Closures outside this range may indicate measurement problems in one or more of the sample matrices or a systematic bias imposed by the experimental design.

Flow Rates

Exhaust gas flow rates and fuel oil flow rates are consistent with unit load and have a high confidence level. The highest degree of uncertainty is associated with measuring solid removal rates for the furnace hopper ash, off-line boiler cleaning, rear pass ash, and sluicing of the ESP hoppers and ash lines. As presented in Table 5-5, the experimental design and the disparate time frames of removal mechanisms and sampling events result in high levels of uncertainty in these measurements. The primary uncertainty is that the sampling scheme may not have provided for complete measurement of all solids removed from the boiler by the four mechanisms listed above.

Table 5-6 presents the material balance results and the uncertainty interval calculated from the error propagation analysis. The table shows that the species fell into four groups: two volatile elements within the target range (mercury, sulfur), one volatile element outside the target range (chlorine), ten non-volatile elements outside the target range (barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, phosphorus, and vanadium), and two non-volatile elements within the target range (manganese, molybdenum). Closures on arsenic, fluorine and selenium were not calculated because they were not detected in either the fuel or the ESP exhaust gas.

The calculated uncertainties in the closures are due primarily to uncertainties in the exhaust gas analysis, and secondarily to uncertainties in the fuel oil analysis. Calculated uncertainties for the furnace hopper ash and off-line boiler wash were high on a relative basis but low on an absolute basis, since a small amount of material was collected. The largest uncertainty, whether or not the experimental design provided for adequate measurement of solids removal from the boiler, could not be quantified and was not included in the analysis. Specific discussions on individual species outside the target range are presented below.

Chlorine

The mass balance for chlorine of 225 $\pm$ 65% appears to be caused by a high bias in the exhaust gas measurement, although no sampling or analytical problems could be identified. Chlorine content in the fuel was typical for INAA analysis at 30μg/g or 1600 lb/10^{12} Btu. Both

TABLE 5-6
MATERIAL BALANCES
SITE 112

Substance	Out/In, %	Uncertainty, % Closure
Arsenic[1]	NC	NC
Barium	16	9
Beryllium	22	14
Cadmium	50	39
Chlorine	225	65
Chromium	35	22
Cobalt	11	6
Copper[4]	23	10
Fluorine[2]	NC	NC
Lead[3] [4]	14	3
Manganese[4]	92	40
Mercury	73	37
Molybdenum[4]	112	55
Nickel	16	5
Phosphorus	14	3
Selenium[1]	NC	NC
Sulfur	106	2
Vanadium	22	14

NC - Not calculated

(1) Arsenic and selenium not detected at ESP outlet.

(2) Fluorine not detected in fuel.

(3) Field blank was greater than 50% of the average uncorrected sample measurement for ESP inlet samples.

(4) Field blank was greater than 50% of the average uncorrected sample measurement for ESP outlet samples.

ESP inlet and outlet exhaust gas chloride measurements were higher than expected from the fuel input. Chlorine content in the furnace hopper ash and off-line boiler wash were negligible and do not contribute significantly to the closure.

Non-Volatile Elements Below Target Range

Closure for ten of the twelve non-volatile elements was below the target range. Calculated uncertainties were relatively low, indicating a systematic bias between fuel input and ESP outlet measurements. Review of the data does not indicate a consistent high bias in fuel measurements, a low bias in exhaust gas sampling, or a low bias in exhaust gas analyses. The exhaust gas values are considered to be representative of unit emissions during the tests, and the fuel oil analyses are considered to be representative of the oil burned. The largest uncertainty is in the experimental design, which may not have allowed for adequate quantification of solids removal from the boiler.

Non-Volatile Elements Within Target Closure Range

The mass balance results for molybdenum and manganese were 112 $\pm$ 55% and 92 $\pm$ 40%, respectively. The calculated uncertainty in the mass balance results for these elements is relatively high. This indicates that closure for these elements may not be substantially different than for other particulate metals. Fuel oil analyses are considered to be accurate. Examination of the ESP outlet analytical data indicates that these two metals have high field blank levels relative to some but not all sample values. Because the field blank levels are not subtracted from the results, the average ESP outlet emissions may be biased high.

Mercury

A few additional comments are needed here regarding the mercury mass balance. Although the mercury mass balance was within the target range at 73% there are concerns that the mercury values measured from the multimetals trains are highly variable. This is exhibited by the unexpected result of 83% mercury removal efficiency by the ESP. There are also concerns that the ESP outlet mercury results from the multimetals train are near the method reporting limit and therefore are known with less certainty and do not completely characterize mercury emissions from this source. The mercury value considered to have the lowest uncertainty from this test program is the fuel mercury value by INAA.

SECTION 6.0

EXAMPLE CALCULATIONS

This section presents the methodology and sample calculations used to develop the results presented in Sections 3.0 and 4.0. Specifically, the calculation of stream flow rates, unit-energy-based results, and confidence intervals are discussed.

6.1 STREAM FLOW RATES

Appendix D presents information about the stream flow rates measured or calculated at Site 112 during the sampling period.

ESP inlet and outlet gas flow rates were calculated from the unit load heat rate and F-factor as described in Section 5.2. Although flue gas flow rates were measured directly during sampling the calculated flow rate is considered to be more accurate for these sampling locations. The heat rate was calculated by the plant from recent Site 112 performance data.

Fuel oil flow rates were measured by plant instrumentation. The plant instrumentation was not more than ±5% accurate when comparing expected fuel flow to unit load at steady operating conditions. The plant instrumentation for fuel flow readings were occasionally as much as 10% different from the expected fuel flow at a given load.

The furnace hopper ash flow rate was estimated from three furnace hopper ash dumps during the test series. The total ash dumped was highly variable ranging from 0.51 lb/hr to 12.02 lb/hr. The average ash flow rate was 5.47 lb/hr or 0.0022 lb/10^6 Btu.

Ash was allowed to accumulate during sampling and was dumped at time intervals to represent the metals tests and the chromium and mercury speciation tests. A final ash dump was used only to contribute to determining the ash flow rate. Grab samples were taken at various depths from the ash bin and composited. For each ash dump the following information was recorded: total volume of ash, density of ash, hours since last ash dump, and the number of barrels of oil used since the last ash dump.

The ash flow rate and ash per 10^6 Btu were calculated from these parameters. For example, the following data were collected for one ash dump:

Time ash accumulated	7/16 - 7/21/92, 120 hours
Total ash volume, cm^3	222,995

Ash density, g/cm^3	0.951
Oil used, barrels	53,940

The furnace hopper ash flow rate is calculated as follows:

Total ash, lb/hr = total ash, cm^3 x density, g/cm^3

x lb/454g x 1/number of hours

= 222,995 cm^3 x 0.951 g/cm x 1/454 g/lb x 1/120 hr

= 3.89 lb/hr

Total ash, lb/10^6 Btu

= total ash, cm^3 x density, g/cm^3 x lb/454 g

÷ (oil used, barrels x 6.32 MMBtu/barrel)

= 222,995 cm^3 x 0.951 g/cm^3 x lb/454g x 1/53,940 barrels x 1/6.32 MMBtu/barrel

= 0.00137 lb/10^6 Btu

Because this system uses char reinjection there are no other ash collection points that can be routinely sampled.

6.2 MEANS AND CONFIDENCE INTERVALS FOR STREAM CONCENTRATIONS

The mean concentrations and 95% confidence intervals (CIs) about the mean were calculated for each target substance in the streams sampled. The means were calculated according to the conventions listed in Section 3.0. The equations used to calculate the 95% confidence intervals are presented in Appendix F. The error propagation equations used to calculate uncertainties for ESP efficiency and mass balance results are also presented in this section.

Example calculations for cadmium in the ESP outlet gas follow here; these results were shown in Table 3-3.

The concentration data (in $\mu g/Nm^3$) given for cadmium in Table 3-3 are:

Run 1	Run 2	Run 3
0.96	0.13	0.18

The mean is calculated from the individual run totals:

Mean $= (0.96 + 0.13 + 0.18)/3$

$= 0.42$

The sample standard deviation of the individual run totals is calculated:

$$S_p = \sqrt{[(0.96-0.42)^2 + (0.13-0.42)^2 + (0.18-0.42)^2]\ /2}$$

$$= 0.465$$

The standard deviation of the average is calculated according to the equation in Appendix F for N = 3:

$$S_{\overline{pi}} = 0.465/\sqrt{3}$$

$$= 0.268$$

The bias error is found by root-sum-squaring the product of the bias error and the sensitivity from each run (see Appendix F). According to the conventions listed in Section 3.0, no bias error is assigned to values above reporting limits, whereas a bias error of one-half the reporting limit is assigned to values below reporting limits. The sensitivity of the mean to each run in this case is 1/3. An additional bias of 14% of the sample value or 0.059 is introduced because of the difference in particle collection from ideal conditions during isokinetic tests.

$$\beta_r = \sqrt{((1/3 \times 0)^2 + (1/3 \times 0)^2 + (1/3 \times 0)^2)^2 + (0.059)^2}$$

$$= \sqrt{(0)^2 + (0.059)^2}$$

$$= 0.059$$

The total uncertainty in the result is found from:

$$U_r = \sqrt{\beta_r^2 + (t \times S_p)^2}$$

$$= \sqrt{(0.059)^2 + (4.3 \times 0.268)^2}$$

$$= 1.15$$

Thus, the result is reported as $0.42 \pm 1.15\ \mu g/Nm^3$.

For ESP removal efficiencies the uncertainty as % efficiency is calculated from the following standard error propagation equations:

$$ESP\ inlet\ value = A \pm \delta A \text{ where } \delta A = Sp/\sqrt{N}$$

$$ESP\ outlet\ value = B \pm \delta B$$

$$ESP\ inlet - outlet = C \pm \sqrt{(\delta A)^2 + (\delta B)^2}$$

$$ESP\ efficiency = \frac{ESP_{inlet} - ESP_{outlet}}{ESP_{inlet}} = efficiency \pm \sqrt{(\frac{(\delta A)^2 + (\delta B)^2}{C})^2 + (\frac{\delta A}{A})^2} * efficiency$$

Using the example of ESP efficiency for cadmium, the following calculations were performed:

	Mean	Sp	$Sp/\sqrt{N}$
ESP inlet, $lb/10^{12}$ Btu	0.47	0.14	0.081
ESP outlet, $lb/10^{12}$ Btu	0.33	0.37	0.211

$$ESP\ inlet - outlet = .14 \pm \sqrt{(0.081)^2 + (0.211)^2} = .14 \pm 0.226$$

$$ESP\ effeciency = \frac{inlet - outlet}{inlet} = 0.299 \pm \sqrt{(\frac{.226}{.14})^2 + (\frac{.081}{0.47})^2} * 0.299$$

$$= 0.299 \pm 0.485$$

or the ESP was 30 ± 49% efficient for the removal of cadmium. This large range reflects the large uncertainty in sample values for cadmium as illustrated in the previous example for confidence interval calculations.

For mass balance results the uncertainty as % closure is calculated similarly to ESP efficiency uncertainty using standard error propagation equations.

Closure = E(Out/in) = (A+B+C)/D
where A = ESP outlet air samples
B = boiler wash
C = furnace hopper ash
D = oil input

where δA, δB, δC, δD are the uncertainties in these measurements, $\left(\frac{Sp}{\sqrt{N}}\right)$, and all values are in lb/10^{12} Btu. The uncertainty in the outputs (A+B+C) is calculated as:

$$\delta(A+B+C+) = \sqrt{(\delta A)^2 + (\delta B)^2 + (\delta C)^2}$$

and the uncertainty in the output/input is calculated as:

$$\delta E = E \times \sqrt{\left(\frac{\delta(A+B+C)}{A+B+C}\right)^2 + \left(\frac{\delta D}{D}\right)^2}$$

Using the example of mass balance uncertainty for chromium, the uncertainty is calculated as:

Uncertainty in A (ESP outlet) = $\frac{Sp}{\sqrt{N}}$, where S_p = sample std deviation.

Uncertainty in D (fuel oil) = $\frac{Sp}{\sqrt{N}}$

Uncertainty in B (boiler wash) = 200%. This uncertainty is based on the bias assumed for missed sampling during the boiler wash.

Uncertainty in C (furnace hopper ash) = 307%. This uncertainty is calculated from the variability in total ash collected from the ash dumps. Using the chromium values in Appendix B, the mass balance uncertainty is calculated as:

$$\delta(A+B+C) = \sqrt{\left(\frac{3.38}{\sqrt{3}}\right)^2 + (2 \times 0.16)^2 + (3.07 \times 0.62)^2} = 2.75\ lb/10^{12}\ Btu$$

$$\delta E = 35\% \times \sqrt{\left(\frac{2.75}{4.48}\right)^2 + \left(\frac{.0404/\sqrt{3}}{0.24}\right)^2} = 21.7\%$$

6.3 UNIT ENERGY EMISSION FACTORS

In addition to the gas-phase concentrations, unit-energy-based emission factors expressed as lb/10^{12} Btu have been developed for each target substance. These values were determined by calculating the concentration of a substance in the flue gas (lb/ft^3) and multiplying by the fuel F-factor and O_2 correction, according to EPA Method 19.

The equation used for trace species emissions is:

$$lb/10^{12}\ Btu = \mu g/m^3 \times m^3/35.31\ ft^3 \times lb/454g \times F\text{-}factor\ @\ 0\%\ O_2,\ dscf/MMBtu$$

$$\times\ 20.9/(20.9 - \%\ O_2) \times 10^6\ \mu g/g \times 10^{-6}$$

The 95% confidence intervals for emission factors were calculated according to the equations presented in Appendix F. For each parameter (concentration, unit heat rate, and unit load) the mean, standard deviation, number of points, and bias estimates were used to calculate the combined uncertainty in the mean emission factors.

SECTION 7.0

GLOSSARY

ASTM	American Society for Testing and Materials
BR	Brooks Rand
Btu	British Thermal Unit
CAAA	Clean Air Act Amendments of 1990
CEM	Continuous Emissions Monitor
CI	Confidence Interval
CV	Coefficient of Variation
CVAAS	Cold Vapor Atomic Absorption Spectrophotometry
CVAFS	Cold Vapor Atomic Fluorescence Spectrophotometry
DL	Detection Limit
DQO	Data Quality Objective
dscfm	Dry Standard Cubic Feet per Minute (1atm, 68°F)
EPA	U.S. Environmental Protection Agency
EPA MM	EPA Multi-metals Train
EPAREC/ICP	EPA Recirculation train for total Chromium with ICP-AES Analysis
EPAREC/IC-PCR	EPA Recirculation Train for Hexavalent Chromium with Analysis by Ion Chromatography with Post Column Reaction
ESP	Electrostatic Precipitator
FCEM	Field Chemical Emissions Monitoring
FD	Forced Draft
GC/PID	Gas Chromatography with Photoionization Detector
GFAAS	Graphite Furnace Atomic Absorption Spectrophotometry
GRAV	Gravimetric Analysis
HHV	Higher Heating Value
HPLC	High Pressure Liquid Chromatography
HRGC/LRMS-SIM	High Resolution Gas Chromatography/Low Resolution Mass Spectrometry with Selected Ion Monitoring
IC	Ion Chromatography
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ID	Induced Draft
INAA	Instrumental Neutron Activation Analysis
ISE	Ion Selective Electrode
LECO-CHN	Leco Carbon, Hydrogen, Nitrogen Analyzer
LECO-SC132	Leco Sulfur Analyzer
LCS	Laboratory Check Standards
MIT	Massachusetts Institute of Technology

MMBtu	Million British Thermal Units
MW	Megawatt
NC	Not Calculated
ND	Not Detected
NIST	National Institute of Standards and Technology
Nm^3	Dry Normal Cubic Meter (0°C, 1atm)
NM	Not Measurable
NP	Not Performed
NR	Not Reported
PAH	Polycyclic Aromatic Hydrocarbons
PISCES	Power Plant Integrated Systems Chemical Emission Study
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RPDM	Relative Percent Difference from the Mean
UOM	Unit of Measure

APPENDIX A
SAMPLING AND ANALYTICAL SUMMARY

This appendix presents the methods used to collect, preserve and analyze each type of sample collected at Site 112. Summary tables presented include the following:

A-1	Reference Table for Sampling Methods
A-2	ESP Inlet and Outlet Test Schedule and Sampling Comments
A-3	3-D Velocity Summaries for the ESP Inlet and Outlet Sampling Locations
A-4	Sampling Train Configurations for ESP Inlet and Outlet Samples
A-5	Sampling and Analytical Methods for ESP Inlet and Outlet Samples
A-6	Sampling Schedule for Fuel Oil and Ash Samples
A-7	Analysis methods for Fuel Oil and Ash Samples
A-8	Sample Handling and Preparation Procedures

Descriptions of the exhaust gas sampling trains and process sample collection methods follow the summary tables.

TABLE A-1
REFERENCE TABLE FOR SAMPLING METHODS

Stream	Target Substances	Collection Method
ESP Inlet and Outlet	Metals: As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, P, Pb, Se, V	EPA Multi-metals
	Polycyclic Aromatic Hydrocarbons	CARB 429
	Benzene, Toluene	CARB 410A (bags)
	Particulate, SO_2, Cl^-, F^-	EPA 5/8, CARB 421
	O_2, CO_2	EPA 3A
	Formaldehyde	CARB 430
	Mercury (Evaluation, ESP Outlet)	Brooks Rand (KCl/soda lime and iodated carbon cartridges)
		MIT (carbon cartridges) Multi-metals
	Total and Hexavalent Chromium (Evaluation)	EPA Recirculation Train
Oil	Metals, anion precursors, composition, heating value	Composited grab samples
Furnace Hopper Ash	Metals, PAH, anions	Composited grab samples
Boiler Wash	Metals, PAH, anions, total solids	Integrated liquid sampling

Note: EPA Method 5 used to collect ESP inlet samples, EPA Method 17 (in-stack filtration) used to collect ESP outlet samples.

TABLE A-2
ESP INLET AND OUTLET TEST SCHEDULE AND SAMPLING COMMENTS
SITE 112

Test No.	Date	Time	Type of Test	Comments
1-PAH-OUT	7/16/92	1045/1702	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
1-PAH-IN	7/16/92	1045/1810	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
1-MTLS-IN	7/16/92	1115/1841	Metals (As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP inlet
1-MTLS-OUT	7/16/92	1134/1744	Metals (As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP outlet
1A-VOC-IN	7/16/92	1600/1611	Benzene and Toluene	
1A-VOC-OUT	7/16/92	1605/1615	Benzene and Toluene	
1B-VOC-IN	7/16/92	1605/1615	Benzene and Toluene	
1B-VOC-OUT	7/16/92	1616/1631	Benzene and Toluene	
1C-VOC-IN	7/16/92	1627/1636	Benzene and Toluene	
1C-VOC-OUT	7/16/92	1631/1647	Benzene and Toluene	
1D-VOC-IN	7/16/92	1638/1648	Benzene and Toluene	
1D-VOC-OUT	7/16/92	1648/1701	Benzene and Toluene	
2-PAH-IN	7/17/92	1008/1516	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
2-PAH-OUT	7/17/92	1008/1551	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
2-MTLS-OUT	7/17/92	1009/1550	Metals (As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP outlet
2-MTLS-IN	7/17/92	1041/1602	Metals (As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP inlet
2A-FORM-IN	7/17/92	1625/1725	Formaldehyde	nonisokinetic/single point, ESP inlet
2A-FORM-OUT	7/17/92	1625/1725	Formaldehyde	nonisokinetic/single point, ESP outlet
2B-FORM-IN	7/17/92	1740/1840	Formaldehyde	nonisokinetic/single point, ESP inlet
2B-FORM-OUT	7/17/92	1740/1840	Formaldehyde	nonisokinetic/single point, ESP outlet
2C-FORM-IN	7/17/92	1855/1955	Formaldehyde	nonisokinetic/single point, ESP inlet
2C-FORM-OUT	7/17/92	1855/1955	Formaldehyde	nonisokinetic/single point, ESP outlet
3-PAH-OUT	7/18/92	1051/1644	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
3-MTLS-OUT	7/18/92	1052/1630	Metals (As, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP outlet
3-PAH-IN	7/18/92	1055/1608	Polycyclic Aromatic Hydrocarbons	VOID, samples brought to dryness during extraction
3-MTLS-IN	7/18/92	1125/1637	Metals (As, Be, Cd, Cr, Co, Cu, Pb, Ni, Hg, Mn, Mo, Se, P, V)	isokinetic/multipoint, ESP inlet
5-CR-OUT	7/21/92	1235/1752	Total and Hexavalent Chromium	isokinetic/single point, ESP outlet
5-CR-IN	7/21/92	1355/1740	Total and Hexavalent Chromium	isokinetic/single point, ESP inlet
5-MM-HG	7/21/92	1507/1944	Total Mercury from Multimetals Train	isokinetic/single point, ESP outlet
5-MIT/BR-HG	7/21/92	1507/1943	Total Mercury from Brooks Rand & MIT Trains	isokinetic/single point, ESP outlet
5-MIT-HG	7/21/92	1508/1943	Total Mercury by MIT Method	nonisokinetic/single point, ESP outlet
5-BR-HG	7/21/92	1511/1930	Mercury Speciation by Brooks Rand Method	nonisokinetic/single point, ESP outlet

(continued)

TABLE A-2 (Continued)
ESP INLET AND OUTLET TEST SCHEDULE AND SAMPLING COMMENTS
SITE 112

Test No.	Date	Time	Type of Test	Comments
6-CR-IN	7/22/92	1035/1212	Total and Hexavalent Chromium	isokinetic/single point, ESP inlet
6-CR-OUT	7/22/92	1035/1213	Total and Hexavalent Chromium	isokinetic/single point, ESP outlet
6-BR-HG	7/22/92	1040/1212	Particle Size Distribution	nonisokinetic/single point, ESP outlet
6-MIT-HG	7/22/92	1050/1213	Particle Size Distribution	nonisokinetic/single point, ESP outlet
6-MM-HG	7/22/92	1050/1212	Total Mercury from Multimetals Train	isokinetic/single point, ESP outlet
7A-MIT-HG	7/22/92	1515/1701	Total Mercury by MIT Method	nonisokinetic/single point, ESP outlet
7B-MIT-HG	7/22/92	1727/1857	Total Mercury by MIT Method	nonisokinetic/single point, ESP outlet
7-MM-HG	7/22/92	1515/1857	Total Mercury from Multimetals Train	isokinetic/single point, ESP outlet
7A-BR-HG	7/22/92	1515/1645	Mercury Speciation by Brooks Rand Method	isokinetic/single point, ESP outlet
7B-BR-HG	7/22/92	1715/1943	Mercury Speciation by Brooks Rand Method	isokinetic/single point, ESP outlet
8-CR-IN	7/23/92	10:35-14:35	Total and Hexavalent Chromium	isokinetic/single point, ESP inlet
8-CR-OUT	7/23/92	10:34-13:37	Total and Hexavalent Chromium	isokinetic/single point, ESP outlet
9-PM/AN-OUT	7/24/92	10:26-16:01	Particulate/Anions	isokinetic/multipoint, ESP outlet
9-PM/AN-IN	7/24/92	12:25-15:29	Particulate/Anions	isokinetic/multipoint, ESP inlet
10-PM/AN-IN	7/24/92	13:06-16:17	Particulate/Anions	isokinetic/multipoint, ESP inlet
10-PM/AN-OUT	7/24/92	13:16-17:06	Particulate/Anions	isokinetic/multipoint, ESP outlet
11-PM/AN-IN	7/24/92	16:29-19:47	Particulate/Anions	isokinetic/multipoint, ESP inlet
11-PM/AN-OUT	7/24/92	16:47-20:26	Particulate/Anions	isokinetic/multipoint, ESP outlet
12-PAH-IN	8/4/92	10:33-15:37	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP inlet
12-PAH-OUT	8/4/92	10:42-16:50	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP outlet
13-PAH-OUT	8/5/92	11:20-16:40	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP outlet
13-PAH-IN	8/5/92	11:24-16:37	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP inlet
14-PAH-IN	8/6/92	10:40-15:25	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP inlet
14-PAH-OUT	8/6/92	10:43-15:36	Polycyclic Aromatic Hydrocarbons	isokinetic/multipoint, ESP outlet

Notes:

The ESP inlet sampling grid was 7 sample points for each of the 12 ports for a total of 84 points. Port D was skipped because of obstruction within the duct, so sampling in port C was two times longer. Point one on each port was sampled near point two because of excessive air in-leakage.

The ESP outlet sampling grid was 11 sample points for each of the 8 ports for a total of 88 points. Port E was skipped because of obstructions within the duct, so sampling in port F was two times longer. Point one was skipped because the in-stack filter was in the port nipple and the filter temperature could not be maintained.

TABLE A-3
3D VELOCITY SUMMARY
ESP INLET
SITE 112

Sample Port/Point	Resultant Angle, °	Sample Port/Point	Resultant Angle, °	Sample Port/Point	Resultant Angle, °
A2	7.0	D1	0.8	I6	0.8
A3	4.1	E7	2.2	I5	0.8
A4	0.8	E6	5.1	I4	4.1
A5	1.3	E5	15.0	I3	3.1
A6	16.0	E4	25.0	I2	50.0
A7	43.2	E3	29.0	J7	2.2
B7	8.1	E2	8.0	J6	1.3
B6	0.8	F7	4.1	J5	10.0
B5	8.0	F6	3.1	J4	32.0
B4	9.0	F5	2.2	J3	0.8
B3	0.8	F4	0.8	J2	0.8
B2	30.8	F3	2.2	J1	0.8
B1	0.8	F2	3.1	K7	3.1
C7	8.7	G7	5.1	K6	25.0
C6	2.2	G6	10.0	K5	46.0
C5	8.0	G5	3.1	K4	62.5
C4	0.8	G4	10.0	K3	8.0
C3	0.8	G3	15.0	K2	8.3
C2	0.8	G2	20.0	L7	62.4
C1	0.8	H7	7.0	L6	141.2
D7	3.1	H6	3.1	L5	21.5
D6	0.8	H5	5.1	L4	123.2
D5	15.0	H4	20.0	L3	72.7
D4	18.0	H3	0.8	L2	65.6
D3	0.8	H2	0.8		
D2	0.8	I7	3.1		

RESULTS:

Yaw Angle:	-7.3 degrees	Velocity:*	35.9 fps (ft/sec.)
Pitch Angle:	-0.2 degrees	Axial Velocity:	35.2 fps
Resultant Angle:	10.2 degrees		
Standard Deviation:	11.9 degrees		

(continued)

Note: All results are averages for the test.
* Velocity in the direction of flow.

Notes:
1. No flow was measured at the following points: B1, B3, C1, C2, C3, D1, D2, D3, H2, H3, J1, J2, and J3.
2. The following points were eliminated due to possible flow obstructions near the duct wall and/or to possible air in-leakage (low stack temp.): A1, E1, F1, G1, H1, I1, and K1.
3. Port L and point K4 was eliminated, flow readings were outside of the calibration curve's specifications.

TABLE A3 (continued)
3D VELOCITY SUMMARY
ESP OUTLET
SITE 112

Sample Port/Point	Resultant Angle, °	Sample Port/Point	Resultant Angle, °	Sample Port/Point	Resultant Angle, °
A11	6.1	C3	16.6	F6	6.8
A10	7.2	C2	16.3	F5	11.1
A9	11.5	C1	25.4	F4	15.8
A8	13.8	D11	21.5	F3	16.6
A7	17.8	D10	21.1	F2	16.7
A6	15.4	D9	17.7	F1	28.7
A5	13.0	D8	17.5	G11	15.2
A4	5.8	D7	16.6	G10	9.3
A3	1.3	D6	11.7	G9	11.8
A2	5.0	D5	5.0	G8	14.0
A1	20.9	D4	5.7	G7	15.7
B11	5.3	D3	6.1	G6	15.8
B10	9.7	D2	12.1	G5	18.7
B9	12.3	D1	3.4	G4	15.5
B8	13.1	E11	5.5	G3	26.5
B7	27.3	E10	11.6	G2	20.2
B6	16.3	39	15.4	G1	31.9
B5	19.5	E8	17.5	H11	20.0
B4	18.5	E7	15.1	H10	18.1
B3	20.6	E6	11.8	H9	12.2
B2	14.1	E5	8.0	H8	11.9
B1	26.7	E4	4.0	H7	11.1
C11	15.1	E3	11.4	H6	10.2
C10	13.7	E2	19.5	H5	9.4
C9	13.8	E1	29.1	H4	9.9
C8	15.3	F11	4.0	H3	1.2
C7	15.0	F10	2.7	H2	3.4
C6	17.5	F9	4.1	H1	11.7
C5	16.8	F8	0.8		
C4	16.3	F7	2.4		

RESULTS:

Yaw Angle:	2.3 degrees	Velocity:*	84.3 fps (ft/sec.)
Pitch Angle:	5.5 degrees	Axial Velocity:	81.5 fps
Resultant Angle:	13.6 degrees		
Standard Deviation:	6.8 degrees		

Note: All results are averages for the test.
* Velocity in the direction of flow.

Notes:
1. Ports A, B, C, and D were measured on 7/14/92 and ports E, F, G, and H were measured on 7/23/92.
2. Average barometric and static pressure was used.

TABLE A-4
SAMPLE TRAIN CONFIGURATIONS FOR ESP INLET AND OUTLET SAMPLES SITE 112

Sample Train	Nozzle	Filter	Filter Holder	Probe	Sample Line	Impinger Contents #1	#2	#3	#4	#5	#6	#7
EPA Multi-Metals	Glass	Inlet-Method 5 ultrapure 110 mm filter Outlet-Method 17 ultrapure 47 mm filter	Inlet-Method 5 glass Outlet-Method 17 teflon coated stainless steel	Teflon	Teflon	100 ml 5% HNO_3/ 10% H_2O_2	100 ml 5% HNO_3/ 10% H_2O_2	Empty	100 ml 4% $KMnO_4$/ 10% H_2SO_4	300-400 g silica gel		
Semi-VOST CARB 429	Glass	Inlet-Method 5 Toluene-rinsed 110 mm filter Outlet-Method 17 Toluene-rinsed 47 mm filter	Inlet-Method 5 glass Outlet-Method 17 teflon coated stainless steel	Teflon	Teflon to XAD-2 resin column	Empty-stub stem	100 ml organic free D.I. H_2O	Empty	300-400 g silica gel	N/A		
Benzene/Toluene CARB 410A	N/A	Quartz wool plug inlet, none at outlet	N/A	Glass	Teflon (short line)	Sample collected over 30 minutes with Tedlar bag						
Solid Particulate/ Anions	Glass	Inlet-Method 5 fiberglass 110 mm filter Outlet-Method 17 fiberglass 47 mm filter	Inlet- Method 5 glass Outlet- Method 17 teflon coated stainless steel	Teflon	Teflon	100 ml $NaHCO_3$/ Na_2CO_3	100 ml $NaHCO_3$/ Na_2CO_3	100 ml 3% H_2O_2	100 ml 3% H_2O_2	300-400 g silica gel		
						Midget Impingers						
Formaldehyde	N/A	47 mm in-stack fiberglass filter	Method 17 teflon coated stainless steel	Glass	Teflon	10 ml DNPH	10 ml DNPH	Empty	10-20 ml silica gel	N/A		
Cr/Cr^{+6}	Glass	N/A	N/A	Teflon with recirculating peristaltic pump, teflon line	Teflon with recirculating peristaltic pump, teflon line	200 ml 5 N KOH (Teflon impinger)	50 ml 0.5 N KOH (Teflon impinger)	50 ml 0.5 N KOH (Teflon impinger)	Empty (Teflon impinger)	Empty Glass impinger	100 ml 0.1 N HNO_3 Glass impinger	300-400 g silica gel
Mercury by Multimetals	Glass	47 mm Method 17	Glass filter holder	Glass	Teflon	100 ml 5% HNO_3/ 10% H_2O_2	100 ml 5% HNO_3/ 10% H_2O_2	Empty	100 ml 4% $KMnO_4$/ 10% H_2SO_4	300-400 g silica gel		
Mercury by Brooks Rand	N/A	N/A	N/A	Glass	Teflon	KCl/soda lime and iodated carbon traps						
Mercury by MIT	N/A	N/A	N/A	Teflon	Teflon	Carbon Traps						
CEM	N/A	N/A	N/A	Stainless steel	Teflon	Water Knockout Only						

N/A = Not Applicable

TABLE A-5
SAMPLING AND ANALYTICAL METHODS FOR ESP INLET AND OUTLET SAMPLES SITE 112

Parameter	No. of Replicates	Duration of Test (Minutes)	Sample Rate	Collection and Preparation Reference Method	Measurement Principle	Analytical Reference Method	Method Detection Limit	Comments
FLUE GAS SAMPLES								
Solid Particulate	3	*	1 m³/hour	EPA 5/EPA 17	Filtration/Gravimetric	EPA 5	0.0002 gr/dscf	
Anions:	3	*	1 m³/hour					Anions from back 1/2 of particulate train
Sulfate				EPA 6/8	Ion chromatography	EPA 300.0	0.1 ppm	
Chloride				CARB 421	Ion chromatography	EPA 300.0	0.1 ppm	
Fluoride				CARB 421	Ion chromatography	EPA 300.0	0.1 ppm	
Phosphate				—	Ion chromatography	EPA 300.0	0.3 ppm	
Metals:**	3	*	1 m³/hour	EPA Multi-metals				
Arsenic					GFAAS	EPASW846 7060	3.1 µg/m³	Method of standard additions used
Barium					ICP-AES	EPASW846 6010	0.13 µg/m³	whenever low spike recoveries occur.
Beryllium					ICP-AES	EPASW846 6010	0.02 µg/m³	Method of standard additions used for
Cadmium					ICP-AES	EPASW846 6010	0.07 µg/m³	all As and some Se analyses.
Chromium					ICP-AES	EPASW846 6010	0.13 µg/m³	
Cobalt					ICP-AES	EPASW846 6010	0.22 µg/m³	
Copper					ICP-AES	EPASW846 6010	0.13 µg/m³	
Lead					ICP-AES	EPASW846 6010	3.1 µg/m³	
Manganese					ICP-AES	EPASW846 6010	0.18 µg/m³	
Mercury					CVAAS	EPASW846 7470	0.42 µg/m³	
Molybdenum					ICP-AES	EPASW846 6010	0.18 µg/m³	
Nickel					ICP-AES	EPASW846 6010	0.44 µg/m³	
Phosphorus					ICP-AES	EPASW846 6010	12.4 µg/m³	
Selenium					GFAAS	EPASW846 7740/6010	6.4 µg/m³	
Vanadium					ICP-AES	EPASW846 6010	0.13 µg/m³	

(continued)

Note: Samples taken at the north and south duct at both the inlet and outlet, except for formaldehyde, VOC, chromium speciation and mercury testing. For these tests, single point sampling was performed at the north or south duct at both the inlet and outlet. Mercury samples were collected at the outlet only.

*Inlet = 252 minutes. Outlet = 264 minutes.
**ICP or graphite furnace atomic absorption used to achieve lowest detection limits.

TABLE A-5 (continued)
SAMPLING AND ANALYTICAL METHODS
FOR ESP INLET AND OUTLET SAMPLES
SITE 112

Parameter	No. of Replicates	Duration of Test (Minutes)	Sample Rate	Collection and Preparation Reference Method	Measurement Principle	Analytical Reference Method	Method Detection Limit	Comments
Polycyclic Aromatic Compounds:	3	*	1 m^3/hour	CARB 429	HRGC/LRMS-SIM	CARB 429	0.022 $\mu g/m^3$	
2-Methylnaphthalene							0.22 $\mu g/m^3$	
3-Methylcholanthrene							0.022 $\mu g/m^3$	
7,12-Dimethylbenz(a)anthracene							0.022 $\mu g/m^3$	Use CARB 429 with isotope
Acenaphthylene							0.022 $\mu g/m^3$	dilution where isotopically
Ancenaphthene							0.022 $\mu g/m^3$	labeled standards are available.
Anthracene							0.022 $\mu g/m^3$	Use method of internal
Benzo(a)anthracene							0.022 $\mu g/m^3$	standardization for
Benzo(a)pyrene							0.022 $\mu g/m^3$	2-Methynaphthalene
Benzo(b)fluoranthene							0.022 $\mu g/m^3$	3-Methylcholanthrene and
Benzo(g,h,i)perylene							0.022 $\mu g/m^3$	7,12-Dimethylbenz(a)anthracene
Benzo(k)fluranthene							0.022 $\mu g/m^3$	
Chrysene							0.022 $\mu g/m^3$	
Dibenzo(a,h)anthracene							0.022 $\mu g/m^3$	
Fluoranthene							0.022 $\mu g/m^3$	
Fluorene							0.022 $\mu g/m^3$	
Indeno(1,2,3-cd)pyrene							0.022 $\mu g/m^3$	
Naphthalene							0.022 $\mu g/m^3$	
Phenanthrene							0.022 $\mu g/m^3$	
Pyrene							0.022 $\mu g/m^3$	
Volatile Organics:	3	30	0.2 ℓ/min.	CARB410A	GC/PID	CARB410A		Collect in Tedlar bags
Benzene							0.15 ppb	
Toluene							0.15 ppb	
Formaldehyde:	3	60	0.10 ft^3/min	CARB 430	HPLC	CARB 430	3 ppb	Collect in midget impingers
Chromium Speciation:	3	97-240	1 m^3/hour	EPA Recirculation Method				
Total Cr					ICP-AES	EPA SW846 6010	1.6 $\mu g/m^3$	
Cr^{6+}					IC/PCR	GEL/RTI	0.35 $\mu g/m^3$	
Mercury:	3	82-197	1m^3/hour	EPA Multi-Metals	CVAAS		0.64 $\mu g/m^3$	
Hg^0	4	120	0.01 ft^3/min	Brooks Rand	CVAFS	N. Bloom*	0.02 $\mu g/m^3$	
Hg^{+2}					CVAFS		0.02 $\mu g/m^3$	
Methyl Hg					GC/CVAFS		0.002 $\mu g/m^3$	
Total Hg					INAA	I. Olmez	0.001 $\mu g/m^3$	
O_2, CO_2	in conjunction with all tests by EPA Methods 7E, 10 and 3A							
Velocity Moisture	in conjunction with all isokinetic tests							

The PAH detection limits are calculated using an average sample volume of 4.5 m^3 for outlet samples. In addition an average laboratory detection limit of 0.1 µg/sample (except for 3-Methylcholanthrene at 1 µg/sample) was used for each species. Exact values vary because of recovery correction calculations.

* Ref: Bloom, N.S. and Fitzgerald, W.F., Determination of Volatile Mercury Species at the Pico gram level by Low Temperature Gas Chromatography with Cold Vapor Atomic Fluorescence Detection, Anal. Chimi. Acta., 208, 151, 1988.

TABLE A-6
SAMPLING SCHEDULE FOR FUEL OIL AND ASH SAMPLES
SITE 112

Stream	Date	Time	Comments
Oil	7/16/92	0945	Metals, Cl, F, S
		1145	Composition, HHV
		1345	
	7/17/92	0800	Metals Cl, F, S
		1100	Composition, HHV
		1400	
	7/18/92	1115	Metals Cl
		1530	
	7/20/92	1030	Not analyzed
		1150	
		1450	
	7/21/92	0850	Mercury, chromium
		1150	
		1450	
	7/22/92	0850	Mercury, chromium
		1150	
		1350	
	7/23/92	0830	Mercury, chromium
		1130	
		1430	
	7/24/92	0830	Not analyzed
		1145	
		1430	
Furnace hopper ash	7/21/92	1400	Metals
	7/24/92	1400	PAH, Cl^-, F^-, S
	8/7/92	1400	Not analyzed

Note: Oil samples were composited into a daily composite before analysis.

TABLE A-7
ANALYTICAL METHODS FOR FUEL OIL AND ASH SAMPLES
SITE 112

Steam	Parameter	Measurement Principle	Reference Method	Method Detection Limit	Comments
Oil	Carbon	CHN Analyzer	LECO CHN/600	0.1%	
	Hydrogen	CHN Analyzer	LECO CHN/600	0.1%	
	Nitrogen	CHN Analyzer	LECO CHN/600	0.01%	
	Oxygen	difference	–	0.1%	
	Moisture	distillation	ASTM D-95	0.01%	
	Ash	gravimetric	ASTM D-482	0.01%	
	Heating Value	calorimetry	ASTM D-240-87	10 Btu/lb	
	Chlorine	INAA	–	0.1 µg/g	Also by ASTM D-808
	Fluorine	Ion Selective Electrode	–	10 µg/g	
	Sulfur	LECO SC-132	LECO	0.01 µg/g	
	Arsenic	INAA	–	0.001 µg/g	Also by EPA SW846 7060
	Barium	INAA	–	0.1 µg/g	Also by EPA SW846 6010
	Beryllium	ICP-AES	EPA SW846 6010	0.002 µg/g	
	Cadmium	ICP-AES	EPA SW846 6010	0.005 µg/g	
	Chromium	INAA	–	0.01 µg/g	Also by EPA SW846 6010
	Cobalt	INAA	–	0.1 µg/g	Also by EPA SW846 6010
	Copper	ICP-AES	EPA SW846 6010	0.01 µg/g	
	Lead	ICP-AES	EPA SW846 6010	0.3 µg/g	
	Manganese	INAA	–	0.01 µg/g	Also by EPA SW846 6010
	Mercury	INAA	–	0.001 µg/g	Also by EPA SW846 7471
	Molybdenum	INAA	–	0.01 ng/g	Also by EPA SW846 6010
	Nickel	ICP-AES	EPA SW846 6010	0.03 µg/g	
	Phosphorus	ICP-AES	EPA SW846 6010	5 µg/g	
	Selenium	INAA	–	0.001 µg/g	Also by EPA SW846 7740
	Vanadium	INAA	–	1 µg/g	Also by EPA SW846 6010
Furnace hopper ash	Chloride	IC	EPA 300.0	250 µg/g	
	Fluoride	IC	EPA 300.0	150 µg/g	
	Sulfur	LECO SC-132	LECO	0.01 µg/g	Also sulfate by EPA 300.0
	Arsenic	GFAAS	EPA SW846 7060	3 µg/g	
	Barium	ICP-AES	EPA SW846 6010	5 µg/g	
	Beryllium	ICP-AES	EPA SW846 6010	1 µg/g	
	Cadmium	ICP-AES	EPA SW846 6010	2 µg/g	
	Chromium	ICP-AES	EPA SW846 6010	5 µg/g	
	Cobalt	ICP-AES	EPA SW846 6010	9 µg/g	
	Copper	ICP-AES	EPA SW846 6010	5 µg/g	
	Lead	GFAAS	EPA SW846 7420	3 µg/g	
	Manganese	ICP-AES	EPA SW846 6010	7 µg/g	
	Mercury	CVAAS	EPA SW846 7471	0.1 µg/g	
	Molybdenum	ICP-AES	EPA SW846 6010	7 µg/g	
	Nickel	ICP-AES	EPA SW846 6010	20 µg/g	
	Phosphorus	ICP-AES	EPA SW846 6010	5 µg/g	Also phosphate by EPA 300.0
	Selenium	GFAAS	EPA SW846 7740	3 µg/g	
	Vanadium	ICP-AES	EPA SW846 6010	5 µg/g	
	Loss on Ignition	Gravimetric	Mod. ASTM C25	0.01%	
	Acenaphthylene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	Isotope dilution used where
	Acenaphthene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	labeled standards were
	Anthracene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	available
	Benzo(a)anthracene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Benzo(a)pyrene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Benzo(b)fluoranthene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Benzo(g,h,i)perylene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.01 µg/g	
	Benzo(k)fluoranthene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Chrysene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.01 µg/g	
	Fluoranthene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Fluorene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Indeno(1,2,3-cd)pyrene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Naphthalene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Phenanthrene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	Pyrene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	2-Methylnaphthalene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	3-Methylcholanthrene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	
	7,12-Dimethylbenz(a)anthracene	HRGC/LRMS-SIM	CARB 429/EPA SW846 8270	0.005 µg/g	

TABLE A-8
SAMPLING HANDLING AND PREPARATION PROCEDURES
SITE 112

Sample Type	Parameter	Sample Fraction Description	Sample Containers	Sample Handling and Preservation	Laboratory Preparation Procedure
Exhaust Gas Samples	Particulate	Filter Front half acetone rinse	Petri dish 500 ml amber glass lined bath with teflon lined lid	Seal Seal and mark liquid levels	Dry at 105°C, desiccate Evaporate at ambient temperature, desiccate
	Anions	$Na_2CO_3/NaHCO_3$, impinger rinse 3% H_2O_2 impinger rinse	1000 ml Nalgene HDPE bottle 1000 ml Nalgene HDPE bottle	Seal and mark liquid levels Seal and mark liquid levels	none none
	PAH	Filter	Hexane-rinsed foil lined petri dish	Seal, Store at ≤ 4°C	Soxhlett extraction
		XAD-2 column	–	Wrap with foil to keep XAD-2 from exposure to light. Store at ≤ 4°C	Soxhlett extraction
		Front-half organic rinse	500 ml organic free amber glass bottle with teflon lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
		Back-half organic rinse	500 ml organic free amber glass bottle with teflon lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
		Back-half water impinger rinse	500 ml organic free amber glass bottle with teflon lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
				All fractions: Sample to be extracted within 7 days of sampling; analysis to be performed within 40 days. Ship at conclusion of PAH tests.	

(continued)

TABLE A-8 (continued)
SAMPLING HANDLING AND PREPARATION PROCEDURES
SITE 112

Sample Type	Parameter	Sample Fraction Description	Sample Containers	Sample Handling and Preservation	Laboratory Preparation Procedure
Exhaust Gas Samples	Metals (and metal trains devoted to Hg)	Filter Front-half nitric peroxide rinse	Petri dish 500 ml acid washed amber HDPE Nalgene	Seal Seal and mark liquid level	Parr Bomb HF/HNO_3 digestion combine with filter, Parr Bomb digestion
		5% HNO_3/10% H_2O_2 impinger rinse	1000 ml acid washed amber HDPE Nalgene	Seal and mark liquid level	Remove Hg fraction, evaporate remainder at 70°C with excess HNO_3 (pH 1)
		4% MnO_4/10% H_2SO_4 impinger rinse	500 ml acid washed amber HDPE Nalgene	Seal and mark liquid level	Digest with H_2SO_4
				All fractions: Ship at conclusion of metal tests	
	Formaldehyde	DNPH solution and line rinse	Organic free DI H_2O washed 40 ml glass sample vials with teflon lined lid	Seal and mark liquid level. Store at $\leq$ 4°C. Analyze within 7 days. Ship at conclusion of formaldehyde tests.	Extraction
	Mercury/ Brooks Rand	Probe wash KCl/soda line cartridge soda/charcoal cartridge	Glass probe Teflon cartridge Teflon cartridge	Seal Seal Seal	BrCl in HCl and H_2O rinse Dissolve in Acetic Acid Digest in HNO_3/H_2SO_4
				All fractions: Ship at conclusion of Hg testing	
	Mercury/MIT	Carbon cartridge	Teflon Cartridge	Seal. Ship at conclusion of Hg testing	Transfer to INAA teflon container
	Total Chromium Hexavalent Chromium	Filtered KOH impinger and probe rinse	1000 ml acid washed HDPE Nalgene bottle	Check total pH $\geq$ 8.5 Seal and mark liquid level	None for Cr^{6+}, concentrated and acid digestion for Cr total
		Nitric acid impinger rinse	500 ml acid washed HDPE Nalgene bottle	Seal and mark liquid level	Concentrate and acid digestion for Cr
		Filtrant (filter)	Petri dish	Seal	KOH extraction for Cr^{6+} Acid digestion for Cr total
		Nitric acid train rinse	500 ml acid wash HDPE nalgene bottle	Seal and mark liquid level	Concentrate and acid digestion for Cr total
				All fractions: ship at conclusion of Cr testing	

(continued)

TABLE A-8 (continued)
SAMPLING HANDLING AND PREPARATION PROCEDURES
SITE 112

Sample Type	Parameter	Sample Fraction Description	Sample Containers	Sample Handling and Preservation	Laboratory Preparation Procedure
Fuel Oil	Ultimate, HHV, anion precursors	400 g composite	500 ml amber glass bottles with teflon lined lids	Seal	None
	Metals	400 g composite	500 ml amber glass bottles with teflon lined lids	Seal	Ash and acid digest for ICP-AES, GFAAS, or AA by modified EPA 3050. Parr Oxygen bomb for Hg. Transfer to teflon INAA vessel for INAA analysis.
Furnace hopper ash	Anions	200g composite	500 ml acid washed amber HDPE Nalgene bottle	Seal	
	Metals	200g composite	500 ml acid washed amber HDPE Nalgene bottle	Seal	
	LOI	200g composite	500 ml HDPE Nalgene bottle	Seal	
	PAH	200g composite	500 ml organic free amber glass bottle with teflon lined lid	Seal, store at ≤ 4°C.	Soxhlett extraction

Fuel Oil and Furnace Hopper Ash Collection Procedures

Fuel Oil

Fuel oil samples were collected at the beginning, middle, and end of each test day. Fuel oil samples were collected at a tap located before the magnesium oxide slurry addition. A total composite of 1500 ml in three separate containers was obtained for each test day. Fuel oil flow rates were determined by the plant's fuel oil flow meter and recorded along with other boiler operating conditions. Integrated daily fuel use data was obtained from the station.

Furnace Hopper Ash

Four times during the test program, the furnace hopper ash hoppers were dumped: 1) at the start of the program, 2) after the metals tests were performed, 3) after the mercury and chromium tests were performed, and 4) after the PAH tests were repeated. Samples were collected and analyzed from the second and third ash dumps.

For the furnace hopper ash, a compost digger was used to remove a group of samples from various locations and depths within the furnace hopper ash pile. These samples were collected in a container and mixed until visible homogeneity was achieved. From this, a 1000 gram composite was removed and divided into five specified containers. To determine a furnace hopper ash mass flow rate, the volume of the shipping containers and the level of ash was documented. A density analysis of the ash provided information needed to calculate the total mass of the furnace hopper ash dumped.

ESP Inlet and Outlet Collection and Analysis Procedures

Combined Metals Train

ESP inlet and outlet samples were withdrawn isokinetically with particulate emissions collected on a heated filter and gaseous emissions collected in a series of iced impingers containing 5% HNO_3/10% H_2O_2 for the first two, empty for the third and 4% $KMnO_4$/10% H_2SO_4 in the fourth. Decomposition of each sample fraction was per the EPA method. Whenever possible, decomposed sample portions were concentrated and combined with regard to preventing loss of volatile metals, to achieve the lowest reporting limits possible for these samples. Materials collected in the sampling train were digested with acid solutions to solubilize inorganic target species and to remove organic constituents that may create analytical interferences. Acid digestion of the front-half and filter was performed using conventional Parr Bomb digestion techniques. Impinger solutions were digested and concentrated after removing an aliquot for mercury. The separate fractions were combined after digestion and before analysis.

Reagent and filter blanks were analyzed for all trace metals. A spiked reagent blank for Hg and spiked reagent blank for all metals was analyzed to assess analytical recovery methods and to ensure that the decomposition procedure was accurate. Following the analysis of the samples and field blanks, a mandatory check for matrix effects and interferences was performed for each metal by spiking one outlet and one inlet sample. The inlet sample spikes were considered representative of the analytical technique because they were spiked at a level comparable to the sample concentrations. If the recovery was less than ±25% of nominal, the sample was run using the method of standard additions or an alternate technique if possible. One duplicate analysis was performed for each metal. A field blank was collected and analyzed from the inlet and the outlet locations. Analyses for the trace metals was performed by ICP-AES, GFAAS, or CVAAS absorption, depending upon the metal of interest.

The multi-metals train was also employed during the mercury evaluation study, and analyzed for mercury only. This allowed direct comparison of mercury data obtained by the new methods to those obtained by this established reference method.

Semi-Volatile Species

Triplicate samples for PAHs were collected according to CARB Method 429 - September 12, 1989 version. In this procedure, a sample was collected isokinetically and passed through a heated filter followed by an XAD-2 sorbent module in a water-cooled condenser. The sorbent module was followed by an impinger train to collect moisture and any species that might pass through the resin.

Prior to release to the field, each XAD-2 resin trap was spiked with deuterated standards to assess field losses or gains. The standards used were

benzo(e)pyrene-d_{12} and terphenyl d_{14}. In addition, sixteen surrogate standards were added to each sample prior to the extraction step to provide recovery corrected results. Deuterated standards were not available for 2-Methylnapthalene, 3-Methylcholanthrene, or 7,12-Dimethylbenzo(a)anthracene; the method of internal standardization was used for these species. Following extraction and cleanup, the processed extract from each sample was analyzed by HRGC/LRMS-SIM.

At each sample location a full field blank train was assembled, recovered and analyzed. During the recovery procedure all glassware was rinsed three times each with organic free methanol, toluene and methylene chloride. The solvent rinses were combined with the filter and sorbent module for extraction and final analysis for each train.

Benzene and Toluene

Tedlar bag samples were drawn simultaneously at a single point at both the ESP inlet and outlet. The samples were collected according to CARB 410A using GC/PID as the method of analysis. Duplicate analyses were performed on one sample at each location. One sample was then spiked with benzene and toluene and reanalyzed to assess recovery.

The inlet sample train used a glass wool plug. Carbon buildup on this plug and absorption of benzene and toluene on the carbon contributed to low inlet results.

Total Solid Particulate/ Anions

Anion and particulate samples were collected isokinetically at the ESP inlet and outlet. The solid particulate was collected and analyzed according to Method 5 at the inlet and Method 17 at the outlet. The first two impingers contained a solution of sodium carbonate/sodium bicarbonate to collect Cl and F. The third and fourth impingers contained 3% H_2O_2 to collect SO_2. Each sample fraction was analyzed for PO_4^{3-} but the detection limit was high so the phosphorus result from the multi-metals train was used.

O_2 and CO_2

O_2 and CO_2 were measured at a single point at the ESP outlet, using Carnot's Continuous Emissions Monitoring System. This system was used in conjunction with all tests to provide O_2 and CO_2 data for molecular weight and dilution calculations. Additionally, portable O_2 meters were used with each sample train to provide sample-specific O_2 data. Concentrations of CO_2 at the ESP inlet were then calculated given percent O_2 and CO_2 at the ESP outlet and percent O_2 at the ESP inlet.

Three-Dimensional Velocity Testing

A United Sensor Three Dimensional Directional Probe was used at the 84 point sampling grid at the ESP inlet and the 88 point grid at the outlet. The 3-D probe measures yaw and pitch angles, as well as total and static pressures, and allows for very accurate gas flow measurements.

Each probe has five measuring holes in its tip. A centrally located pressure hole measures pressure P1, while two lateral pressure holes measure pressures P2 and P3. If the probe is rotated manually until P2 and P3 are identical as a readout on the manometer, the yaw angle of flow is then indicated by the number of degrees rotated.

When the yaw angle has been determined, an additional differential pressure P4 - P5 is measured by pressure holes located above and below the total pressure (P1) hole. Pitch angle is determined by calculating (P4 - P5)/(P1 - P2) and using the calibration data for the individual probe and interpolating between the bracketing data. At any particular pitch angle, the velocity pressure coefficient (Pt - Ps)/(P1 - P2) can also be interpolated from the calibration data and Pt - Ps and Ps calculated.

Velocity and Moisture

Stack gas velocity and moisture content were measured by EPA Methods 2 and 4 in conjunction with every isokinetic test.

Formaldehyde

Triplicate samples for formaldehyde were collected non-isokinetically at a single point simultaneously on both in inlet and the outlet in acidic 2,4 dinitrophenylhydrazine (DNPH) solution as per CARB Method 430 using midget impingers. An in-stack filter was used to remove particulate. The analysis for formaldehyde was performed by reverse phase HPLC with a UV Detector. The collection solution was analyzed before release to the field to verify that there was no significant level of detectable formaldehyde. All samples were kept cold and sealed. Three field blanks were taken and analyzed by attaching blank vials of DNPH to the sampling equipment and recovering it the same way as a sample. In this way, blank DNPH solution is exposed to the ambient air and the sampling equipment for the same period of time as the sample vials. A field spike that contained 5.0 μg of formaldehyde was prepared, exposed to sampling conditions using the same procedure as the field blanks and analyzed, along with a trip blank and a trip spike (neither of which were opened).

Mercury Evaluation Test

Two mercury sampling trains that are under development were operated at a single point at the ESP outlet. These were the Brooks Rand Method and the MIT method. The Brooks Rand method employed potassium chloride/soda lime traps to collect oxidated mercury and methyl mercury. Elemental mercury was collected in iodated charcoal traps. The analysis involved a series of successive desorption steps and measurement by cold vapor atomic fluorescence spectroscopy (CVAFS). The MIT sampling train collected total mercury in a charcoal cartridge. The contents

were transferred to a teflon container then analyzed by instrumental neutron activation analysis (INAA).

Total Chromium and Hexavalent Chromium Speciation

Total chromium and hexavalent chromium samples were collected isokinetically at a single point at both the ESP inlet and outlet using a recirculating train. To eliminate the possibility of Cr^{6+} reduction between the nozzle and impingers, liquid from the first impinger was continuously recirculated to the probe trip. There were seven impingers in this train. The first four were teflon, the last three were glass.

Impinger 1: 5N KOH
Impinger 2 and 3: 0.5 N KOH
Impinger 4: Empty (teflon)
Impinger 5: Empty (glass)
Impinger 6: 0.1 N HNO_3
Impinger 7: Silica Gel

The caustic impinger solution was analyzed for Cr^{6+} by ion chromatography with a post-column reactor (IC/PCR). Total chromium was measured in all fractions of the train by ICP-AES.

One inlet and one outlet sample was spiked with radioactively labelled Cr^{6+} to certify that Cr^{6+} is not converted to Cr^{3+} during sampling. One field blank was also spiked with radioactively labelled Cr^{6+}. The labelled Cr^{6+} was analyzed by gamma spectroscopy.

APPENDIX B
FCEM SITE 112 INDIVIDUAL STREAM CONCENTRATIONS

This appendix presents the Site 112 sampling results that were used to calculate the emissions and mass balances presented in this report. Provided here are results for the following streams: ESP inlet and outlet gases, fuel oil, furnace hopper ash, and boiler wash.

The following data flags are used in this table:

@	Concentration is less than five times the reporting limit
E	Estimated analyte result
NA	Not analyzed
ND<	Not detected at less than the reporting limit
B	Blank correction exceeded 50% of uncorrected result

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		Run 1		Run 2		Run 3		Average Used
ESP, Outlet Gas, Metals	Arsenic	GFAAS	ug/Nm3	ND<	2.98	ND<	0.60	ND<	3.16	ND<	3.16
ESP, Outlet Gas, Metals	Barium	ICP-AES	ug/Nm3		23.4		2.98		14.7		13.7
ESP, Outlet Gas, Metals	Beryllium	ICP-AES	ug/Nm3		0.92		0.30		1.08		0.77
ESP, Outlet Gas, Metals	Cadmium	ICP-AES	ug/Nm3		0.96		0.13@		0.18@		0.42
ESP, Outlet Gas, Metals	Cobalt	ICP-AES	ug/Nm3		15.6		4.50		18.5		12.9
ESP, Outlet Gas, Metals	Copper	ICP-AES	ug/Nm3		9.04		4.35		11.8		8.41
ESP, Outlet Gas, Metals	Lead	ICP-AES	ug/Nm3		4.05@		2.98@		3.16@		3.40@
ESP, Outlet Gas, Metals	Manganese	ICP-AES	ug/Nm3		7.78		23.1		26.8		19.2
ESP, Outlet Gas, Metals	Mercury	CVAAS	ug/Nm3		0.29		0.44	ND<	0.41		0.31
ESP, Outlet Gas, Metals	Molybdenum	ICP-AES	ug/Nm3		7.14		5.44		10.7		7.77
ESP, Outlet Gas, Metals	Nickel	ICP-AES	ug/Nm3		468		161		564		398
ESP, Outlet Gas, Metals	Phosphorus	ICP-AES	ug/Nm3		149		104		174		143
ESP, Outlet Gas, Metals	Selenium	GFAAS/ICP-AES	ug/Nm3	ND<	6.18	ND<	6.18	ND<	3.16	ND<	6.18
ESP, Outlet Gas, Metals	Vanadium	ICP-AES	ug/Nm3		383		112		451		316

Stream	Substance	Method	UOM	Run 9	Run 10	Run 11	Average Used
ESP, Outlet Gas, PM	Particulate, total	GRAV	mg/Nm3	20.6	23.0	25.3	23.0
ESP, Outlet Gas, Anions	Chloride	IC	ug/Nm3	3,241	5,258	5,477	4,659
ESP, Outlet Gas, Anions	Fluoride	IC	ug/Nm3	1,051	497	253	600
ESP, Outlet Gas, Anions	Sulfate (SO4 -2)	IC	ug/Nm3	1.87E+06	1.94E+06	1.83E+06	1.88E+06

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		Run 12		Run 13		Run 14		Average Used
ESP, Outlet Gas, PAH	Naphthalene	HRGC/LRMS-SIM	ug/Nm3		0.45@		0.39@		0.42@		0.42@
ESP, Outlet Gas, PAH	Acenaphthylene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.016	ND<	0.060	ND<	0.015	ND<	0.060
ESP, Outlet Gas, PAH	Acenaphthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.032	ND<	0.030	ND<	0.068	ND<	0.068
ESP, Outlet Gas, PAH	Fluorene	HRGC/LRMS-SIM	ug/Nm3		0.014@		0.007@		0.059		0.027
ESP, Outlet Gas, PAH	Phenanthrene	HRGC/LRMS-SIM	ug/Nm3		0.030		0.025@		0.023@		0.026
ESP, Outlet Gas, PAH	Anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.014	ND<	0.014	ND<	0.013	ND<	0.014
ESP, Outlet Gas, PAH	Fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.023	ND<	0.016	ND<	0.023	ND<	0.023
ESP, Outlet Gas, PAH	Pyrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.025	ND<	0.014	ND<	0.023	ND<	0.025
ESP, Outlet Gas, PAH	Benz(a)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.100	ND<	0.044	ND<	0.042	ND<	0.100
ESP, Outlet Gas, PAH	Chrysene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.034	ND<	0.034	ND<	0.032	ND<	0.034
ESP, Outlet Gas, PAH	Benzo(b)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.025	ND<	0.011	ND<	0.011	ND<	0.025
ESP, Outlet Gas, PAH	Benzo(k)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.032	ND<	0.014	ND<	0.013	ND<	0.032
ESP, Outlet Gas, PAH	Benzo(a)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.016	ND<	0.016	ND<	0.015	ND<	0.016
ESP, Outlet Gas, PAH	Indeno(1,2,3-cd)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.089	ND<	0.055	ND<	0.038	ND<	0.089
ESP, Outlet Gas, PAH	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.139	ND<	0.078	ND<	0.063	ND<	0.139
ESP, Outlet Gas, PAH	Benzo(g,h,i)perylene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.102	ND<	0.057	ND<	0.042	ND<	0.102
ESP, Outlet Gas, PAH	2-Methylnaphthalene	HRGC/LRMS-SIM	ug/Nm3		0.021@		0.018@		0.018@		0.019@
ESP, Outlet Gas, PAH	7,12-Dimethylbenz(a)anthrace	HRGC/LRMS-SIM	ug/Nm3	ND<	0.011	ND<	0.115	ND<	0.011	ND<	0.115
ESP, Outlet Gas, PAH	3-Methylcholanthrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.227	ND<	0.230	ND<	0.211	ND<	0.230

Stream	Substance	Method	UOM	Run 1A	Run 1B	Run 1C	Run 1D	Average Used
ESP, Outlet Gas, VOC	Benzene	GC/PID	ug/Nm3	2.47@	3.90	3.21	2.51@	3.02
ESP, Outlet Gas, VOC	Toluene	GC/PID	ug/Nm3	183	124	74.8	26.9	102

Stream	Substance	Method	UOM	Run 2A	Run 2B	Run 2C	Average Used
ESP, Outlet Gas, Aldehyde	Formaldehyde	HPLC	ug/Nm3	7.82@B	41.1	3.44@B	17.5

Stream	Substance	Method	UOM	Run 5	Run 6	Run 8	Average Used
ESP, Outlet Gas,Chrome	Chromium, total	EPAREC/ICP	ug/Nm3	7.50	3.10	4.20	4.90

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Run 1	Run 2	Run 3	Average Used
ESP, Inlet Gas, Metals	Arsenic	GFAAS	ug/Nm3	3.90@	6.15@	8.10@	6.05@
ESP, Inlet Gas, Metals	Barium	ICP-AES	ug/Nm3	20.5	46.2	17.1	27.9
ESP, Inlet Gas, Metals	Beryllium	ICP-AES	ug/Nm3	2.63	3.02	3.68	3.11
ESP, Inlet Gas, Metals	Cadmium	ICP-AES	ug/Nm3	0.76	0.43@	0.53	0.57
ESP, Inlet Gas, Metals	Chromium	ICP-AES	ug/Nm3	9.79	8.98	12.5	10.4
ESP, Inlet Gas, Metals	Cobalt	ICP-AES	ug/Nm3	47.9	45.1	48.8	47.3
ESP, Inlet Gas, Metals	Copper	ICP-AES	ug/Nm3	33.4	33.0	45.8	37.4
ESP, Inlet Gas, Metals	Lead	ICP-AES	ug/Nm3	9.01@	6.46@	4.67@	6.72@
ESP, Inlet Gas, Metals	Manganese	ICP-AES	ug/Nm3	27.0	15.3	11.2	17.8
ESP, Inlet Gas, Metals	Mercury	CVAAS	ug/Nm3	1.12	2.95	1.03	1.70
ESP, Inlet Gas, Metals	Molybdenum	ICP-AES	ug/Nm3	16.2	18.6	18.9	17.9
ESP, Inlet Gas, Metals	Nickel	ICP-AES	ug/Nm3	1,372	1,394	1,443	1,403
ESP, Inlet Gas, Metals	Phosphorus	ICP-AES	ug/Nm3	390	400	467	419
ESP, Inlet Gas, Metals	Selenium	GFAAS/ICP-AES	ug/Nm3	ND< 7.07	ND< 8.92	ND< 9.03	ND< 9.03
ESP, Inlet Gas, Metals	Vanadium	ICP-AES	ug/Nm3	1,116	1,347	1,489	1,317

Stream	Substance	Method	UOM	Run 9	Run 10	Run 11	Average Used
ESP, Inlet Gas, PM	Particulate, total	GRAV	mg/Nm3	117	96.7	94.5	103
ESP, Inlet Gas, Anions	Chloride	IC	ug/Nm3	3,784	3,373	2,815	3,324
ESP, Inlet Gas, Anions	Fluoride	IC	ug/Nm3	1,005	525	422	651
ESP, Inlet Gas, Anions	Sulfate (SO4 -2)	IC	ug/Nm3	2.11E+06	2.07E+06	1.92E+06	2.03E+06

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Run 12	Run 13	Run 14	Average Used
ESP, Inlet Gas, PAH	Naphthalene	HRGC/LRMS-SIM	ug/Nm3	0.59@	0.58@	0.58@	0.58@
ESP, Inlet Gas, PAH	Acenaphthylene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.024	ND< 0.026	ND< 0.176	ND< 0.176
ESP, Inlet Gas, PAH	Acenaphthene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.083	ND< 0.095	ND< 0.079	ND< 0.095
ESP, Inlet Gas, PAH	Fluorene	HRGC/LRMS-SIM	ug/Nm3	0.024@	0.018@	0.014@	0.019@
ESP, Inlet Gas, PAH	Phenanthrene	HRGC/LRMS-SIM	ug/Nm3	0.159	0.120	0.086	0.122
ESP, Inlet Gas, PAH	Anthracene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.021	ND< 0.022	ND< 0.022	ND< 0.022
ESP, Inlet Gas, PAH	Fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.048	0.018	0.011	ND< 0.048
ESP, Inlet Gas, PAH	Pyrene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.048	ND< 0.033	ND< 0.061	ND< 0.061
ESP, Inlet Gas, PAH	Benz(a)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.100	ND< 0.047	ND< 0.072	ND< 0.100
ESP, Inlet Gas, PAH	Chrysene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.103	ND< 0.036	ND< 0.072	ND< 0.103
ESP, Inlet Gas, PAH	Benzo(b)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.034	ND< 0.036	ND< 0.032	ND< 0.036
ESP, Inlet Gas, PAH	Benzo(k)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.034	ND< 0.040	ND< 0.032	ND< 0.040
ESP, Inlet Gas, PAH	Benzo(a)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.028	ND< 0.026	ND< 0.029	ND< 0.029
ESP, Inlet Gas, PAH	Indeno(1,2,3-cd)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.003	ND< 0.029	ND< 0.022	ND< 0.029
ESP, Inlet Gas, PAH	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.010	ND< 0.073	ND< 0.036	ND< 0.073
ESP, Inlet Gas, PAH	Benzo(g,h,i)perylene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.010	ND< 0.033	ND< 0.029	ND< 0.033
ESP, Inlet Gas, PAH	2-Methylnaphthalene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.017	0.034@	0.040@	0.027@
ESP, Inlet Gas, PAH	7,12-Dimethylbenz(a)anthrace	HRGC/LRMS-SIM	ug/Nm3	ND< 0.017	ND< 0.018	ND< 0.180	ND< 0.180
ESP, Inlet Gas, PAH	3-Methylcholanthrene	HRGC/LRMS-SIM	ug/Nm3	ND< 0.345	ND< 0.365	ND< 0.360	ND< 0.365

Stream	Substance	Method	UOM	Run 1A	Run 1B	Run 1C	Run 1D	Average Used
ESP, Inlet Gas, VOC	Benzene	GC/PID	ug/Nm3	0.87@	1.12@	0.87@	ND< 0.52	0.78@
ESP, Inlet Gas, VOC	Toluene	GC/PID	ug/Nm3	32.8	16.3	17.9	15.5	20.6

Stream	Substance	Method	UOM	Run 2A	Run 2B	Run 2C	Average Used
ESP, Inlet Gas, Aldehydes	Formaldehyde	HPLC	ug/Nm3	26.0	26.8	23.2 B	25.3

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		FO 7/16		FO 7/17	FO 7/18		Average Used
Fuel Oil, Metals	Arsenic	INAA	mg/kg		0.059		0.070	NA		0.065
Fuel Oil, Metals	Barium	INAA	mg/kg		1.1		1.2	1.6		1.3
Fuel Oil, Metals	Beryllium	ICP-AES	mg/kg		0.053		0.066	0.062		0.060
Fuel Oil, Metals	Cadmium	ICP-AES	mg/kg		0.010@		0.015@	0.014@		0.013@
Fuel Oil, Metals	Chromium	INAA	mg/kg		0.23		0.28	0.20		0.24
Fuel Oil, Metals	Cobalt	INAA	mg/kg		1.3		1.5	3.0		1.93
Fuel Oil, Metals	Copper	ICP-AES	mg/kg		0.64		0.63	0.62		0.63
Fuel Oil, Metals	Lead	ICP-AES	mg/kg		0.40@		0.36@	0.40@		0.39@
Fuel Oil, Metals	Manganese	INAA	mg/kg		0.32		0.38	0.31		0.34
Fuel Oil, Metals	Mercury	INAA	mg/kg		0.0028		0.0043	0.011		0.0060
Fuel Oil, Metals	Molybdenum	INAA	mg/kg		0.13		0.15	0.12		0.13
Fuel Oil, Metals	Nickel	ICP-AES	mg/kg		39.9		41.9	39.9		40.6
Fuel Oil, Metals	Selenium	INAA	mg/kg		0.056		0.044	NA		0.05
Fuel Oil, Metals	Phosphorus	ICP-AES	mg/kg		17.0@		16.0@	12.0@		15.0@
Fuel Oil, Metals	Vanadium	INAA	mg/kg		24.0		33.0	24.0		27.0
Fuel Oil, Metals	Chlorine	INAA	mg/kg		30.0		34.0	25.0		29.7
Fuel Oil, Ult- Anions	Sulfur	LECO-SC132	%		0.86		0.84			0.85
Fuel Oil, Ult- Anions	Fluorine	ISE	mg/kg	ND<	10.0	ND<	10.0		ND<	10.0
Fuel Oil, Ultimate	Moisture	ASTM	%		0.04		0.04			0.040
Fuel Oil, Ultimate	Carbon	LECO-CHN	%		85.9		85.9			85.9
Fuel Oil, Ultimate	Hydrogen	LECO-CHN	%		10.0		10.06			10.0
Fuel Oil, Ultimate	Oxygen	Difference	%		2.69		2.73			2.71
Fuel Oil, Ultimate	Nitrogen	LECO-CHN	%		0.50		0.43			0.47
Fuel Oil, Ultimate	Ash	GRAV	%		0.01		0.05			0.030
Fuel Oil, Ultimate	Higher Heating Value	ASTM D-240-87	Btu/lb		18,620		18,544			18,582

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Ash 7/21	Ash 7/24	Average Used
Furnace Hopper Ash, Metals	Arsenic	GFAAS	mg/kg	14.0@		14.0@
Furnace Hopper Ash, Metals	Barium	ICP-AES	mg/kg	190		190
Furnace Hopper Ash, Metals	Beryllium	ICP-AES	mg/kg	57.0		57.0
Furnace Hopper Ash, Metals	Cadmium	ICP-AES	mg/kg	5.0@		5.0@
Furnace Hopper Ash, Metals	Chromium	ICP-AES	mg/kg	300		300
Furnace Hopper Ash, Metals	Cobalt	ICP-AES	mg/kg	520		520
Furnace Hopper Ash, Metals	Copper	ICP-AES	mg/kg	380		380
Furnace Hopper Ash, Metals	Lead	GFAAS	mg/kg	93.0		93.0
Furnace Hopper Ash, Metals	Manganese	ICP-AES	mg/kg	640		640
Furnace Hopper Ash, Metals	Mercury	CVAAS	mg/kg	ND< 0.1		ND< 0.1
Furnace Hopper Ash, Metals	Molybdenum	ICP-AES	mg/kg	340		340
Furnace Hopper Ash, Metals	Nickel	ICP-AES	mg/kg	16,000		16,000
Furnace Hopper Ash, Metals	Selenium	GFAAS	mg/kg	ND< 3.0		ND< 3.0
Furnace Hopper Ash, Metals	Phosphorus	ICP-AES	mg/kg	1,600		1,600
Furnace Hopper Ash, Metals	Vanadium	ICP-AES	mg/kg	25,000		25,000
Furnace Hopper Ash, Metals	Mercury	CVAFS	mg/kg	0.00096		0.00096
Furnace Hopper Ash, Anions	Chloride	IC	mg/kg		ND< 250	ND< 250
Furnace Hopper Ash, Anions	Fluoride	IC	mg/kg		ND< 150	ND< 150
Furnace Hopper Ash, Ult- Anions	Sulfur	LECO SC-132	%		2.32	2.32
Furnace Hopper Ash, PAH	Naphthalene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Acenaphthylene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Acenaphthene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Fluorene	HRGC/LRMS-SIM	mg/kg		0.020@	0.020@
Furnace Hopper Ash, PAH	Phenanthrene	HRGC/LRMS-SIM	mg/kg		0.25@	0.25@
Furnace Hopper Ash, PAH	Anthracene	HRGC/LRMS-SIM	mg/kg		0.024@	0.024@
Furnace Hopper Ash, PAH	Fluoranthene	HRGC/LRMS-SIM	mg/kg		0.013@	0.013@
Furnace Hopper Ash, PAH	Pyrene	HRGC/LRMS-SIM	mg/kg		0.092	0.092
Furnace Hopper Ash, PAH	Benz(a)anthracene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Chrysene	HRGC/LRMS-SIM	mg/kg		ND< 0.015	ND< 0.015
Furnace Hopper Ash, PAH	Benzo(b)fluoranthene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Benzo(k)fluoranthene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Benzo(a)pyrene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Indeno(1,2,3-cd)pyrene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	Benzo(g,h,i)perylene	HRGC/LRMS-SIM	mg/kg		ND< 0.01	ND< 0.01
Furnace Hopper Ash, PAH	2-Methylnaphthalene	HRGC/LRMS-SIM	mg/kg		0.013@	0.013@
Furnace Hopper Ash, PAH	3-Methylcholanthrene	HRGC/LRMS-SIM	mg/kg		ND< 0.005	ND< 0.005
Furnace Hopper Ash, PAH	7,12-Dimethylbenz(a)-	HRGC/LRMS-SIM	mg/kg		ND< 0.005	ND< 0.005

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Fuel Oil		Additive		Total lb/10^12 Btu
		(Note: The volume used to calculate the total mass is different for fuel oil and fireside additive)						
Boiler Wash, Inputs	Arsenic	ICP-AES	mg/kg	ND<	1.0	ND<	2.5	ND< 54.3
Boiler Wash, Inputs	Barium	ICP-AES	mg/kg		1.5		0.89	80.9
Boiler Wash, Inputs	Beryllium	ICP-AES	mg/kg	ND<	1.0	ND<	1.0	ND< 54.0
Boiler Wash, Inputs	Cadmium	ICP-AES	mg/kg	ND<	1.0	ND<	2.5	ND< 54.3
Boiler Wash, Inputs	Chromium	ICP-AES	mg/kg		1.6	ND<	4.8	86.5
Boiler Wash, Inputs	Cobalt	ICP-AES	mg/kg	ND<	3.0	ND<	0.9	ND< 162
Boiler Wash, Inputs	Copper	ICP-AES	mg/kg		1.0		9.0	55.4
Boiler Wash, Inputs	Lead	ICP-AES	mg/kg		2.2		7.2	120
Boiler Wash, Inputs	Manganese	ICP-AES	mg/kg	ND<	1.0		58.0	ND< 53.8
Boiler Wash, Inputs	Mercury	ICP-AES	mg/kg		0.03	ND<	0.10	1.62
Boiler Wash, Inputs	Molybdenum	ICP-AES	mg/kg	ND<	10.0	ND<	7.0	ND< 539
Boiler Wash, Inputs	Nickel	ICP-AES	mg/kg		49.0		3.0	2,637
Boiler Wash, Inputs	Selenium	ICP-AES	mg/kg	ND<	1.0	ND<	2.5	ND< 54.3
Boiler Wash, Inputs	Vanadium	ICP-AES	mg/kg		67.0		5.8	3,607

Stream	Substance	Method	UOM	Total lb/10^12 Btu
	Note: Boiler wash outlet total consists of soda wash, high pressure wash, and bottom ash. Individual data were not included here because of lack in common basis (individual volumes are different, blank volumes are different, units are different,etc.)			
Boiler Wash, Outputs	Arsenic	ICP-AES		ND< 0.017
Boiler Wash, Outputs	Barium	ICP-AES		0.12
Boiler Wash, Outputs	Beryllium	ICP-AES		0.023
Boiler Wash, Outputs	Cadmium	ICP-AES		0.012
Boiler Wash, Outputs	Chromium	ICP-AES		0.16
Boiler Wash, Outputs	Cobalt	ICP-AES		0.63
Boiler Wash, Outputs	Copper	ICP-AES		0.47
Boiler Wash, Outputs	Lead	ICP-AES		0.041
Boiler Wash, Outputs	Manganese	ICP-AES		0.75
Boiler Wash, Outputs	Mercury	CVAAS		ND< 4.252E-05
Boiler Wash, Outputs	Molybdenum	ICP-AES		1.4
Boiler Wash, Outputs	Nickel	ICP-AES		21.0
Boiler Wash, Outputs	Selenium	ICP-AES		ND< 0.02
Boiler Wash, Outputs	Vanadium	ICP-AES		26.7
Boiler Wash, Outputs	Fluoride	IC		0.036
Boiler Wash, Outputs	Phosphate	IC		0.034
Boiler Wash, Outputs	Chloride	IC		0.0042
Boiler Wash, Outputs	Sulfate	IC		15.3

APPENDIX B
SITE 112 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Total lb/10^12 Btu
Boiler Wash, Outputs	TDS	GRAV		3,437
Boiler Wash, Outputs	TSS	GRAV		175
Boiler Wash, Outputs	Naphthalene	HRGC/LRMS-SIM		ND< 2.34E-05
Boiler Wash, Outputs	Acenaphthylene	HRGC/LRMS-SIM		ND< 4.67E-06
Boiler Wash, Outputs	Acenaphthene	HRGC/LRMS-SIM		ND< 4.67E-06
Boiler Wash, Outputs	Fluorene	HRGC/LRMS-SIM		ND< 2.46E-06
Boiler Wash, Outputs	Phenanthrene	HRGC/LRMS-SIM		ND< 6.40E-06
Boiler Wash, Outputs	Anthacene	HRGC/LRMS-SIM		ND< 1.41E-05
Boiler Wash, Outputs	Fluoranthene	HRGC/LRMS-SIM		ND< 6.99E-06
Boiler Wash, Outputs	Pyrene	HRGC/LRMS-SIM		ND< 6.99E-06
Boiler Wash, Outputs	Benz(a)anthracene	HRGC/LRMS-SIM		ND< 6.99E-06
Boiler Wash, Outputs	Chrysene	HRGC/LRMS-SIM		ND< 6.99E-06
Boiler Wash, Outputs	Benzo(b)fluoranthene	HRGC/LRMS-SIM		ND< 1.18E-05
Boiler Wash, Outputs	Benzo(k)fluoranthene	HRGC/LRMS-SIM		ND< 1.18E-05
Boiler Wash, Outputs	Benzo(a)pyrene	HRGC/LRMS-SIM		ND< 1.18E-05
Boiler Wash, Outputs	Indeno(1,2,3-c,d)pyrene	HRGC/LRMS-SIM		ND< 2.32E-05
Boiler Wash, Outputs	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM		ND< 2.32E-05
Boiler Wash, Outputs	Benzo(g,h,i)perylene	HRGC/LRMS-SIM		ND< 2.32E-05

APPENDIX C
DATA NOT USED IN CALCULATIONS

This appendix contains data that was not used in emissions or mass balance calculations. The mercury and chromium evaluation results are presented here, except for the ESP outlet total chromium result which is included in Appendix B.

APPENDIX C
SITE 112 DATA NOT USED IN CALCULATIONS

Stream	Substance	Method	UOM	Run 1	Run 2	Run 3
ESP, Outlet Gas, Metals	Chromium	ICP-AES	ug/Nm3	29.5	93.4	42.5

Stream	Substance	Method	UOM	Run 9	Run 10	Run 11
ESP, Outlet Gas, Anions	Phosphate (PO4 -3)	IC	ug/Nm3	ND< 2,095	ND< 307	ND< 512
ESP, Inlet Gas, Anions	Phosphate (PO4 -3)	IC	ug/Nm3	ND< 2,649	ND< 2,683	ND< 2,271

Stream	Substance	Method	UOM	Run 5	Run 6	Run 8
ESP, Outlet Gas,Chrome	Hexavalent Chromium	EPAREC/IC-PCR	ug/Nm3	ND< 0.48	ND< 0.61	ND< 1.07
ESP, Inlet Gas,Chrome	Chromium, total	EPAREC/ICP	ug/Nm3	9.30	8.80	9.30
ESP, Inlet Gas,Chrome	Hexavalent Chromium	EPAREC/IC-PCR	ug/Nm3	1.24	ND< 0.46	ND< 1.15

Stream	Substance	Method	UOM	Run 5	Run 6	Run 7A	Run 7B
ESP, Outlet Gas,Mercury	Mercury, total	MIT/INAA	ug/Nm3			1.97	1.73
ESP, Outlet Gas,Mercury	Mercury, total	EPAMM/CVAAS	ug/Nm3	0.44	ND< 1.12	0.41	
ESP, Outlet Gas,Mercury	Mercury, total	BR/CVAFS	ug/Nm3	0.036	0.025	0.036	0.034
ESP, Outlet Gas,Mercury	Hg(II)	BR/CVAFS	ug/Nm3	ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021
ESP, Outlet Gas,Mercury	Hg(0)	BR/CVAFS	ug/Nm3	ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021
ESP, Outlet Gas,Mercury	Methyl Hg	BR/CVAFS	ug/Nm3	0.015	0.003	0.015	0.013

Stream	Substance	Method	UOM	FO 7/16	FO 7/17	FO 7/18
Fuel Oil, Metals	Arsenic	GFAAS	mg/kg	0.008@	ND< 0.005	ND< 0.005
Fuel Oil, Metals	Barium	ICP-AES	mg/kg	1.7	1.9	3.2
Fuel Oil, Metals	Chromium	ICP-AES	mg/kg	0.19	0.21	0.25
Fuel Oil, Metals	Cobalt	ICP-AES	mg/kg	1.2	1.4	1.3
Fuel Oil, Metals	Manganese	ICP-AES	mg/kg	0.24	0.26	0.42
Fuel Oil, Metals	Mercury	CVAAS	mg/kg	0.08@	ND< 0.02	ND< 0.02
Fuel Oil, Metals	Molybdenum	ICP-AES	mg/kg	0.24	0.25	0.23
Fuel Oil, Metals	Selenium	GFAAS	mg/kg	ND< 0.005	ND< 0.005	ND< 0.005
Fuel Oil, Metals	Vanadium	ICP-AES	mg/kg	21.9	25.9	24.9

APPENDIX C

SITE 112 DATA NOT USED IN CALCULATIONS

Stream	Substance	Method	UOM	FO 7/16	FO 7/17	FO 7/18
Fuel Oil, Ult- Anions	Chlorine	ASTM D808	mg/kg	500	400	NA

Stream	Substance	Method	UOM	FO 7/21 - 7/23 Composite
Fuel Oil, Evalu. test metals	Chromium	ICP-AES	mg/kg	0.33
Fuel Oil, Evalu. test metals	Mercury	CVAAS	mg/kg	ND< 0.02
Fuel Oil, Evalu. test metals	Chromium	INAA	mg/kg	0.64
Fuel Oil, Evalu. test metals	Mercury	INAA	mg/kg	0.015
Fuel Oil, Evalu. test metals	Mercury	CVAFS	mg/kg	0.0009

Stream	Substance	Method	UOM	Ash 7/24
Furnace Hopper Ash, Anions	Sulfate	IC	mg/kg	4,850
Furnace Hopper Ash, Anions	Phosphate	IC	mg/kg	ND< 1,000
Furnace Hopper Ash, LOI	Loss on Ignition		%	4.58

APPENDIX D

PROCESS STREAM FLOW RATES AND CALCULATION PROCEDURES

The tables in Appendix D summarize the following information:

Table D-1: Mean process stream flows at Site 112

Table D-2: ESP inlet and ESP outlet gas conditions and flow rate summary, including comparison of the measured flow rate to the calculated flow rate

Table D-3: Sample train test summaries including sample volumes and isokinetic ratios

Table D-4: Summary of furnace hopper ash collection

Table D-5: Calculations

TABLE D-1
MEAN PROCESS STREAM FLOWS AT SITE 112

Stream	Mean Flow Rate	Standard Deviation	Source
Oil (lb/hr)	177,000	10,000	Measured*
Bottom Ash (lb/hr, dry)	5.47	5.92	Measured**
(lb/MMBtu)	0.0022	0.0025	
ESP Outlet Gas (dscfm)	757,163	13,289	Calculated***
ESP Inlet Gas (dscfm)	743,393	46,732	Calculated***

* Measured from plant instrumentation. Run 7 at 50% load excluded.

** Measured by dumping ash in hopper and calculating the weight from measured ash density and volume. Collection rates were highly variable ranging from 0.51 - 12.02 lb/hr.

*** Calculated from unit heat rate and load. Run 7 at 50% load excluded.

TABLE D-2
SUMMARY OF EXHAUST GAS CONDITIONS AND FLOW RATES FOR ISOKINETIC TESTS, SITE 112

Test No.	Date	Time	O_2, %	CO_2, %	H_2O, %	Stack Temp. °F	Vm std dscf	Flow Rate (Pitot) dscfm	Gross Output, MW	Flow Rate* (Heat RT) dscfm
1-MTLS-IN	7/16/92	1115/1841	7.55	10.72	9.8	330	155.53	903,051	362	803,499
1-MTLS-OUT	7/16/92	1134/1744	6.83	11.20	9.1	337	177.82	835,261	362	762,382
2-MTLS-OUT	7/17/92	1009/1550	6.62	11.23	9.2	338	177.75	844,584	366	759,755
2-MTLS-IN	7/17/92	1041/1602	7.05	10.90	10.5	330	123.16	870,911	366	783,343
3-MTLS-OUT	7/18/92	1052/1630	6.23	11.42	9.7	339	167.75	832,559	366	739,557
3-MTLS-IN	7/18/92	1125/1637	7.97	10.06	10.8	330	121.64	875,452	366	839,080
5-CR-OUT	7/21/92	1235/1752	6.06	11.58	7.8	336	132.3	SP	365	729,020
5-CR-IN	7/21/92	1355/1740	5.30	12.17	10.0	362	131.25	SP	365	693,504
5-MIT/BR-HG	7/21/92	1507/1943	7.08	10.78	9.5	337	100.95	SP	365	782,826
5-MM-HG	7/21/92	1507/1944	6.68	11.09	10.0	334	104.88	SP	365	760,806
6-CR-IN	7/22/92	1035/1212	6.06	11.73	9.3	358	73.28	SP	367	733,151
6-CR-OUT	7/22/92	1035/1213	6.58	11.32	8.5	333	51.20	SP	367	759,773
6-MM-HG	7/22/92	1050/1212	6.21	11.61	9.8	332	44.69	SP	367	740,637
7-MM-HG	7/22/92	1515/1857	10.40	7.80	7.3	308	85.35	SP	187	510,796
8-CR-IN	7/23/92	1035/1435	5.51	12.11	11.1	363	139.83	SP	360	693,010
8-CR-OUT	7/23/92	1034/1337	7.12	10.93	9.5	335	94.23	SP	360	773,978
9-PM/AN-OUT	7/24/92	1026/1601	6.84	11.07	9.0	343	110.37	856,477	361	760,745
9-PM/AN-IN	7/24/92	1225/1529	6.19	11.59	9.7	333	70.11	864,635	361	727,129
10-PM/AN-IN	7/24/92	1306/1617	6.98	10.96	10.0	338	66.40	830,468	361	768,396
10-PM/AN-OUT	7/24/92	1316/1706	6.68	11.20	9.5	345	111.28	912,037	361	752,185
11-PM/AN-IN	7/24/92	1629/1947	6.09	11.68	9.6	331	71.77	898,021	366	732,566
11-PM/AN-OUT	7/24/92	1647/2026	6.70	11.20	9.1	343	110.99	881,720	366	764,036
12-PAH-IN	8/4/92	1033/1537	5.61	11.81	10.8	346	109.95	847,765	355	687,520
12-PAH-OUT	8/4/92	1042/1650	6.96	10.81	11.7	355	166.87	802,912	355	754,102
13-PAH-OUT	8/5/92	1120/1640	6.30	11.28	9.4	352	165.11	853,656	374	759,897
13-PAH-IN	8/5/92	1124/1637	5.77	11.69	10.0	343	103.95	828,071	374	733,278
14-PAH-IN	8/6/92	1040/1525	5.75	11.64	9.6	344	105.30	860,320	371	726,241
14-PAH-OUT	8/6/92	1043/1536	6.38	11.16	9.1	345	179.38	851,723	371	757,751
AVERAGE INLET			6.32	11.42	10.1	342		864,299		743,393
AVERAGE OUTLET**			6.62	11.19	9.4	340		852,235		757,163
STANDARD DEVIATION INLET			0.86	0.63	0.6	13		26,347		46,732
STANDARD DEVIATION OUTLET**			0.32	0.24	0.8	7		30,888		13,289

SP - single point test NA - not applicable

* Flow rate calculated from average heat rate using:

DSCFM = Heat Rate, Btu/kW(net)-hr * (Gross Load, kW - Aux. Demand, kW) * F-factor @ 0% O_2, dscf/mmBtu * 20.9/(20.9-%O_2) * hr/60 min.

** Does not include run 7-MM-HG, which was at half load

TABLE D-3
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	MULTI-METAL ESP INLET	ESP OUTLET
Date	7/16/92	7/16/92
Test Number	1-MTL-IN	1-MTL-OUT
Std Sample Vol (SCF)	156	178
Std Sample Vol (SCM)	4.40	5.04
Moisture Fraction	0.098	0.091
Stack Gas Mol Wt.	28.8	29.0
Stack Gas Velocity (ft/sec)	38.4	89.8
Stack Flow Rate (wacfm)	1,554,653	1,374,377
Stack Flow Rate (dscfm)	903,051	835,261
Isokinetic Ratio (%)	99.9	104.5
Date	7/17/92	7/17/92
Test Number	2-MTL-IN	2-MTL-OUT
Std Sample Vol (SCF)	123	178
Std Sample Vol (SCM)	3.49	5.03
Moisture Fraction	0.104	0.092
Stack Gas Mol Wt	28.8	29.0
Stack Gas Velocity (ft/sec)	37.0	90.7
Stack Flow Rate (wacfm)	1,498,431	1,389,014
Stack Flow Rate (dscfm)	870,911	844,584
Isokinetic Ratio (%)	101.2	103.3
Date	7/18/92	7/18/92
Test Number	3-MTL-IN	3-MTL-OUT
Std Sample Vol (SCF)	122	168
Std Sample Vol (SCM)	3.44	4.75
Moisture Fraction	0.108	0.097
Stack Gas Mol Wt	28.6	28.9
Stack Gas Velocity (ft/sec)	37.6	90.4
Stack Flow Rate (wacfm)	1,521,103	1,383,611
Stack Flow Rate (dscfm)	875,452	832,559
Isokinetic Ratio (%)	99.4	98.9

Note: Stack flow rate as measured by S-Type pitot traverse.

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	PAH ESP INLET	ESP OUTLET
Date	08/04/92	08/04/92
Test Number	12-PAH-IN	12-PAH-OUT
Std Sample Vol (SCF)	110	167
Std Sample Vol (SCM)	3.11	4.73
Moisture Fraction	0.108	0.117
Stack Gas Mol Wt	28.8	28.6
Stack Gas Velocity (ft/sec)	37.2	91.1
Stack Flow Rate (wacfm)	1,504,045	1,394,864
Stack Flow Rate (dscfm)	847,765	802,912
Isokinetic Ratio (%)	103.5	102.0
Date	08/05/92	08/05/92
Test Number	13-PAH-IN	13-PAH-OUT
Std Sample Vol (SCF)	104	165
Std Sample Vol (SCM)	2.94	4.68
Moisture Fraction	0.100	0.094
Stack Gas Mol Wt	28.9	28.9
Stack Gas Velocity (ft/sec)	35.6	93.3
Stack Flow Rate (wacfm)	1,441,501	1,428,490
Stack Flow Rate (dscfm)	828,071	853,656
Isokinetic Ratio (%)	100.2	94.9
Date	08/06/92	08/06/92
Test Number	14-PAH-IN	14-PAH-OUT
Std Sample Vol (SCF)	105	179
Std Sample Vol (SCM)	2.98	5.08
Moisture Fraction	0.096	0.091
Stack Gas Mol Wt	28.9	28.9
Stack Gas Velocity (ft/sec)	36.8	92.0
Stack Flow Rate (wacfm)	1,490,602	1,408,599
Stack Flow Rate (dscfm)	860,320	851,723
Isokinetic Ratio (%)	97.7	103.4

Note: Stack flow rate is as measured by S-Type pitot traverse

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	FORMALDEHYDE ESP INLET	ESP OUTLET
Date	7/17/92	7/17/92
Test Number	2A-FORM-IN	2A-FORM-OUT
Std Sample Vol (SCF)	3.48	5.28
Std Sample Vol (SCM)	0.099	0.150
% O_2	7.05	6.62
Date	7/17/92	7/17/92
Test Number	2B-FORM-IN	2B-FORM-OUT
Std Sample Vol (SCF)	3.45	5.28
Std Sample Vol (SCM)	0.098	0.150
% O_2	7.05	6.62
Date	7/17/92	7/17/92
Test Number	2C-FORM-IN	2C-FORM-OUT
Std Sample Vol (SCF)	3.57	5.28
Std Sample Vol (SCM)	0.101	0.150

Note: % O_2 values are from 2-MTLS-IN and 2-MTLS-OUT

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	BENZENE AND TOLUENE ESP INLET	ESP OUTLET
Date	7/16/92	7/16/92
Test Number	1A-VOC-IN	1A-VOC-OUT
% O_2	7.55	6.83
Date	7/16/92	7/16/92
Test Number	1B-VOC-IN	1B-VOC-OUT
% O_2	7.55	6.83
Date	7/16/92	7/16/92
Test Number	1C-VOC-IN	1C-VOC-OUT
% O_2	7.55	6.83
Date	7/16/92	7/16/92
Test Number	1D-VOC-IN	1D-VOC-OUT
%O_2	7.55	6.83

Note: % O_2 values are from 1-MTLS-IN and 1-MTLS-OUT

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	PARTICULATE/ANIONS ESP INLET	ESP OUTLET
Date	7/24/92	7/24/92
Test Number	9-PM/AN-IN	9-PM/AN-OUT
Std Sample Vol (SCF)	70	110
Std Sample Vol (SCM)	1.99	3.13
Moisture Fraction	0.097	0.090
Stack Gas Mol Wt	28.9	29.0
Stack Gas Velocity (ft/sec)	36.4	91.9
Stack Flow Rate (wacfm)	1,473,004	1,406,166
Stack Flow Rate (dscfm)	864,635	856,477
Isokinetic Ratio (%)	99.5	98.0
Date	7/24/92	7/24/92
Test Number	10-PM/AN-IN	10-PM/AN-OUT
Std Sample Vol (SCF)	66	111
Std Sample Vol (SCM)	1.88	3.15
Moisture Fraction	0.100	0.095
Stack Gas Mol Wt	28.8	28.9
Stack Gas Velocity (ft/sec)	35.3	98.4
Stack Flow Rate (wacfm)	1,428,302	1,505,832
Stack Flow Rate (dscfm)	830,468	912,037
Isokinetic Ratio (%)	95.7	100.1
Date	7/24/92	7/24/92
Test Number	11-PM/AM-IN	11-PM/AN-OUT
Std Sample Vol (SCF)	72	111
Std Sample Vol (SCM)	2.03	3.14
Moisture Fraction	0.096	0.091
Stack Gas Mol Wt	29.0	29.0
Stack Gas Velocity (ft/sec)	37.6	94.3
Stack Flow Rate (wacfm)	1,520,738	1,443,109
Stack Flow Rate (dscfm)	898,021	881,720
Isokinetic Ratio (%)	94.6	103.3

Note: Stack flow rate is as measured by S-Type pitot traverse

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

PARAMETER	CHROMIUM ESP INLET	ESP OUTLET
Date	7/21/92	7/21/92
Test Number	5-CR-IN	5-CR-OUT
Std Sample Vol (SCF)	131	132
Std Sample Vol (SCM)	3.72	3.75
Moisture Fraction	0.100	0.078
Stack Gas Mol Wt	28.9	29.1
Stack Gas Velocity (ft/sec)	52.8	71.6
Stack Flow Rate (dscfm)	693,504	729,020
Isokinetic Ratio (%)	94.2	105.5
Date	7/22/92	7/22/92
Test Number	6-CR-IN	6-CR-OUT
Std Sample Vol (SCF)	73	51
Std Sample Vol (SCM)	2.08	1.45
Moisture Fraction	0.093	0.085
Stack Gas Mol Wt	29.0	29.1
Stack Gas Velocity (ft/sec)	52.3	71.7
Stack Flow Rate (dscfm)	733,151	759,773
Isokinetic Ratio (%)	98.6	99.1
Date	7/23/92	7/23/92
Test Number	8-CR-IN	8-CR-OUT
Std Sample Vol (SCF)	140	94
Std Sample Vol (SCM)	3.96	2.67
Moisture Fraction	0.111	0.095
Stack Gas Mol Wt	28.8	28.9
Stack Gas Velocity (ft/sec)	52.4	73.7
Stack Flow Rate (dscfm)	693,010	773,978
Isokinetic Ratio (%)	100.1	101.1

Note: The test were conducted at a single point in the gas stream.
The stack flow rates are calculated from the heat rate; see Table D-2 for calculations.

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 112

	MERCURY			
PARAMETER	ESP OUTLET	ESP OUTLET	ESP OUTLET	ESP OUTLET
Date	7/21/92			
Test Number	5-MIT/BR-HG			
Std Sample Vol (SCF):				
Isokinetic	92.01			
MIT (VOID)	7.454			
Brooks Rand	1.5			
TOTAL VOLUME	100.9			
Std Sample Vol (SCM)	3			
Moisture Fraction - from iso	0.1			
Stack Gas Mol Wt	28.9			
Stack Gas Velocity (ft/sec)	68.6			
Stack Flow Rate (dscfm)	782,826			
Isokinetic Ratio (%) - from tot vol	108			

NOTE: Test 5-MIT/BR-HG consisted of drawing isokinetic exhaust gas sample that was then split between the Brooks Rand train and the MIT train. This technique allowed isokinetic sampling for the BR/MIT trains. The majority of the exhaust gas was used to determine moisture only. A separate multi-metal train for Hg was performed.

Date	7/21/92	7/22/92	7/22/92	
Test Number	5-MM-HG	6-MM-HG	7-MM-HG	
Std Sample Vol (SCF)	105	45	85	
Std Sample Vol (SCM)	2.97	1.27	2.42	
Moisture Fraction	0.100	0.098	0.073	
Stack Gas Mol Wt	28.8	28.9	28.8	
Stack Gas Velocity (ft/sec)	71.8	74.4	32.8	
Stack Flow Rate (dscfm)	760,806	740,637	510,796	
Isokinetic Ratio (%)	103.9	101.1	103.2	
Date		7/22/92	7/22/92	7/22/92
Test Number		6-BR-HG	7A-BR-HG	7B-BR-HG
Std Sample Vol (SCF)		1.27	1.31	1.27
Std Sample Vol (SCM)		0.036	0.037	0.036
Date			7/22/92	7/22/92
Test Number			7A-MIT-HG	7B-MIT-HG
Std Sample Vol (SCF)			9	9
Std Sample Vol (SCM)			0.26	0.24

Note: These tests were conducted at a single point in the gas stream. The stack flow rates are calculated from the heat rate. See Table D-2 for calculations.

TABLE D-4
SUMMARY OF FURNACE HOPPER ASH COLLECTION
SITE 112

Dates	Total ash volume, cm^3	Ash density g/cm^3	Oil used, barrels	Total ash, $lb/10^6$ Btu	Total ash, lb/hr
7/16 - 7/21 (120 hrs)	222,995	0.951	53,940	0.00137	3.89
7/21 - 7/24 (72 hrs)	18,604	0.894	24,420	0.000237	0.51
8/4 - 8/7 (72 hrs)	426,719	0.921	27,114	0.00505	12.02
Average				0.0022	5.47

TABLE D-5
SAMPLE TRAIN CALCULATION PROCEDURES
SITE 112

1. To Calculate Sample Volume, Actual Exhaust Flow Rate and Isokinetics for Each Sample Train

a. Sample gas volume, dscf

$$V_{m\ std} = 0.03342\ V_m \left(P_{bar} + \frac{H}{13.6}\right)\left(\frac{T_{ref}}{T_m}\right)(Y)$$

b. Water vapor volume, scf

$$V_{w\ std} = 0.0472\ V_{lc}\left(\frac{T_{ref}}{528\ °R}\right)$$

c. Moisture content, nondimensional

$$B_{wo} = \frac{V_{w\ std}}{V_{m\ std} + V_{w\ std}}$$

d. Stack gas molecular weight, lb/lb mole

$$MW_{dry} = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2)$$

$$MW_{wet} = MW_{dry}\ (1 - B_{wo}) + 18\ (B_{wo})$$

e. Absolute stack pressure, in Hg

$$P_s = P_{bar} + \frac{P_{sg}}{13.6}$$

f. Stack velocity, ft/sec

$$V_s = 2.90\ C_p \sqrt{\Delta P T_s}\ \sqrt{\left(\frac{29.92}{P_s}\right)\left(\frac{28.95}{MW_{wet}}\right)}$$

g. Actual stack flow rate, wacfm

$$Q = (V_s)(A_s)(60)$$

h. Standard stack gas flow rate, dscfm

$$Q_{sd} = Q\ (1 - B_{wo})\left(\frac{T_{ref}}{T_s}\right)\left(\frac{P_s}{29.92}\right)$$

i. Percent isokinetic

$$I = \left(\frac{17.32(T_s)(V_{m\ std})}{(1 - B_{wo})(\Theta)(V_s)(P_s)(D_n^2)}\right)\left(\frac{528\ °R}{T_{ref}}\right)$$

2. To Calculate Particulate Emissions

a. Grain loading, gr/dscf

$$C = 0.01543 \left(\frac{M_n}{V_{m\ std}}\right)$$

b. Grain loading at 12% CO_2, gr/dscf

$$C_{12\%CO_2} = C\left(\frac{12}{\%CO_2}\right)$$

c. Mass emissions, lb/hr

$$M = C(Q_{sd})\frac{(60\ \text{min/hr})}{(7000\ gr/lb)}$$

3. To Calculate Gaseous Emissions, lb/hr

$$M = (ppm)(10^{-6})\left(\frac{MW_i\ lb/lb\ mole}{SV}\right)(Q_{sd})(60\ \text{min/hr})$$

where,

SV = *specific molar volume of an ideal gas:*

$SV = 385.3\ ft^3/lb\ mole \quad for\ T_{ref} = 528\ °R$

$SV = 379.5\ ft^3/lb\ mole \quad for\ T_{ref} = 520\ °R$

4. To Estimate Emissions Rates in lb/10^6 Btu Using EPA Method 19 and Given Fuel Analysis

a. Fuel factor at 68 °F, dscf/10^6 Btu at 0% O_2

$$F_{68} = \frac{10^6[3.64(\%H) + 1.53(\%C) + 0.14\ (\%N) + 0.57(\%S) - 0.46(\%O_2,fuel)]}{HHV,\ Btu/lb}$$

b. Fuel factor at 60 °F

$$F_{60} = F_{68}\left(\frac{520\ °R}{528\ °R}\right)$$

c. Gaseous Emissions factor, lb/10^6 Btu

$$\left(\frac{lb}{10^6\ Btu}\right)_i = (ppm)_i\ (10^{-6})\left(\frac{MW_i\ lb}{lb\ mole}\right)\left(\frac{1}{SV}\right)(F)\left(\frac{20.9}{20.9\ -\ \%O_2}\right)$$

d. Gaseous Emissions factor, lb/10^{12} Btu

$$\left(\frac{lb}{10^{12}\ Btu}\right)_i = \left(\frac{lb}{10^6\ Btu}\right)_i \times 10^6$$

e. Particulate emission factor, lb/10^6 Btu

$$\left(\frac{lb}{10^6\ Btu}\right) = C\left(\frac{1\ lb}{7000\ gr}\right)(F)\left(\frac{20.9}{20.9\ -\ \%O_2}\right)$$

f. Particulate emission factor, lb/10^{12} Btu

$$\left(\frac{lb}{10^{12}\ Btu}\right) = \left(\frac{lb}{10^6\ Btu}\right) \times 10^6$$

5. To Calculate Trace Species Emissions Given Laboratory Results

a. ng/sample train = (ng detected) - (ng in field or reagent blank)

b. ng/dscm = ng sample train x (35.31/$V_{m\ std}$)

c. ng/Nm^3 = ng/sample train x (35.31/$V_{m\ std\ dscf}$) x 492/Tref

d. lb/hr = ng/dscm x (1 g/10^9 ng) x (1 lb 454 g) x (1 m^3/35.31 ft^3) x Q_{sd} x (60 min/hr)
where Q_{sd} = standard flow rate, dscfm and Nm^3 = normal cubic meter (0°C, 1 atm)

e. For Formaldehyde Results
ppb = (μg/sample train) x 1/$V_{m\ std}$) x (1 lb/454 g) x (1 g/10^6 μg) x SV/MW_i x 10^9
lb/hr = ppb x 10^{-9} MW_i/SV x Q_{sd} x 60 min/hr

f. For Anion Results
ppm = (mg/sample train) x (1/$V_{m\ std}$) x (1 lb/454 g) x (1 g/10^3 mg) x SV/MW_i x 10^6
lb/hr - ppm x 10^{-6} MW_i/SV x Q_{sd} x 60 min/hr

Notes: Laboratory results could be in either μg or mg. PAH, metals, chromium and formaldehyde results will be in μg and anion results will be in mg.

Field and reagent blank values must be evaluated before subtracting them. For example, very low blanks may merely indicate "noise" and might be disregarded. On the other hand, very high blank values may indicate sampling or analysis problems which should be investigated. It may be acceptable to use a blank correction on some projects or with some reference methods. Typically a reagent blank is a more appropriate indicator of blank levels than a field blank.

6. To Calculate CO_2, % for Each Sample Train

a. Given CEM results for O_2, % and CO_2, % at the outlet and the portable O_2 meter results at each sample train.

b. $$Test\ CO_2 = CEM\ CO_2 \times \frac{20.9\ -\ test\ O_2}{20.9\ -\ CEM\ O_2}$$

7. To Construct a Mass Balance Around the Boiler-ESP System for a Given Parameter, *i*

   a. Given boiler wash, flue gas, ash and fuel sample results.

   b. M_i (fuel) = M_i (flue gas) + M_i (ash) + M_i (boiler wash)
   where M_i is in units of either lb_i/day or $lb_i/10^{12}$ Btu and *i* denotes the particular parameter of interest.

   c. Mass balance$_i$ = (M_i (flue gas) + M_i (ash) + M_i (boiler wash))/M_i (fuel), expressed as %

8. To Calculate Exhaust Gas Flow Rate from Heat Rate and F-factor:

   Flow rate, dscfm = Heat rate, Btu/kW(net)-hr x (Gross Load, kW - Aux. Demand, kW) x F-factor @ 0% O_2, dscf/MMBtu x 20.9/(20.9-%O_2) x hr/60 mi

9. To Calculate Ash Flow Rate and lb ash/10^6 Btu

   total ash, lb/hr = total ash, cm^3 x density, g/cm^3 x lb/454g x 1/number of hours

   lb ash/10^6 Btu = total ash, cm^3 x density, g/cm^3 x lb/454g ÷ (oil used, barrels x MMBtu/barrel)

10. To Calculate lb/10^{12} Btu of Trace Species in Ash

    i = trace species, i
    a = ash
    f = fuel oil
    lb(i)/10^{12} Btu(f) - μg(i)/gram(a) x g(a)/cm^3
    x total ash volume, cm^3 x lb(i)/454g(i) x g/$10^6\mu$g
    x 1/HHV, Btu/lb(f) x 1/total fuel burned, lb(f)
    x 10^{12}

11. To Calculate lb/10^{12} Btu of Trace Species in Fuel

    lb/10^{12} Btu = μg/g x 1/HHV, Btu/lb x 10^6

12. Nomenclature:

A_s	=	stack area, ft^2
B_{wo}	=	flue gas moisture content
$C_{12\% CO_2}$	=	particulate grain loading, gr/dscf corrected to 12% CO_2
C	=	particulate grain loading, gr/dscf
C_p	=	pitot calibration factor, dimensionless
Dn	=	nozzle diameter, in.
F	=	fuel F factor, dscf/10^6 Btu at 0% O_2
H	=	orifice pressure differential, iwg
I	=	% isokinetics
M_n	=	mass of collected particulate, mg
M_i	=	mass emissions of species i, lb/hr
MW	=	molecular weight of flue gas
MW_i	=	molecular weight of species i:

NO_x	:	46
CO	:	28
SO_x	:	64
HC	:	16

θ	=	sample time, min.
ΔP	=	average velocity head, iwg = $\left(\overline{\sqrt{\Delta P}}\right)^2$
P_{bar}	=	barometric pressure, in.Hg
P_s	=	stack absolute pressure, in.Hg
P_{sg}	=	stack static pressure, iwg
Q	=	wet stack gas flow rate at actual conditions, wacfm
Qsd	=	dry stack gas flow rate at standard conditions, dscfm
SV	=	specific molar volume of an ideal gas at standard conditions, ft^3/lb mole
Tm	=	meter temperature, °R
T_{ref}	=	reference temperature, °R
Ts	=	stack temperature, °R
V_s	=	stack velocity, ft/sec
V_{lc}	=	volume of liquid collected in impingers, ml
Vm	=	dry meter volume uncorrected, dcf
$V_{m\ std}$	=	dry meter volume at standard conditions, dscf
$V_{w\ std}$	=	volume of water vapor at standard conditions, scf
Y	=	meter calibration coefficient

APPENDIX E
PROCESS OPERATION

TABLE E-1
SUMMARY OF UNIT OPERATION
SITE 112

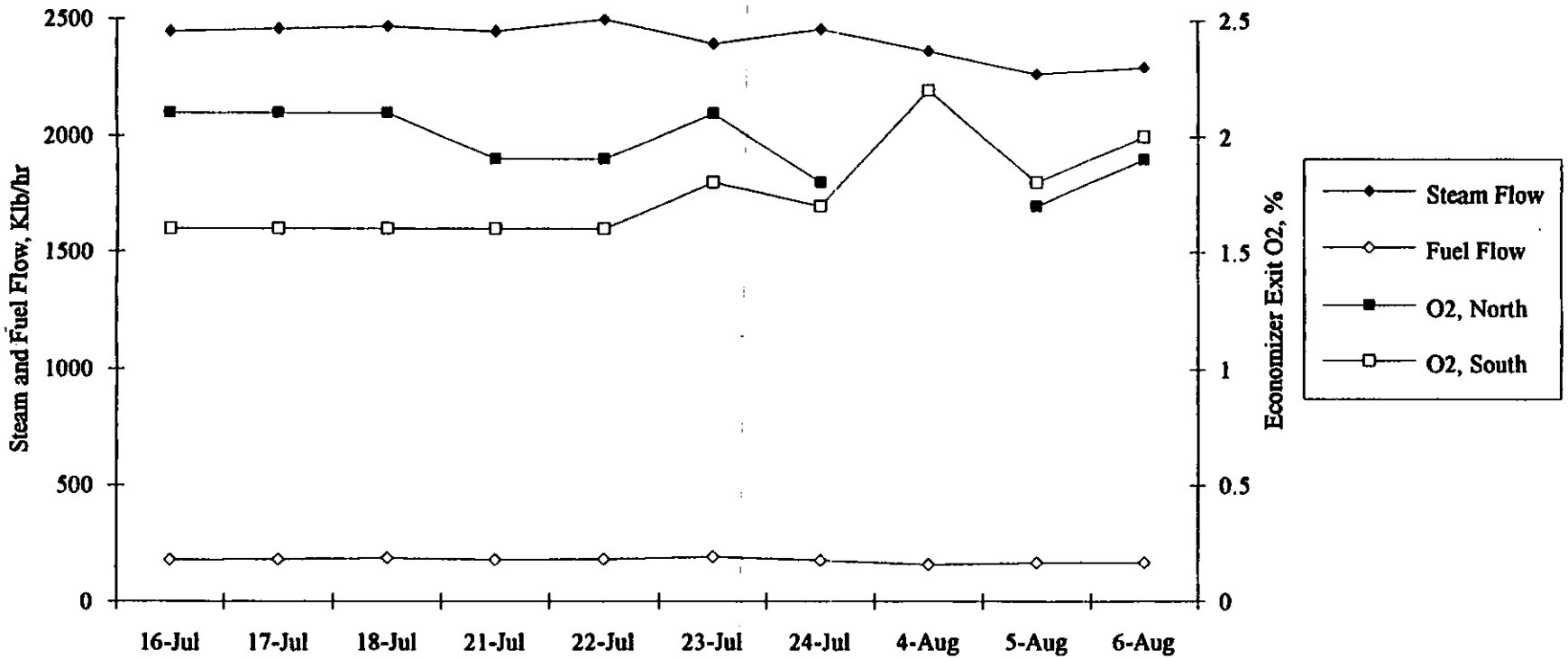
Date	7/16/92	7/17/92	7/18/92	7/21/92	7/22/92	7/22/92	7/23/92	7/24/92	7/24/92	8/4/92	8/5/92	8/6/92
Test No.	1	2	3	5	6	7+	8	9,10	11	12	13	14
Unit load, MW gross	362	366	366	365	367	187	360	361	366	355	374	371
Steam flow, 10^6 lb/hr	2.45	2.46	2.47	2.45	2.5	1.3	2.4	2.44	2.48	2.37	2.27	2.30
O_2, % N/S	2.1/1.6	2.1/1.6	2.1/1.6	1.9/1.6	1.9/1.6	6.5/5.7	2.1/1.8	1.8/1.8	1.8/1.6	OOS/2.2	1.7/1.8	1.9/2.0
Opacity, %: 6-min. avg.	--	3-4	5	6	4	4	4	7	7	6	7	7
range	3-5	3	2-5	2-3	2-3	1	3	3-5	4-5	3-4	2-4	3
spikes	10	None	15-60	10-55	1-60	1-40	None	--	--	--	--	--
Fuel flow, klb/hr	180	182	187	180	182	112	192	181	174	160	167	166
Air flow, %	96	98	97	99	99	65	100	95	96	87	90	90
FD fan controller, %	61	68	65	65	68	35	65	57	62	50	55	54
ID fan controller, %	105	105	105	105	105	60	105	105	105	105	105	105
Aux air dampers, %	80	50	67	105	72	44	100	58	61	57	70	70
Fuel air dampers, %	97	100	100	100	100	54	100	100	100	94	100	105
GR fan controller, %	105	69	89	100	100	38	70	38	30	105	105	105
ESP power, kVA**												
North	139	141	128	143	--	135	140	167	167	107	126	--
South	73	104	72	103	--	86	79	73	72	57	55	--
No. ESP sections in service												
(of 8): N/S	8/6	6/7	6/8	6/6	--	6/8	7/8	7/8	7/8	7/7	7/7	--

* Opacity readings are for south duct only for Tests 1-8 -- north duct opacity meter was out of service.

** No power factor assumed.

\+ Test 7 at 50% load. Evaluation tests for mercury only were performed.

Figure E-1 Unit Operation Parameters Site 112



APPENDIX F
UNCERTAINTY ANALYSIS

Because the data generated in this program may be used in conducting risk assessments and in making policy and regulatory decisions, consideration of the uncertainties in the results generated in the program are important. Assessment of the uncertainty level of a measurement is especially important when the measured results are near the detection level of the methods.

In calculating uncertainties that are presented in this report, procedures were followed that have been previously established for FCEM data treatment. This procedure involved calculating an overall uncertainty for each result using standard statistical techniques and known measurement biases. An error propagation analysis was performed on calculated results to determine the contribution of process, sampling and analytical variability, and measurement bias, to the overall uncertainty in the result. This uncertainty was determined by propagating the bias and precision error of individual parameters in the calculation of the results.

This uncertainty does not represent the total uncertainty in the result since many important sources of uncertainty are unknown and have been assigned a value of zero for this analysis. This uncertainty is only the uncertainty in the result for the period of time that the measurements were taken and does not represent long-term process variations. In addition, the following calculations assume that the population distribution of each measurement is normally distributed and that the samples collected reflect the true population.

The method described below is based on ANSI/ASME PTC 19.1-1985, "Measurement Uncertainty."

Nomenclature

r = Calculated result;
S_{pi} = Sample standard deviation of parameter i;
$S_{\overline{pi}}$ = Standard deviation of the average of parameter i;
Θ_i = Sensitivity of the result to parameter i;
B_{pi} = Bias error estimate for parameter i;
ν_i = Degrees of freedom in parameter i;
ν_r = Degrees of freedom in result;
S_r = Precision component of result uncertainty;
B_r = Bias component of result uncertainty;
t = Student "t" factor (two-tailed distribution at 95%);
U_r = Uncertainty in r;
P_i = Parameter i;
ΔP_i = Perturbation in parameter i;
N_i = Number of measurements of parameter i; and
E = Emission rate

For a result, r, the uncertainty in r is calculated as:

$$U_r = \sqrt{B_r^2 + (S_r * t)^2}$$

The components are calculated by combining the errors in the parameters used in the result calculation.

$$B_r = \sqrt{\sum_{i=1}^{j} (\theta_i * B_{pi})^2}$$

$$S_r = \sqrt{\sum_{i=1}^{j} (\theta_i * S_{\overline{pi}})^2}$$

The sensitivity of the result to each parameter is found from a Taylor series estimation method:

$$\theta_1 = \frac{\partial r}{\partial pi}$$

Or using a perturbation method (useful in computer applications):

$$\theta_i = \frac{r(P_i + \Delta P_i) - r(P_i)}{\Delta P_i}$$

The standard deviation of the average for each parameter is calculated as:

$$S_{\overline{pi}} = \frac{S_{pi}}{\sqrt{N_i}}$$

The degrees of freedom for each parameter is found from

$$\nu_i = N_i - 1$$

and the degrees of freedom for the result is found be weighting the sensitivity and precision error in each parameter.

$$\nu_r = \frac{S_r^4}{\sum_{i=1}^{j} \left[\frac{(S_{\overline{pi}} * \theta_i)^4}{\nu_i} \right]}$$

The Student "t" in the first equation is associated with the degrees of freedom in the result.

The precision error terms are generated using collected data, and assigning degrees of freedom to each parameter. Bias errors are more qualitative in nature. Bias values are assigned based on observation of the process and engineering judgment.

For this report the following sources of bias were considered:

- No bias was assigned to analytical results unless the result is less than the detection limit. Then one-half the detection limit is used for both the parameter value and its bias in calculations.

  This bias component for results below the detection limit is calculated as:

$$B_{pi} = \sqrt{\sum_{i=1}^{N_i} \left(B_i * \frac{1}{N_i} \right)^2}$$

- The nonaxial nature of the gas flow at the sample locations resulted in measured velocities by the s-type pitot probes that were 14% higher than flow rates calculated from unit heat rate information and stoichiometric calculations. During all isokinetic tests, sample flow rate was set based on the faster velocity measured by the pitot probe, as specified in EPA Methods 1, 2 and 5. This means that "true" isokinetic sampling rates may have been 14% low. Estimating errors induced by nonisokinetic sampling, this would correspond to an uncertainty of 14% in the concentrations of particulate species. Thus an uncertainty of 14% was applied to all particulate species measured from isokinetic tests.

- A 5% uncertainty was applied to the heat rate factor which was provided by the plant. The heat rate is defined as:

$$\textit{Heat Rate}, \frac{\textit{Btu}}{\textit{MW-hr}} = \textit{HHV of fuel, Btu/lb} \times \textit{Fuel Flow, lb/hr} \div \textit{Load, MW}$$

  The heat rate is used in all exhaust gas flow rate calculations. The uncertainty applied to the heat rate is used instead of a separate uncertainty applied to fuel flow rates.

- An uncertainty of 307% was used on furnace hopper ash rates. This uncertainty represents the large variability in the measured ash rate from the three ash dumps. This value is calculated as the uncertainty in the three ash dumps based on the mass of ash per unit mass of oil burned at the 95% C.I. This uncertainty is applied because of concerns that not all of the ash was completely dumped from the furnace hopper on individual cleanings. The uncertainty in an emission measurement of a target substance in the ash includes this collection variability of 307%.

- A bias of 200% was applied to boiler wash results. This bias is applied because it is estimated that half of the surface area downstream of the economizer was missed during sampling.

In interpreting and understanding the uncertainty values, it should be pointed out that when two levels of uncertainty are combined using a root-sum-squared process, the larger uncertainty predominates. A few examples are presented below:

- Combining two uncertainties of 10% results in a total uncertainty of 14%.

- No bias was assigned to analytical results unless the result is less than the detection limit. Then one-half the detection limit is used for both the parameter value and its bias in calculations.

  This bias component for results below the detection limit is calculated as:

$$B_{pi} = \sqrt{\sum_{i=1}^{N_i} \left(B_i * \frac{1}{N_i} \right)^2}$$

- The nonaxial nature of the gas flow at the sample locations resulted in measured velocities by the s-type pitot probes that were 14% higher than flow rates calculated from unit heat rate information and stoichiometric calculations. During all isokinetic tests, sample flow rate was set based on the faster velocity measured by the pitot probe, as specified in EPA Methods 1, 2 and 5. This means that "true" isokinetic sampling rates may have been 14% low. Estimating errors induced by nonisokinetic sampling, this would correspond to an uncertainty of 14% in the concentrations of particulate species. Thus an uncertainty of 14% was applied to all particulate species measured from isokinetic tests.

- A 5% uncertainty was applied to the heat rate factor which was provided by the plant. The heat rate is defined as:

$$Heat\ Rate, \frac{Btu}{MW-hr} = HHV\ of\ fuel,\ Btu/lb \times Fuel\ Flow,\ lb/hr \div Load,\ MW$$

  The heat rate is used in all exhaust gas flow rate calculations. The uncertainty applied to the heat rate is used instead of a separate uncertainty applied to fuel flow rates.

- An uncertainty of 307% was used on furnace hopper ash rates. This uncertainty represents the large variability in the measured ash rate from the three ash dumps. This value is calculated as the uncertainty in the three ash dumps based on the mass of ash per unit mass of oil burned at the 95% C.I. This uncertainty is applied because of concerns that not all of the ash was completely dumped from the furnace hopper on individual cleanings. The uncertainty in an emission measurement of a target substance in the ash includes this collection variability of 307%.

- A bias of 200% was applied to boiler wash results. This bias is applied because it is estimated that half of the surface area downstream of the economizer was missed during sampling.

In interpreting and understanding the uncertainty values, it should be pointed out that when two levels of uncertainty are combined using a root-sum-squared process, the larger uncertainty predominates. A few examples are presented below:

- Combining two uncertainties of 10% results in a total uncertainty of 14%.

- Combining uncertainties of 50% and 8% results in a total uncertainty of 51%.
- Combining uncertainties of 90% and 10% results in an uncertainty of 90.5%.

Confidence Interval Calculations

In this report the confidence interval is reported with the sample results. The uncertainty values calculated for this report are based on the 95% confidence interval calculated for mass emissions of the target species. This confidence interval equation propagates the error associated with the parameters required to determine concentration, mass emissions, and emission factors. The uncertainty is then calculated as a percentage so that it may be applied to an average result expressed in the required units.

Emission factors are calculated in units of lb/10^{12} Btu. However, the equations used for uncertainty calculations are in mass emission units of lb/hr since these equations allow for an estimate of overall uncertainty incorporating all parameters.

The following are sample calculations for the 95% confidence interval around the mean emission rate for flue gas, fuel and ash samples. This procedure utilized the same method outlined earlier in this section and used in the computer program.

FLUE GAS

$$E,\ lb/hr = Concentration,\ \frac{\mu g}{Nm^3} \times Heat\ Rate,\ \frac{Btu}{MW-hr} \times F-Factor,\ \frac{dscf}{MMBtu} \times \frac{20.9}{20.9 - 0_2(test), \%} \times Load,\ MW \times 5.8127 \times 10^{-17}$$

FUEL

$$E,\ lb/hr = Concentration,\ \frac{mg}{kg} \times Heat\ Rate,\ \frac{Btu}{MW-hr} \times 10^{-6} \times Load,\ MW \times \frac{1}{HHV,\ Btu/lb}$$

ASH

$$E,\ lb/hr = Concentration,\ \frac{mg}{kg} \times Heat\ Rate,\ \frac{Btu}{MW-hr} \times 10^{-6} \times Load,\ MW \times \frac{1}{HHV,\ Btu/lb} \times \left(\frac{Ash\ Flow\ Rate}{Fuel\ Flow\ Rate}\right) \frac{lb\ (ash)}{lb\ (fuel)}$$

The following example calculation shows how the overall uncertainty of the ESP outlet cadmium value from this program was determined.

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	$\mu g/Nm^3$	0.96	0.13	0.18	0.42
Heat Rate	Btu/MW-hr	9.78×10^6	9.78×10^6	9.78×10^6	9.78×10^6
F-Factor	dscf/MMBtu	8980	9019	N/A	9000
O_2 (test)	%	6.83	6.62	6.23	6.56
Load (net)	MW	350	354	354	353

The sensitivity of each variable is calculated with a perturbation for each parameter that is equal to the larger value of the standard deviation of the average, $S_{\overline{pi}}$, or the bias error, B_{pi}. For the concentration variable:

$$S_{\overline{pc}} = \frac{S_{pi}}{\sqrt{N_i}} = \frac{0.465}{\sqrt{3}} = 0.269$$

$$E_{(c = 0.42)} = 0.42 \times 9.78 \times 10^6 \times 9000 \times \frac{20.9}{20.9 - 6.56} \times 353 \times 5.8127 \times 10^{-17} = 0.0011$$

$$E_{(c = 0.69)} = 0.69 \times 9.78 \times 10^6 \times 9000 \times \frac{20.9}{20.9 - 6.56} \times 353 \times 5.8127 \times 10^{-17} = 0.0018$$

$$\theta_c = \frac{E_{(Pi + \Delta Pi)} - E_{Pi}}{\Delta P_i} = \frac{E_{(c = 0.69)} - E_{(c = 0.42)}}{0.27}$$

$$\theta_c = \frac{0.0018 - 0.0011}{0.27} = 0.0026$$

Similar calculations for each parameter produce the following results:

	PARAMETER		
	Concentration, $\mu g/Nm^3$	Heat Rate, Btu/MW-hr	F-Factor, dscf/MMBtu
Mean	0.42	9.78×10^6	9000
S_{pi}	0.47	0	28
$S_{\overline{pi}}$	0.27	0	20
N_i	3	3	3
B_{pi}*	0.059	489,000	0
Θ_i	2.6×10^{-3}	1.1×10^{-10}	1.2×10^{-7}
ν_i	2	2	2
ΔP_i	0.27	489,000	20

Notes: The bias estimate for concentration includes no bias for analytical results and a 14% collection bias. The bias estimate for heat rate is 5%.

The precision and bias components are then calculated by root-sum-squaring the product of the parameter $S_{\overline{pi}}$ or B_{pi} and the sensitivity:

$$S_r = \sqrt{(\theta_c * S_{\overline{pc}})^2 + (\theta_{hr} * S_{\overline{phr}})^2 + (\theta_{ff} * S_{\overline{pff}})^2}$$

$$S_r = 7 \times 10^{-4}$$

$$B_r = \sqrt{(\theta_c * B_{pc})^2 + (\theta_{hr} * B_{phr})^2 + (\theta_{ff} * B_{pff})^2}$$

$$B_r = 2 \times 10^{-4}$$

The Student "t" factor for two degrees of freedom and a 95% confidence interval is 4.3.

The uncertainty in the result is then

$$U_r = \sqrt{B_r^2 = (S_r * t)^2} = \sqrt{(2 \times 10^{-4})^2 + (7 \times 10^{-4} \times 4.3)^2} = 0.0030$$

The overall emission rate is reported as

0.0011 ± 0.0030 lb/hr or 274% uncertainty

ESP REMOVAL EFFICIENCY UNCERTAINTY

Substance	D	C	δA	δB	δC	δD
Ba	0.536	12.12	6.95	4.60	8.33	0.404
Be	0.773	1.97	0.287	0.179	0.338	0.159
Cd	0.299	0.14	0.081	0.211	0.226	0.485
Cl	—					
Cr	0.568	4.86	1.05	0.92	1.40	0.177
Co	0.747	28.91	1.66	3.21	3.61	0.099
Cu	0.792	24.31	4.02	1.62	4.33	0.175
Pb	0.527	2.9	1.00	0.276	1.04	0.211
Mn	—					
*Hg	0.825	1.13	0.479	0.052	0.482	0.455
Mo	0.598	8.8	0.780	1.12	1.36	0.098
Ni	0.736	845	36.4	90.8	97.8	0.088
P	0.682	234	25.8	14.9	29.8	0.101
V	0.778	839	99.9	77.7	126.6	0.138
S (as sulfate)	0.058	90,000	62,452	23,334	66,669	0.043
F	0.053	26	132	184	226	0.461
Particulate (lb/MMBtu)	0.772	0.060	0.0051	0.0010	0.0052	0.0839

ESP inlet = $A \pm \delta A$

ESP outlet = $B \pm \delta B$

ESP inlet - ESP outlet = $C \pm \sqrt{(\delta A)^2 + (\delta B)^2}$

$$ESP\ efficiency = \frac{ESP\ inlet - ESP\ outlet}{ESP\ inlet} = D \pm \left(\sqrt{\left(\frac{(\delta A)^2 = (\delta B)^2}{C} \right) + \left(\frac{\delta A}{A} \right)^2} \right) (D)$$

All values in lb/10^{12} Btu except for particulate

*Use ND values at half value for Hg

No apparent ESP removal of Cl and Mn

Arsenic and selenium not detected at ESP outlet

METALS --
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2	RUN #3	AVERAGE (r)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
			In ug/Nm3							In lb/hr			
ARSENIC	IN	3.9	6.2	8.1	6.05E+00	2.10E+00	86.3%	14.9%	87.6%	1.71E-02	1.5E-02	23.71%	0.0%
BARIUM		20.5	46.2	17.1	2.79E+01	1.59E+01	141.3%	14.9%	142.1%	7.87E-02	1.1E-01	43.54%	0.0%
BERYLLIUM		2.63	3.0	3.7	3.11E+00	5.28E-01	42.3%	14.9%	44.8%	8.76E-03	3.9E-03	12.20%	0.0%
CADMIUM		0.76	0.43	0.53	5.72E-01	1.66E-01	72.3%	14.9%	73.8%	1.61E-03	1.2E-03	21.38%	0.0%
CHROMIUM		9.8	9.0	12.5	1.04E+01	1.85E+00	44.2%	14.9%	46.6%	2.94E-02	1.4E-02	13.35%	0.0%
COBALT		47.9	45.1	48.8	4.73E+01	1.92E+00	10.1%	14.9%	18.0%	1.33E-01	2.4E-02	3.04%	0.0%
COPPER		33.4	33.0	45.8	3.74E+01	7.31E+00	48.5%	14.9%	50.8%	1.05E-01	5.4E-02	15.03%	0.0%
LEAD		9.0	6.5	4.7	6.72E+00	2.18E+00	80.7%	14.9%	82.1%	1.89E-02	1.6E-02	22.81%	0.0%
MANGANESE		27.0	15.3	11.2	1.78E+01	8.21E+00	114.5%	14.9%	115.4%	5.03E-02	5.8E-02	34.31%	0.0%
MERCURY		1.12	2.95	1.03	1.70E+00	1.09E+00	158.6%	14.9%	159.3%	4.80E-03	7.6E-03	49.11%	0.0%
MOLYBDENUM		16.2	18.6	18.9	1.79E+01	1.47E+00	20.4%	14.9%	25.2%	5.05E-02	1.3E-02	6.29%	0.0%
NICKEL		1372	1394	1443	1.40E+03	3.62E+01	6.5%	14.9%	16.2%	3.96E+00	6.4E-01	1.89%	0.0%
SELENIUM	ND<	7.1	ND< 8.9	ND< 9.0	ND< 9.03E+00	1.11E+00	30.4%	30.7%	43.2%	ND< 2.55E-02	1.1E-02	7.67%	100.0%
PHOSPHORUS		390	400	467	4.19E+02	4.21E+01	25.0%	14.9%	29.1%	1.18E+00	3.4E-01	7.68%	0.0%
VANADIUM		1116	1347	1489	1.32E+03	1.88E+02	35.5%	14.9%	38.5%	3.71E+00	1.4E+00	10.20%	0.0%
					AVERAGES:		61.1%	15.9%	64.8%	6.25E-01	1.8E-01	18.15%	
ARSENIC	OUT	ND< 2.98	ND< 0.60	ND< 3.16	ND< 3.16E+00	1.43E+00	112.5%	27.5%	115.8%	ND< 8.32E-03	9.6E-03	28.93%	100.0%
BARIUM		23.44	2.98	14.68	1.37E+01	1.03E+01	186.1%	14.9%	186.7%	3.60E-02	6.7E-02	52.15%	0.0%
BERYLLIUM		0.92	0.30	1.08	7.66E-01	4.14E-01	134.2%	14.9%	135.0%	2.02E-03	2.7E-03	40.70%	0.0%
CADMIUM		0.96	0.13	0.18	4.23E-01	4.65E-01	273.6%	14.9%	274.0%	1.11E-03	3.0E-03	84.64%	0.0%
CHROMIUM		29.5	93.4	42.5	5.51E+01	3.38E+01	152.3%	14.9%	153.0%	1.45E-01	2.2E-01	46.31%	0.0%
COBALT		15.58	4.50	18.55	1.29E+01	7.40E+00	142.9%	14.9%	143.6%	3.39E-02	4.9E-02	43.37%	0.0%
COPPER		9.04	4.35	11.84	8.41E+00	3.78E+00	111.8%	14.9%	112.8%	2.21E-02	2.5E-02	32.18%	0.0%
LEAD		4.05	2.98	3.16	3.40E+00	5.70E-01	41.7%	14.9%	44.3%	8.94E-03	4.0E-03	12.75%	0.0%
MANGANESE		7.78	23.1	26.8	1.92E+01	1.01E+01	130.2%	14.9%	131.1%	5.06E-02	6.6E-02	39.70%	0.0%
MERCURY		0.29	0.44	ND< 0.41 #	3.1E-01	1.18E-01	95.1%	26.5%	98.7%	8.13E-04	8.0E-04	27.52%	21.9%
MOLYBDENUM		7.14	5.44	10.7	7.77E+00	2.70E+00	86.4%	14.9%	87.7%	2.04E-02	1.8E-02	25.42%	0.0%
NICKEL		468	161	564	3.98E+02	2.10E+02	131.3%	14.9%	132.2%	1.05E+00	1.4E+00	39.62%	0.0%
SELENIUM	ND<	6.18	ND< 6.18	ND< 3.16	ND< 6.18E+00	1.74E+00	70.0%	29.1%	75.9%	ND< 1.63E-02	1.2E-02	16.30%	100.0%
PHOSPHORUS		149	104	174	1.43E+02	3.52E+01	61.4%	14.9%	63.2%	3.75E-01	2.4E-01	17.80%	0.0%
VANADIUM		383	112	451	3.16E+02	1.79E+02	141.1%	14.9%	141.9%	8.30E-01	1.2E+00	42.92%	0.0%
					AVERAGES:		124.7%	17.4%	126.4%	1.73E-01	2.2E-01	36.69%	

METALS –
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spi)	%STDEV (Spi,%)	N STDEV (Spi')	% BIAS (Bpi,%)	BIAS (Bpi)
METALS IN:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	350	354	354	353	2.31	0.65%	1.33	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2	7.55	7.05	7.97	7.52	0.46	6.12%	0.27	0.00%	0.00
O2 Correction Factor	1.566	1.509	1.616	1.564	0.05	3.43%	0.03	0.00%	0.00
Particle Collection Bias								14%	

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV	%STDEV	N STDEV	% BIAS	BIAS
METALS OUT:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	350	354	354	353	2.31	0.65%	1.33	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2	6.83	6.62	6.23	6.56	0.30	4.64%	0.18	0.00%	0.00
O2 Correction Factor	1.485	1.464	1.425	1.458	0.03	2.11%	0.02	0.00%	0.00
Particle Collection Bias								14%	

Degrees FREEDOM	T-VALUE
1	12.71
2	4.30
3	3.18
4	2.78
5	2.57
6	2.45
7	2.37
8	2.31

PRELIMINARY

DO NOT CITE OR QUOTE

METALS
UNCERTAINTY ANALYSIS
SITE 112
PAGE 3 OF 3

SPECIES	LOC	CONC. DELTA P' DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAf)	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
ARSENIC	IN	1.21E+00	0.00E+00	NSTDV	8.47E-01	2.8E-03	1.7E-09	1.9E-06	3.4E-03	2.5E-03	2.00	2	4.3	1.5E-02	87.6%
BARIUM		9.17E+00	0.00E+00	NSTDV	3.91E+00	2.8E-03	8.1E-09	8.7E-06	2.6E-02	1.2E-02	2.00	2	4.3	1.1E-01	142.1%
BERYLLIUM		3.05E-01	0.00E+00	**BIAS**	4.35E-01	2.8E-03	9.0E-10	9.7E-07	8.6E-04	1.3E-03	2.00	2	4.3	3.9E-03	44.8%
CADMIUM		9.60E-02	0.00E+00	NSTDV	8.01E-02	2.8E-03	1.6E-10	1.8E-07	2.7E-04	2.4E-04	2.00	2	4.3	1.2E-03	73.8%
CHROMIUM		1.07E+00	0.00E+00	**BIAS**	1.46E+00	2.8E-03	3.0E-09	3.3E-06	3.0E-03	4.4E-03	2.00	2	4.3	1.4E-02	46.6%
COBALT		1.11E+00	0.00E+00	**BIAS**	6.62E+00	2.8E-03	1.4E-08	1.5E-05	3.1E-03	2.0E-02	2.03	2	4.3	2.4E-02	18.0%
COPPER		4.22E+00	0.00E+00	**BIAS**	5.24E+00	2.8E-03	1.1E-08	1.2E-05	1.2E-02	1.6E-02	2.00	2	4.3	5.4E-02	50.8%
LEAD		1.26E+00	0.00E+00	NSTDV	9.40E-01	2.8E-03	1.9E-09	2.1E-06	3.6E-03	2.8E-03	2.00	2	4.3	1.6E-02	82.4%
MANGANESE		4.74E+00	0.00E+00	NSTDV	2.50E+00	2.8E-03	5.1E-09	5.6E-06	1.3E-02	7.5E-03	2.00	2	4.3	5.8E-02	115.4%
MERCURY		6.27E-01	0.00E+00	NSTDV	2.38E-01	2.8E-03	4.9E-10	5.3E-07	1.8E-03	7.1E-04	2.00	2	4.3	7.6E-03	159.3%
MOLYBDENUM		8.48E-01	0.00E+00	**BIAS**	2.51E+00	2.8E-03	5.2E-09	5.6E-06	2.4E-03	7.5E-03	2.01	2	4.3	1.3E-02	25.2%
NICKEL		2.09E+01	0.00E+00	**BIAS**	1.96E+02	2.8E-03	4.0E-07	4.4E-04	6.0E-02	5.9E-01	2.08	2	4.3	6.4E-01	16.2%
SELENIUM		6.38E-01	2.42E+00	**BIAS**	1.26E+00	2.8E-03	2.6E-09	2.8E-06	1.8E-03	7.8E-03	2.00	2	4.3	1.1E-02	43.2%
PHOSPHORUS		2.43E+01	0.00E+00	**BIAS**	5.87E+01	2.8E-03	1.2E-07	1.3E-04	6.9E-02	1.8E-01	2.01	2	4.3	3.4E-01	29.1%
VANADIUM		1.09E+02	0.00E+00	**BIAS**	1.84E+02	2.8E-03	3.8E-07	4.1E-04	3.1E-01	5.5E-01	2.00	2	4.3	1.4E+00	38.5%
															64.8%

		CONC. DELTA P' DETERMINATION NORM. STD DEV	ND BIAS	> OF NSTD OR BIAS	Particle Coll. Eff. Bias	THETA CALCULATIONS FOR: CONC.	HEAT RT	F-factor	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
ARSENIC	OUT	8.27E-01	7.31E-01	**BIAS**	4.43E-01	2.6E-03	8.5E-10	9.2E-07	2.2E-03	2.3E-03	2.00	2	4.3	9.6E-03	115.8%
BARIUM		5.93E+00	0.00E+00	NSTDV	1.92E+00	2.6E-03	3.7E-09	4.0E-06	1.6E-02	5.4E-03	2.00	2	4.3	6.7E-02	186.7%
BERYLLIUM		2.39E-01	0.00E+00	NSTDV	1.07E-01	2.6E-03	2.1E-10	2.2E-07	6.3E-04	3.0E-04	2.00	2	4.3	2.7E-03	135.0%
CADMIUM		2.69E-01	0.00E+00	NSTDV	5.92E-02	2.6E-03	1.1E-10	1.2E-07	7.1E-04	1.7E-04	2.00	2	4.3	3.0E-03	274.0%
CHROMIUM		1.95E+01	0.00E+00	NSTDV	7.72E+00	2.6E-03	1.5E-08	1.6E-05	5.1E-02	2.2E-02	2.00	2	4.3	2.2E-01	153.0%
COBALT		4.27E+00	0.00E+00	NSTDV	1.80E+00	2.6E-03	3.5E-09	3.8E-06	1.1E-02	5.0E-03	2.00	2	4.3	4.9E-02	143.6%
COPPER		2.18E+00	0.00E+00	NSTDV	1.18E+00	2.6E-03	2.3E-09	2.5E-06	5.7E-03	3.3E-03	2.00	2	4.3	2.3E-02	112.8%
LEAD		3.29E-01	0.00E+00	**BIAS**	4.76E-01	2.6E-03	9.1E-10	9.9E-07	8.7E-04	1.3E-03	2.00	2	4.3	4.0E-03	44.3%
MANGANESE		5.82E+00	0.00E+00	NSTDV	2.69E+00	2.6E-03	5.2E-09	5.6E-06	1.5E-02	7.5E-03	2.00	2	4.3	6.6E-02	131.1%
MERCURY		6.83E-02	6.78E-02	**BIAS**	4.33E-02	2.6E-03	8.3E-11	9.0E-08	1.8E-04	2.2E-04	2.00	2	4.3	8.0E-04	98.7%
MOLYBDENUM		1.56E+00	0.00E+00	NSTDV	1.09E+00	2.6E-03	2.1E-09	2.3E-06	4.1E-03	3.0E-03	2.00	2	4.3	1.8E-02	87.7%
NICKEL		1.21E+02	0.00E+00	NSTDV	5.57E+01	2.6E-03	1.0E-07	1.2E-04	3.2E-01	1.6E-01	2.00	2	4.3	1.4E+00	132.2%
SELENIUM		1.01E+00	1.55E+00	**BIAS**	8.66E-01	2.6E-03	1.7E-09	1.8E-06	2.6E-03	4.7E-03	2.00	2	4.3	1.2E-02	75.9%
PHOSPHORUS		2.03E+01	0.00E+00	NSTDV	2.00E+01	2.6E-03	3.8E-08	4.2E-05	5.3E-02	5.6E-02	2.00	2	4.3	2.4E-01	63.2%
VANADIUM		1.03E+02	0.00E+00	NSTDV	4.42E+01	2.6E-03	8.5E-08	9.2E-05	2.7E-01	1.2E-01	2.00	2	4.3	1.2E+00	141.9%
															126.4%

PRELIMINARY

DO NOT CITE OR QUOTE

PAH -
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2 (In ug/Nm3)	RUN #3		AVERAGE (r)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Ur,%)	% UNCERT. (Ur,%)		ABSOL. VALUE In lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
Naphthalene	IN	0.59	0.58	0.58		5.82E-01	5.25E-03	1.8%	14.9%	15.0%		1.45E-03	2.2E-04	0.67%	0.0%
Acenaphthylene		ND < 0.024	ND < 0.026	ND < 0.176	ND<	1.76E-01	8.75E-02	123.3%	22.6%	125.3%	ND<	4.40E-04	5.5E-04	57.28%	100.0%
Acenaphthene		ND < 0.083	ND < 0.095	ND < 0.079	ND<	9.48E-02	8.18E-03	21.5%	30.1%	36.9%	ND<	2.37E-04	9.7E-05	9.73%	100.0%
Fluorene		0.024	0.018	0.014		1.89E-02	4.90E-03	64.4%	14.9%	66.1%		4.72E-05	3.1E-05	18.36%	0.0%
Phenanthrene		0.159	0.120	0.086		1.22E-01	3.61E-02	73.7%	14.9%	75.2%		3.04E-04	2.3E-04	20.15%	0.0%
Anthracene		ND < 0.021	ND < 0.022	ND < 0.022	ND<	2.19E-02	6.24E-04	7.1%	31.9%	32.7%	ND<	5.46E-05	1.8E-05	2.25%	100.0%
Fluoranthene		ND < 0.048	0.018	0.011	@ ND<	4.83E-02	1.98E-02	102.1%	22.3%	104.5%	ND<	1.20E-04	1.3E-04	46.62%	100.0%
Pyrene		ND < 0.048	ND < 0.033	ND < 0.061	ND<	6.12E-02	1.42E-02	57.7%	27.4%	63.9%	ND<	1.53E-04	9.8E-05	22.50%	100.0%
Benz(a)anthracene		ND < 0.100	ND < 0.047	ND < 0.072	ND<	9.99E-02	2.63E-02	65.4%	26.6%	70.6%	ND<	2.49E-04	1.8E-04	26.86%	100.0%
Chrysene		ND < 0.103	ND < 0.036	ND < 0.072	ND<	1.03E-01	3.35E-02	80.5%	25.8%	84.5%	ND<	2.58E-04	2.2E-04	31.71%	100.0%
Benzo(b)fluoranthene		ND < 0.034	ND < 0.036	ND < 0.032	ND<	3.65E-02	2.03E-03	13.9%	31.1%	34.0%	ND<	9.10E-05	3.1E-05	5.54%	100.0%
Benzo(k)fluoranthene		ND < 0.034	ND < 0.040	ND < 0.032	ND<	4.01E-02	3.99E-03	24.7%	29.8%	38.7%	ND<	1.00E-04	3.9E-05	11.09%	100.0%
Benzo(a)pyrene		ND < 0.028	ND < 0.026	ND < 0.029	ND<	2.88E-02	1.65E-03	14.3%	31.2%	34.3%	ND<	7.18E-05	2.5E-05	5.20%	100.0%
Indeno(1,2,3-cd)pyrene		ND < 0.003	ND < 0.029	ND < 0.022	ND<	2.92E-02	1.32E-02	112.6%	25.6%	115.5%	ND<	7.28E-05	8.4E-05	38.05%	100.0%
Dibenzo(a,h)anthracene		ND < 0.010	ND < 0.073	ND < 0.036	ND<	7.29E-02	3.15E-02	107.2%	23.9%	109.8%	ND<	1.82E-04	2.0E-04	45.49%	100.0%
Benzo(g,h,i)perylene		ND < 0.010	ND < 0.033	ND < 0.029	ND<	3.28E-02	1.20E-02	90.7%	27.2%	94.7%	ND<	8.19E-05	7.8E-05	26.91%	100.0%
2-Methylnaphthalene		ND < 0.017	0.034	0.040		2.75E-02	1.66E-02	149.7%	18.2%	150.8%		6.86E-05	1.0E-04	45.77%	10.4%
7,12-Dimethlbenz(a)anth		ND < 0.017	ND < 0.018	ND < 0.180	ND<	1.80E-01	9.36E-02	129.3%	22.5%	131.2%	ND<	4.49E-04	5.9E-04	60.10%	100.0%
3-Methylcholanthrene		ND < 0.345	ND < 0.365	ND < 0.360	ND<	3.65E-01	1.04E-02	7.1%	31.9%	32.7%	ND<	9.10E-04	3.0E-04	2.25%	100.0%
								AVERAGES	65.6%	24.9%	74.5%	2.81E-04	1.6RE-04	25.1%	

SPECIES	LOC	RUN #1	RUN #2 (In ug/Nm3)	RUN #3		AVERAGE (r)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Ur,%)	% UNCERT. (Ur,%)		ABSOL. VALUE In lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
Naphthalene	OUT	0.45	0.39	0.42		4.22E-01	3.20E-02	18.9%	14.9%	24.0%		1.12E-03	2.7E-04	5.07%	0.0%
Acenaphthylene		ND < 0.016	ND < 0.060	ND < 0.015	ND<	5.97E-02	2.56E-02	106.6%	23.1%	109.1%	ND<	1.58E-04	1.7E-04	49.53%	100.0%
Acenaphthene		ND < 0.032	ND < 0.030	ND < 0.068	ND<	6.76E-02	2.13E-02	78.1%	24.8%	82.0%	ND<	1.79E-04	1.5E-04	36.28%	100.0%
Fluorene		0.014	0.007	0.059		2.66E-02	2.84E-02	266.0%	14.9%	266.4%		7.02E-05	1.9E-04	81.84%	0.0%
Phenanthrene		0.010	0.025	0.023		2.60E-02	3.21E-03	30.7%	14.9%	34.1%		6.87E-05	2.3E-05	9.02%	0.0%
Anthracene		ND < 0.014	ND < 0.014	ND < 0.013	ND<	1.38E-02	5.95E-04	10.8%	31.7%	33.5%	ND<	3.64E-05	1.2E-05	3.00%	100.0%
Fluoranthene		ND < 0.023	ND < 0.016	ND < 0.023	ND<	2.32E-02	4.00E-03	42.7%	29.9%	52.2%	ND<	6.14E-05	3.2E-05	11.05%	100.0%
Pyrene		ND < 0.025	ND < 0.014	ND < 0.023	ND<	2.50E-02	6.03E-03	60.0%	28.7%	66.5%	ND<	6.60E-05	4.4E-05	17.28%	100.0%
Benz(a)anthracene		ND < 0.100	ND < 0.044	ND < 0.042	ND<	9.99E-02	3.29E-02	81.8%	24.5%	85.4%	ND<	2.64E-04	2.3E-04	38.02%	100.0%
Chrysene		ND < 0.034	ND < 0.034	ND < 0.032	ND<	3.44E-02	1.49E-03	10.8%	31.7%	33.5%	ND<	9.10E-05	3.0E-05	3.00%	100.0%
Benzo(b)fluoranthene		ND < 0.025	ND < 0.011	ND < 0.011	ND<	2.50E-02	8.07E-03	80.3%	24.6%	84.0%	ND<	6.60E-05	5.5E-05	37.26%	100.0%
Benzo(k)fluoranthene		ND < 0.032	ND < 0.014	ND < 0.013	ND<	3.18E-02	1.07E-02	83.9%	24.4%	87.4%	ND<	8.40E-05	7.3E-05	38.94%	100.0%
Benzo(a)pyrene		ND < 0.016	ND < 0.016	ND < 0.015	ND<	1.61E-02	6.94E-04	10.8%	31.7%	33.5%	ND<	4.24E-05	1.4E-05	3.00%	100.0%
Indeno(1,2,3-cd)pyrene		ND < 0.089	ND < 0.055	ND < 0.038	ND<	8.86E-02	2.57E-02	72.1%	25.6%	76.5%	ND<	2.34E-04	1.8E-04	31.62%	100.0%
Dibenzo(a,h)anthracene		ND < 0.139	ND < 0.078	ND < 0.063	ND<	1.39E-01	3.98E-02	71.4%	25.4%	75.8%	ND<	3.66E-04	2.8E-04	32.64%	100.0%
Benzo(g,h,i)perylene		ND < 0.102	ND < 0.057	ND < 0.042	ND<	1.02E-01	3.12E-02	75.8%	25.2%	79.9%	ND<	2.70E-04	2.2E-04	34.17%	100.0%
2-Methylnaphthalene		0.021	0.018	0.018		1.90E-02	1.85E-03	24.2%	14.9%	28.4%		5.02E-05	1.4E-05	7.44%	0.0%
7,12-Dimethylbenz(a)anthracene		ND < 0.011	ND < 0.115	ND < 0.011	ND<	1.15E-01	5.99E-02	129.7%	22.4%	131.7%	ND<	3.03E-04	4.0E-04	60.30%	100.0%
3-Methylcholanthrene		ND < 0.227	ND < 0.230	ND < 0.211	ND<	2.30E-01	9.92E-03	10.8%	31.7%	33.5%	ND<	6.06E-04	2.0E-04	3.00%	100.0%
								AVERAGES	66.6%	24.5%	74.6%	2.17E-04	1.35E-04	26.4%	

PRELIMINARY

DO NOT CITE OR QUOTE

PAII -
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spi)	%STDEV (Spi,%)	N STDEV (Spi')	% BIAS (Bpi,%)	BIAS (Bpi)
PAII IN:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	343	362	359	355	10.21	2.88%	5.90	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2	5.61	5.77	5.75	5.71	0.09	1.53%	0.05	0.00%	0.00
O2 Correction Factor	1.367	1.381	1.380	1.376	0.01	0.57%	0.00	0.00%	0.00
Particle Collection Bias								14%	

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spi)	%STDEV (Spi,%)	N STDEV (Spi')	% BIAS (Bpi,%)	BIAS (Bpi)
PAII OUT:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	343	362	359	355	10.21	2.88%	5.90	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2	6.96	6.30	6.38	6.55	0.36	5.50%	0.21	0.00%	0.00
O2 Correction Factor	1.499	1.432	1.439	1.457	0.04	2.54%	0.02	0.00%	0.00
Particle Collection Bias								14%	

DEGREES FREEDOM	T-VALUE
2	4.30
3	3.18
4	2.78
5	2.57
6	2.45
7	2.37
8	2.31

PRELIMINARY

PAH
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAf)	RESULTS: Sr	Br	vr	vr	L	Ur	% Ur
Naphthalene	IN	3.03E-03	0.00E+00	**BIAS**	8.14E-02	2.5E-03	1.5E-10	1.6E-07	8.2E-06	2.2E-04	2.67	3	3.2	2.2E-04	15.0%
Acenaphthylene		5.05E-02	3.00E-02	NSTDV	2.47E-02	2.5E-03	4.5E-11	4.9E-08	1.3E-04	9.9E-05	2.00	2	4.3	5.5E-04	125.3%
Acenaphthene		4.72E-03	2.48E-02	**BIAS**	1.33E-02	2.5E-03	2.4E-11	2.6E-08	1.2E-05	7.1E-05	2.01	2	4.3	8.7E-05	36.9%
Fluorene		2.83E-03	0.00E+00	NSTDV	2.65E-03	2.5E-03	4.8E-12	5.2E-09	7.1E-06	7.0E-06	2.00	2	4.3	3.1E-05	66.1%
Phenanthrene		2.08E-02	0.00E+00	NSTDV	1.70E-02	2.5E-03	3.1E-11	3.4E-08	5.2E-05	4.5E-05	2.00	2	4.3	2.3E-04	75.2%
Anthracene		3.60E-04	6.17E-03	**BIAS**	3.06E-03	2.5E-03	5.6E-12	6.1E-09	9.1E-07	1.7E-05	2.07	2	4.3	1.8E-05	32.7%
Fluoranthene		1.14E-02	8.04E-03	NSTDV	6.76E-03	2.5E-03	1.2E-11	1.3E-08	2.9E-05	2.7E-05	2.00	2	4.3	1.3E-04	104.5%
Pyrene		8.20E-03	1.41E-02	**BIAS**	8.56E-03	2.5E-03	1.6E-11	1.7E-08	2.0E-05	4.2E-05	2.00	2	4.3	9.8E-05	63.9%
Benz(a)anthracene		1.52E-02	2.20E-02	**BIAS**	1.40E-02	2.5E-03	2.6E-11	2.8E-08	3.8E-05	6.6E-05	2.00	2	4.3	1.8E-04	70.6%
Chrysene		1.93E-02	2.19E-02	**BIAS**	1.45E-02	2.5E-03	2.6E-11	2.9E-08	4.8E-05	6.7E-05	2.00	2	4.3	2.2E-04	84.5%
Benzo(b)fluoranthene		1.17E-01	9.95E-03	**BIAS**	5.10E-03	2.5E-03	9.3E-12	1.0E-08	2.9E-06	2.8E-05	2.02	2	4.3	3.1E-05	38.7%
Benzo(k)fluoranthene		2.30E-03	1.03E-02	**BIAS**	5.61E-03	2.5E-03	1.0E-11	1.1E-08	5.8E-06	3.0E-05	2.01	2	4.3	3.9E-05	34.3%
Benzo(a)pyrene		9.55E-04	7.89E-03	**BIAS**	4.03E-03	2.5E-03	7.3E-12	8.0E-09	2.4E-06	2.2E-05	2.02	2	4.3	2.5E-05	34.3%
Indeno(1,2,3-cd)pyrene		7.63E-03	6.07E-03	NSTDV	4.08E-03	2.5E-03	7.4E-12	8.1E-09	1.9E-05	1.9E-05	2.00	2	4.3	8.4E-05	115.5%
Dibenzo(a,h)anthracene		1.82E-02	1.37E-02	NSTDV	1.02E-02	2.5E-03	1.9E-11	2.0E-08	4.5E-05	4.4E-05	2.00	2	4.3	2.0E-04	109.8%
Benzo(g,h,i)perylene		6.92E-03	7.48E-03	**BIAS**	4.59E-03	2.5E-03	8.4E-12	9.1E-09	1.7E-05	2.2E-05	2.00	2	4.3	7.8E-05	94.7%
2-Methylnaphthalene		9.56E-03	2.87E-03	NSTDV	3.85E-03	2.5E-03	7.0E-12	7.6E-09	2.4E-05	1.2E-05	2.00	2	4.3	1.0E-04	150.8%
7,12-Dimethlbenz(a)anth		5.41E-02	3.03E-02	NSTDV	2.52E-02	2.5E-03	4.6E-11	5.0E-08	1.3E-04	1.0E-04	2.00	2	4.3	5.9E-04	131.2%
3-Methylcholanthrene		6.01E-03	1.03E-01	**BIAS**	5.10E-02	2.5E-03	9.3E-11	1.0E-07	1.5E-05	2.9E-04	2.07	2	4.3	3.0E-04	32.7%

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAf)	RESULTS: Sr	Br	vr	vr	L	Ur	% Ur
Naphthalene	OUT	1.85E-02	0.00E+00	**BIAS**	5.91E-02	2.6E-03	1.1E-10	1.2E-07	4.9E-05	1.7E-04	2.0	2	4.3	2.7E-04	24.0%
Acenaphthylene		1.48E-02	1.06E-02	NSTDV	8.35E-03	2.6E-03	1.6E-11	1.8E-08	3.9E-05	3.6E-05	2.0	2	4.3	1.7E-04	109.1%
Acenaphthene		1.23E-02	1.34E-02	**BIAS**	9.46E-03	2.6E-03	1.8E-11	2.0E-08	3.2E-05	4.4E-05	2.0	2	4.3	1.5E-04	82.0%
Fluorene		1.64E-02	0.00E+00	NSTDV	3.72E-03	2.6E-03	7.2E-12	7.8E-09	4.3E-05	1.0E-05	2.0	2	4.3	1.9E-04	266.4%
Phenanthrene		1.85E-03	0.00E+00	**BIAS**	3.64E-03	2.6E-03	7.0E-12	7.6E-09	4.9E-06	1.0E-05	2.0	2	4.3	2.3E-05	34.1%
Anthracene		3.44E-04	3.86E-03	**BIAS**	1.93E-03	2.6E-03	3.7E-12	4.0E-09	9.1E-07	1.2E-05	2.0	2	4.3	1.2E-05	33.5%
Fluoranthene		2.31E-03	6.04E-03	**BIAS**	3.25E-03	2.6E-03	6.3E-12	6.8E-09	6.1E-06	1.8E-05	2.0	2	4.3	3.2E-05	52.2%
Pyrene		3.48E-03	6.13E-03	**BIAS**	3.50E-03	2.6E-03	6.8E-12	7.3E-09	9.2E-06	1.9E-05	2.0	2	4.3	4.4E-05	66.5%
Benz(a)anthracene		1.90E-02	1.95E-02	**BIAS**	1.40E-02	2.6E-03	2.7E-11	2.9E-08	5.0E-05	6.5E-05	2.0	2	4.3	2.3E-04	85.4%
Chrysene		8.59E-04	9.65E-03	**BIAS**	4.82E-03	2.6E-03	9.3E-12	1.0E-08	2.3E-06	2.9E-05	2.0	2	4.3	3.0E-05	33.5%
Benzo(b)fluoranthene		4.66E-03	4.91E-03	**BIAS**	3.50E-03	2.6E-03	6.8E-12	7.3E-09	1.2E-05	1.6E-05	2.0	2	4.3	5.5E-05	84.0%
Benzo(k)fluoranthene		6.20E-03	6.15E-03	**BIAS**	4.45E-03	2.6E-03	8.6E-12	9.3E-09	1.6E-05	2.0E-05	2.0	2	4.3	7.3E-05	87.4%
Benzo(a)pyrene		4.01E-04	4.50E-03	**BIAS**	2.25E-03	2.6E-03	4.3E-12	4.7E-09	1.1E-06	1.3E-05	2.0	2	4.3	1.4E-05	33.5%
Indeno(1,2,3-cd)pyrene		1.48E-02	1.85E-02	**BIAS**	1.24E-02	2.6E-03	2.4E-11	2.6E-08	3.9E-05	6.0E-05	2.0	2	4.3	1.8E-04	76.5%
Dibenzo(a,h)anthracene		2.30E-02	2.85E-02	**BIAS**	1.94E-02	2.6E-03	3.7E-11	4.1E-08	6.1E-05	9.3E-05	2.0	2	4.3	2.8E-04	75.8%
Benzo(g,h,i)perylene		1.80E-02	2.08E-02	**BIAS**	1.43E-02	2.6E-03	2.8E-11	3.0E-08	4.8E-05	6.8E-05	2.0	2	4.3	2.2E-04	79.9%
2-Methylnaphthalene		1.07E-03	0.00E+00	**BIAS**	2.66E-03	2.6E-03	5.1E-12	5.6E-09	2.8E-06	7.5E-06	2.0	2	4.3	1.4E-05	28.4%
7,12-Dimethylbenz(a)anthracene		3.46E-02	1.93E-02	NSTDV	1.61E-02	2.6E-03	3.1E-11	3.4E-08	9.1E-05	6.8E-05	2.0	2	4.3	4.0E-04	131.7%
3-Methylcholanthrene		5.73E-03	6.43E-02	**BIAS**	3.21E-02	2.6E-03	6.2E-11	6.7E-08	1.5E-05	1.9E-04	2.0	2	4.3	2.0E-04	33.5%

DO NOT CITE OR QUOTE

PRELIMINARY

PM/ANIONS
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2	RUN #3	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
		In ppm											
CHLORIDE	IN	2.39	2.13	1.78	2.10E+00	3.07E-01	36.4%	14.9%	39.3%	8.61E+00	3.38E+00	10.22%	0.0%
FLOURIDE		1.19	0.62	0.50	7.67E-01	3.67E-01	118.8%	14.9%	119.7%	1.69E+00	2.02E+00	36.30%	0.0%
PHOSPHORUS		ND< 0.62	ND 0.63	ND 0.54	ND< 6.33E-01	5.39E-02	21.2%	31.1%	37.7%	ND< 6.95E+00	2.62E+00	5.54%	100.0%
SULFATE		492.74	482.97	448.09	4.75E+02	2.35E+01	12.3%	14.9%	19.3%	5.27E+03	1.02E+03	3.72%	0.0%
					AVERAGE:	6.05E+00	47.2%	18.9%	54.0%	1.32E+03	2.56E+02	13.94%	
CHLORIDE	OUT	2.05	3.32	3.46	2.94E+00	7.78E-01	65.7%	14.9%	67.4%	1.23E+01	8.31E+00	20.28%	0.0%
FLOURIDE		1.24	0.59	0.30	7.07E-01	4.82E-01	169.2%	14.9%	169.9%	1.59E+00	2.70E+00	50.04%	0.0%
PHOSPHORUS		ND< 0.49	ND 0.07	ND 0.12	ND< 4.94E-01	2.31E-01	116.0%	22.8%	118.3%	ND< 5.54E+00	6.56E+00	53.64%	100.0%
SULFATE		436.91	451.57	426.69	4.38E+02	1.25E+01	7.1%	14.9%	16.5%	4.97E+03	8.20E+02	2.00%	0.0%
					AVERAGE:	3.50E+00	89.5%	16.9%	93.0%	1.25E+03	2.10E+02	31.49%	

SPECIES	LOC	RUN #1	RUN #2	RUN #3	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
		In mg/Nm^3											
PM-AN	IN	117.4	96.7	94.5	1.03E+02	1.26E+01	30.5%	14.9%	33.9%	2.66E+02	9.04E+01	9.41%	0.0%
PM-AN	OUT	20.6	23.0	25.3	2.30E+01	2.37E+00	25.6%	14.9%	29.6%	6.08E+01	1.80E+01	6.96%	0.0%

DO NOT CITE OR QUOTE

PRELIMINARY

DO NOT CITE OR QUOTE

PM/ANIONS
UNCERTAINTY ANALYSIS
SITE 112
PAGE 2 OF 3

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spi)	%STDEV (Spi,%)	N STDEV (Spi')	% BIAS (Bpi,%)	BIAS (Bpi)
ANIONS IN:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	349	349	354	351	2.89	0.82%	1.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	6.19	6.98	6.09	6.42	0.49	7.59%	0.28	0.00%	0.00
O2 Correction Factor	1.421	1.501	1.411	1.444	4.96E-02	3.43%	0	0.00%	0.00
Particle Collection Bias								14%	
ANIONS OUT:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	349	349	354	351	2.89	0.82%	1.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 OUTLET	6.84	6.68	6.70	6.74	0.09	1.29%	0.05	0.00%	0.00
O2 Correction Factor	1.486	1.470	1.472	1.476	9.12E-03	0.62%	0	0.00%	0.00
Particle Collection Bias								14%	

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spi)	%STDEV (Spi,%)	N STDEV (Spi')	% BIAS (Bpi,%)	BIAS (Bpi)
PARTICULATE:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	349	349	354	351	2.89	0.82%	1.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	6.19	6.98	6.09	6.42	0.49	7.59%	0.28	0.00%	0.00
O2 Correction Factor IN	1.421	1.501	1.411	1.444	4.96E-02	3.43%	0	0.00%	0.00
% O2 OUTLET	6.84	6.68	6.70	6.74	0.09	1.29%	0.05	0.00%	0.00
O2 Correction Factor OUT	1.486	1.470	1.472	1.476	9.12E-03	0.62%	0	0.00%	0.00
Particle Collection Bias								14%	

PRELIMINARY

PM/ANIONS
UNCERTAINTY ANALYSIS
SITE 112
PAGE 3 OF 3

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAff)	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
CHLORIDE	IN	1.77E-01	0.00E+00	**BIAS**	2.94E-01	4.1E+00	8.8E-07	9.6E-04	7.3E-01	1.3E+00	2.0	2	4.3	3.4E+00	39.3%
FLOURIDE		2.12E-01	0.00E+00	NSTDV	1.07E-01	2.2E+00	1.7E-07	1.9E-04	4.7E-01	2.5E-01	2.0	2	4.3	2.0E+00	119.7%
PHOSPHORUS		3.11E-02	1.73E-01	**BIAS**	8.86E-02	1.1E+01	7.1E-07	7.7E-04	3.4E-01	2.2E+00	2.0	2	4.3	2.6E+00	37.7%
SULFATE		1.36E+01	0.00E+00	**BIAS**	6.64E+01	1.1E+01	5.4E-04	5.9E-01	1.5E+02	7.8E+02	2.0	2	4.3	1.0E+03	19.3%
CHLORIDE	OUT	4.49E-01	0.00E+00	NSTDV	4.12E-01	4.2E+00	1.3E-06	1.4E-03	1.9E+00	1.8E+00	2.0	2	4.3	8.3E+00	67.4%
FLOURIDE		2.78E-01	0.00E+00	NSTDV	9.90E-02	2.2E+00	1.6E-07	1.8E-04	6.2E-01	2.4E-01	2.0	2	4.3	2.7E+00	169.9%
PHOSPHORUS		1.33E-01	8.56E-02	NSTDV	6.91E-02	1.1E+01	5.7E-07	6.2E-04	1.5E+00	1.3E+00	2.0	2	4.3	6.6E+00	118.3%
SULFATE		7.22E+00	0.00E+00	**BIAS**	6.14E+01	1.1E+01	5.1E-04	5.5E-01	8.3E+01	7.4E+02	2.1	2	4.3	8.2E+02	16.5%

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAff)	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
PM-AN	IN	7.29E+00	0.00E+00	**BIAS**	1.44E+01	2.6E+00	2.7E-05	3.0E-02	1.9E+01	4.0E+01	2.0	2	4.3	9.0E+01	33.9%
PM-AN	OUT	1.37E+00	0.00E+00	**BIAS**	3.21E+00	2.6E+00	6.2E-06	6.8E-03	3.6E+00	9.0E+00	2.0	2	4.3	1.8E+01	29.6%

DO NOT CITE OR QUOTE

VOC/FORM
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2	RUN #3	RUN #4	AVERAGE (c)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
			In ppb								In lb/hr			
BENZENE	IN	0.25	0.32	0.25	ND< 0.15	2.24E-01	1.05E-01	74.3%	12.2%	75.3%	2.2E-03	1.6E-03	33.24%	8.4%
TOLUENE	IN	7.97	3.97	4.36	3.77	5.02E+00	1.98E+00	62.9%	5.0%	63.1%	5.8E-02	3.6E-02	29.42%	0.0%
BENZENE	OUT	0.71	1.12	0.92	0.72	8.68E-01	1.94E-01	35.6%	5.0%	36.0%	8.0E-03	2.9E-03	17.58%	0.0%
TOLUENE	OUT	44.5	30.2	18.2	6.54	2.49E+01	1.63E+01	104.1%	5.0%	104.3%	2.7E-01	2.8E-01	50.24%	0.0%
FORMALDEHYDE	IN	19.4	20.0	17.3		1.89E+01	1.42E+00	18.7%	5.0%	19.3%	6.9E-02	1.3E-02	5.64%	0.0%
FORMALDEHYDE	OUT	5.8	30.7	2.6		1.30E+01	1.54E+01	293.2%	5.0%	293.3%	4.6E-02	1.4E-01	90.37%	0.0%

PRELIMINARY

DO NOT CITE OR QUOTE

VOC/FORM
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
VOC IN:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	350	350	350	350	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	7.55	7.55	7.55	7.55	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor IN	1.566	1.566	1.566	1.566	0.00E+00	0.00%	0	0.00%	0.00
%O2 OUTLET	6.83	6.83	6.83	6.83	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor OUT	1.485	1.485	1.485	1.485	2.98E-08	0.00%	0	0.00%	0.00
Particle Collection Bias								0%	
VOC OUT:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	354	354	354	354	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	7.05	7.05	7.05	7.05	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor IN	1.509	1.509	1.509	1.509	0.00E+00	0.00%	0	0.00%	0.00
%O2 OUTLET	6.62	6.62	6.62	6.62	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor OUT	1.464	1.464	1.464	1.464	0.00E+00	0.00%	0	0.00%	0.00
Particle Collection Bias								0%	

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
PSD:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	349	349	354	351	2.89	0.82%	1.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	6.19	6.98	6.09	6.42	0.49	7.59%	0.28	0.00%	0.00
O2 Correction Factor IN	1.421	1.501	1.411	1.444	4.96E-02	3.43%	0	0.00%	0.00
% O2 OUTLET	6.84	6.68	6.70	6.74	0.09	1.29%	0.05	0.00%	0.00
O2 Correction Factor OUT	1.486	1.470	1.472	1.476	9.12E-03	0.62%	0	0.00%	0.00
Particle Collection Bias								14%	
Inlet Particulate, mg/Nm^3				102.9					

VOC/FORM
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	CONC. DELTA P DETERMINATION: NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAf)	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
BENZENE	IN	5.23E-02	2.50E-02	NSTDV	0.00E+00	9.8E-03	2.2E-10	2.4E-07	5.1E-04	2.7E-04	3.00	3	3.2	1.6E-03	75.3%
TOLUENE	IN	9.92E-01	0.00E+00	NSTDV	0.00E+00	1.2E-02	5.9E-09	6.4E-06	1.1E-02	2.9E-03	3.00	3	3.2	3.6E-02	63.1%
BENZENE	OUT	9.71E-02	0.00E+00	NSTDV	0.00E+00	9.3E-03	8.2E-10	8.9E-07	9.0E-04	4.0E-04	3.00	3	3.2	2.9E-03	36.0%
TOLUENE	OUT	8.14E+00	0.00E+00	NSTDV	0.00E+00	1.1E-02	2.8E-08	3.0E-05	8.9E-02	1.4E-02	3.00	3	3.2	2.8E-01	104.3%
FORMALDEHYDE	IN	8.19E-01	0.00E+00	NSTDV	0.00E+00	3.7E-03	7.1E-09	7.7E-06	3.0E-03	3.5E-03	2.01	2	4.3	1.3E-02	19.3%
FORMALDEHYDE	OUT	8.88E+00	0.00E+00	NSTDV	0.00E+00	3.5E-03	4.7E-09	5.1E-06	3.2E-02	2.3E-03	2.00	2	4.3	1.4E-01	293.3%

PRELIMINARY

METALS SPECIATON TESTS
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2	RUN #3	RUN #4	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
		In ug/Nm^3												
Mercury, MM	OUT	0.44	ND< 1.12	0.41	#	4.72E-01	7.72E-02	40.6%	42.2%	58.6%	1.16E-03	6.8E-04	12.32%	39.5%
Mercury, MIT	OUT	1.97	1.73			1.85E+00	1.71E-01	83.1%	5.0%	83.2%	3.29E-03	2.7E-03	13.08%	0.0%
Mercury, BR	OUT													
Hg(II)		ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021	ND< 2.15E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 5.02E-05	1.7E-05	0.00%	100.0%
Hg(0)		ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021	ND< 2.13E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 5.02E-05	1.7E-05	0.00%	100.0%
MMHg		0.015	0.003	0.015	0.013	1.15E-02	5.64E-03	77.7%	5.0%	77.9%	2.70E-05	2.1E-05	36.05%	0.0%
Hg(ox)-BR		ND< 0.054	ND< 0.054	ND< 0.054	ND< 0.054	ND< 5.37E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 1.25E-04	4.2E-05	0.00%	100.0%
Hg(ox)-PISCES		0.036	0.025	0.036	0.034	3.30E-02	5.64E-03	27.2%	5.0%	27.6%	7.72E-05	2.1E-05	12.60%	0.0%

SPECIES	LOC	RUN #1	RUN #2	RUN #3	RUN #4	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
		In ug/Nm^3												
Total Chrome	IN	9.3	8.8	9.4		9.17E+00	3.21E-01	8.8%	14.9%	17.3%	2.26E-02	3.9E-03	2.67%	0.0%
Hexavalent Chrome		1.24	ND< 0.46	ND< 1.15	@ ND<	1.15E+00	4.26E-01	91.8%	23.3%	94.7%	ND< 2.84E-03	2.7E-03	22.44%	100.0%
Total Chrome	OUT	7.5	3.1	4.2		4.93E+00	2.29E+00	115.3%	14.9%	116.3%	1.30E-02	1.5E-02	34.68%	0.0%
Hexavalent Chrome		ND< 0.48	ND< 0.61	ND< 1.07	ND<	1.07E+00	3.06E-01	71.4%	25.5%	75.8%	ND< 2.80E-03	2.1E-03	32.40%	100.0%

DO NOT CITE OR QUOTE

PRELIMINARY

DO NOT CITE OR QUOTE

METALS SPECIATON TESTS
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpi)
MERCURY MM/MIT:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	353	355	175	294	103.35	35.11%	59.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 OUTLET	6.68	6.21	10.40	7.76	2.30	0.00%	0.00	0.00%	0.00
O2 Correction Factor OUT	1.470	1.423	1.990	1.628	3.15E-01	19.36%	0	0.00%	0.00
Particle Collection Bias								14%	

MERCURY BR:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	353	355	175	265	103.35	39.07%	59.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 OUTLET	7.08	6.21	10.4	8.52	2.20	0.00%	0.00	0.00%	0.00
O2 Correction Factor OUT	1.512	1.423	1.990	1.729	0.30	17.59%	0	0.00%	0.00
Particle Collection Bias								0%	

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpi)
CHROMIUM:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	NA	NA	NA	NA	NA	NA	NA	0.00%	NA
LOAD, MW	353	355	348	352	3.61	1.02%	2.08	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05
%O2 INLET	5.30	6.06	5.51	5.62	0.39	0.00%	0.00	0.00%	0.00
O2 Correction Factor IN	1.340	1.408	1.358	1.369	3.55E-02	2.60%	0	0.00%	0.00
%O2 OUTLET	6.06	6.58	7.12	6.59	0.53	0.00%	0.00	0.00%	0.00
O2 Correction Factor OUT	1.408	1.459	1.517	1.462	5.42E-02	3.71%	0	0.00%	0.00
Particle Collection Bias								14%	

METALS SPECIATON TESTS-
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2	RUN #3	RUN #4	AVERAGE (r)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
			In ug/Nm^3								In lb/hr			
Mercury, MM	OUT	0.44	ND< 1.12	0.41	#	4.72E-01	7.72E-02	40.6%	42.2%	58.6%	1.16E-03	6.8E-04	12.32%	39.5%
Mercury, MH	OUT	1.97	1.73			1.85E+00	1.71E-01	83.1%	5.0%	83.2%	3.29E-03	2.7E-03	13.08%	0.0%
Mercury, HR	OUT													
Hg(II)		ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021	ND< 2.15E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 5.02E-05	1.7E-05	0.00%	100.0%
Hg(0)		ND< 0.021	ND< 0.021	ND< 0.021	ND< 0.021	ND< 2.15E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 5.02E-05	1.7E-05	0.00%	100.0%
MMHg		0.015	0.003	0.015	0.013	1.15E-02	5.64E-03	77.7%	5.0%	77.9%	2.70E-05	2.1E-05	36.05%	0.0%
Hg(tot)-BR		ND< 0.054	ND< 0.054	ND< 0.054	ND< 0.054	ND< 5.37E-02	0.00E+00	0.7%	33.7%	33.7%	ND< 1.25E-04	4.2E-05	0.00%	100.0%
Hg(tot)-PISCES		0.036	0.025	0.036	0.034	3.30E-02	5.64E-03	27.2%	5.0%	27.6%	7.72E-05	2.1E-05	12.60%	0.0%

SPECIES	LOC	RUN #1	RUN #2	RUN #3	RUN #4	AVERAGE (r)	SAMPLE STD. DEV. (Sp)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
			In ug/Nm^3								In lb/hr			
Total Chrome	IN	9.3	8.8	9.3		9.12E+00	2.84E-01	7.8%	14.9%	16.8%	2.25E-02	3.8E-03	2.40%	0.0%
Hexavalent Chrome		1.24	ND< 0.46	ND< 1.15	@ ND<	1.15E+00	4.26E-01	91.8%	23.3%	94.7%	ND< 2.84E-03	2.7E-03	22.44%	100.0%
Total Chrome	OUT	7.5	3.1	4.2		4.93E+00	2.29E+00	115.3%	14.9%	116.3%	1.30E-02	1.5E-02	34.68%	0.0%
Hexavalent Chrome		ND< 0.48	ND< 0.61	ND< 1.07	ND<	1.07E+00	3.06E-01	71.4%	25.5%	75.8%	ND< 2.80E-03	2.1E-03	32.40%	100.0%

PRELIMINARY

DO NOT CITE OR QUOTE

METALS/ANIONS - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1		RUN #2		RUN #3		AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)		ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
		In mg/Kg															
METALS (CATE																	
ARSENIC	OIL	0.008	ND<	0.005	ND<	0.005	#	4.33E-03	3.18E-03	182.1%	27.7%	184.1%		8.0E-04	1.5E-03	56.41%	38.5%
BARIUM		1.7		1.9		3.2		2.27E+00	8.14E-01	89.3%	5.0%	89.4%		4.2E-01	3.8E-01	27.45%	0.0%
BERYLLIUM		0.053		0.066		0.062		6.03E-02	6.66E-03	27.4%	5.0%	27.9%		1.1E-02	3.1E-03	8.10%	0.0%
CADMIUM		0.010		0.015		0.014		1.30E-02	2.65E-03	50.6%	5.0%	50.8%		2.4E-03	1.2E-03	15.38%	0.0%
CHROMIUM		0.19		0.21		0.25		2.17E-01	3.06E-02	35.0%	5.0%	35.4%		4.0E-02	1.4E-02	10.26%	0.0%
COBALT		1.2		1.4		1.3		1.30E+00	1.00E-01	19.1%	5.0%	19.8%		2.4E-01	4.8E-02	5.13%	0.0%
COPPER		0.64		0.63		0.62		6.30E-01	1.00E-02	4.0%	5.0%	6.4%		1.2E-01	7.5E-03	1.06%	0.0%
LEAD		0.4		0.4		0.4		3.87E-01	2.31E-02	14.9%	5.0%	15.7%		7.2E-02	1.1E-02	4.60%	0.0%
MANGANESE		0.24		0.26		0.42		3.07E-01	9.87E-02	79.9%	5.0%	80.1%		5.7E-02	4.6E-02	24.64%	0.0%
MERCURY		0.08		0.02		0.02		4.00E-02	3.46E-02	215.2%	5.0%	215.2%		7.4E-03	1.6E-02	66.67%	0.0%
MOLYBDENUM		0.24		0.25		0.23		2.40E-01	1.00E-02	10.4%	5.0%	11.5%		4.5E-02	5.1E-03	2.78%	0.0%
NICKEL		40		42		40		4.06E+01	1.15E+00	7.1%	5.0%	8.7%		7.5E+00	6.6E-01	2.19%	0.0%
SELENIUM	ND<	0.005	ND<	0.005	ND<	0.005	ND<	5.00E-03	8.23E-11	0.9%	29.3%	29.3%	ND<	9.3E-04	2.7E-04	0.00%	100.0%
PHOSPHORUS		17		16		12		1.50E+01	2.65E+00	43.8%	5.0%	44.1%		2.8E+00	1.2E+00	13.33%	0.0%
VANADIUM		22		26		25		2.42E+01	2.08E+00	21.4%	5.0%	21.9%		4.5E+00	9.9E-01	6.42%	0.0%
									AVERAGES:	53.4%	8.1%	56.0%		1.1E+00	2.3E-01	16.29%	
ANIONS:	OIL																
Chlorine, as Cl-		500		400				4.50E+02	7.07E+01	141.2%	5.0%	141.3%		8.3E+01	1.2E+02	22.22%	0.0%
Fluorine, as F-	ND<	10	ND<	10			ND<	1.0E+01	0.00E+00	2.6%	24.1%	24.2%	ND<	1.8E+00	4.5E-01	0.00%	100.0%
Phosphorus, as PO4 3-		52		49		37		4.6E+01	8.11E+00	43.8%	5.0%	44.1%		8.5E+00	3.7E+00	13.33%	0.0%
Sulfur, as SO4 2-		25,768		25,169				2.5E+04	4.24E+02	15.2%	5.0%	16.0%		4.7E+03	7.5E+02	2.35%	0.0%
									AVERAGES:	50.7%	9.8%	56.4%		1.2E+03	2.2E+02	9.48%	

METALS/ANIONS - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
FUEL METALS:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 •	27.58 •	0.31%	19.50 •	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 •	53.74 •	0.29%	38.00 •	0.00%	0.00
FUEL FLOW, lb/hr	184,135	186,240	186,240	185,538	1,215	0.65%	701.5	0.00%	NA
LOAD, MW	350	354	354	353	2.31	0.65%	1.33	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05

DEGREES FREEDOM	T-VALUE
2	4.30
3	3.18
4	2.78
5	2.57
6	2.45
7	2.37
8	2.31

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV	%STDEV	N STDEV	% BIAS	BIAS
FUEL ANIONS:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 •	27.58 •	0.31%	19.50 •	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 •	53.74 •	0.29%	38.00 •	0.00%	0.00
FUEL FLOW, lb/hr	183,609	183,609	186,240	184,486	1,519	0.82%	876.8	0.00%	NA
LOAD, MW	349	349	354	351	2.89	0.82%	1.67	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05

METALS/ANIONS - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc)	> OF NSTD OR BIAS	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	HHV (THETAhhv)	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
METALS (C&T):														
ARSENIC	OIL	1.83E-03	1.18E-03	NSTDV	1.9E-01	8.2E-11	-4.3E-08	3.4E-04	2.2E-04	2.00	2	4.3	1.5E-03	184.1%
BARIUM		4.70E-01	0.00E+00	NSTDV	1.9E-01	4.3E-08	-2.3E-05	8.7E-02	2.1E-02	2.00	2	4.3	3.8E-01	89.4%
BERYLLIUM		3.84E-03	0.00E+00	NSTDV	1.9E-01	1.1E-09	-6.0E-07	7.1E-04	5.6E-04	2.00	2	4.3	3.1E-03	27.9%
CADMIUM		1.53E-03	0.00E+00	NSTDV	1.9E-01	2.5E-10	-1.3E-07	2.8E-04	1.2E-04	2.00	2	4.3	1.2E-03	50.8%
CHROMIUM		1.76E-02	0.00E+00	NSTDV	1.9E-01	4.1E-09	-2.2E-06	3.3E-03	2.0E-03	2.00	2	4.3	1.4E-02	35.4%
COBALT		5.77E-02	0.00E+00	NSTDV	1.9E-01	2.5E-08	-1.3E-05	1.1E-02	1.2E-02	2.01	2	4.3	4.8E-02	19.8%
COPPER		5.77E-03	0.00E+00	NSTDV	1.9E-01	1.2E-08	-6.3E-06	1.1E-03	5.8E-03	2.20	2	4.3	7.5E-03	6.4%
LEAD		1.33E-02	0.00E+00	NSTDV	1.9E-01	7.3E-09	-3.9E-06	2.5E-03	3.6E-03	2.01	2	4.3	1.1E-02	15.7%
MANGANESE		5.70E-02	0.00E+00	NSTDV	1.9E-01	5.8E-09	-3.1E-06	1.1E-02	2.8E-03	2.00	2	4.3	4.6E-02	80.1%
MERCURY		2.00E-02	0.00E+00	NSTDV	1.9E-01	7.6E-10	-4.0E-07	3.7E-03	3.7E-04	2.00	2	4.3	1.6E-02	215.2%
MOLYBDENUM		5.77E-03	0.00E+00	NSTDV	1.9E-01	4.6E-09	-2.4E-06	1.1E-03	2.2E-03	2.03	2	4.3	5.1E-03	11.5%
NICKEL		6.67E-01	0.00E+00	NSTDV	1.9E-01	7.7E-07	-4.0E-04	1.2E-01	3.8E-01	2.06	2	4.3	6.6E-01	8.7%
SELENIUM		4.75E-11	1.44E-03	*ND BIAS*	1.9E-01	9.5E-11	-5.0E-08	1.9E-06	2.7E-04	2.00	2	4.3	2.7E-04	29.3%
PHOSPHORUS		1.53E+00	0.00E+00	NSTDV	1.9E-01	2.8E-07	-1.5E-04	2.8E-01	1.4E-01	2.00	2	4.3	1.2E+00	44.1%
VANADIUM		1.20E+00	0.00E+00	NSTDV	1.9E-01	4.6E-07	-2.4E-04	2.2E-01	2.2E-01	2.01	2	4.3	9.9E-01	21.9%
														56.0%

ANIONS:	OIL	CONC. DELTA P DETERMINATION NORM. STD DEV	ND BIAS	> OF NSTD OR BIAS	THETA CALCULATIONS FOR: CONC.	HEAT RT	HHV	RESULTS: Sr	Br	vr	vr	t-	Ur	% Ur
Chlorine, as Cl-		9.28E+01	6.67E+01	NSTDV	1.8E-01	7.2E-06	-3.8E-03	1.7E+01	1.3E+01	2.00	2	4.3	7.5E+01	105.7%
Fluorine, as F-		0.00E+00	2.89E+00	*ND BIAS*	1.8E-01	1.9E-07	-9.9E-05	3.8E-03	5.4E-01	2.00	2	4.3	5.4E-01	29.3%
Phosphorus, as PO4 3-		4.68E+00	0.00E+00	NSTDV	1.8E-01	8.7E-07	-4.6E-04	8.6E-01	4.2E-01	2.00	2	4.3	3.7E+00	44.1%
Sulfur, as SO4 2-		1.73E+02	0.00E+00	NSTDV	1.8E-01	4.8E-04	-2.5E-01	3.3E+01	2.3E+02	2.36	2	4.3	2.8E+02	5.9%
														46.3%

INAA - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2 (in mg/Kg	RUN #3	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
METALS (INAA):													
Arsenic	OIL	0.059	0.070		6.5E-02	7.78E-03	108.4%	5.0%	108.5%	1.2E-02	1.3E-02	17.05%	0.0%
Barium		1.1	1.2	1.6	1.3E+00	2.65E-01	50.6%	5.0%	50.8%	2.4E-01	1.2E-01	15.38%	0.0%
Cobalt		1.3	1.5	3.0	1.9E+00	9.29E-01	119.4%	5.0%	119.5%	3.6E-01	4.3E-01	36.78%	0.0%
Chromium		0.23	0.28	0.20	2.4E-01	4.04E-02	42.4%	5.0%	42.7%	4.4E-02	1.9E-02	12.21%	0.0%
Manganese		0.32	0.38	0.31	3.4E-01	3.79E-02	28.0%	5.0%	28.4%	6.2E-02	1.8E-02	8.58%	0.0%
Mercury		0.0028	0.0043	0.011	6.0E-03	4.37E-03	179.8%	5.0%	179.9%	1.1E-03	2.0E-03	54.88%	0.0%
Molybdenum		0.13	0.15	0.12	1.3E-01	1.53E-02	28.5%	5.0%	28.9%	2.5E-02	7.2E-03	8.33%	0.0%
Selenium		0.056	0.044		5.0E-02	8.49E-03	152.5%	5.0%	152.6%	9.3E-03	1.4E-02	24.00%	0.0%
Vanadium		24	33	24	2.7E+01	5.20E+00	47.8%	5.0%	48.1%	5.0E+00	2.4E+00	14.81%	0.0%
Chloride		30	34	25	3.0E+01	4.51E+00	37.8%	5.0%	38.1%	5.5E+00	2.1E+00	10.49%	0.0%
					AVERAGES:		75.6%	5.0%	75.9%	7.2E-01	3.8E-01	21.0%	

PRELIMINARY

DO NOT CITE OR QUOTE

INAA - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
METALS FUEL NAA:									
F-factor, dscf/mmBtu	8,980	9,019	NA	9,000 *	27.58 *	0.31%	19.50 *	0.00%	0.00
HHV, Btu/lb	18,620	18,544	NA	18,582 *	53.74 *	0.29%	38.00 *	0.00%	0.00
FUEL FLOW, lb/hr	184,135	186,240	186,240	185,538	1,215	0.65%	701.5	0.00%	NA
LOAD, MW	350	354	354	353	2.31	0.65%	1.33	0.00%	0.00
HEAT RATE, Btu/MWhr	9.78E+06	9.78E+06	9.78E+06	9.78E+06	0.00E+00	0.00%	0.00E+00	5.00%	4.89E+05

DEGREES FREEDOM	T-VALUE
1	12.71
2	4.30
3	3.18
4	2.78
5	2.57
6	2.45
7	2.37
8	2.31

INAA - FUEL OIL
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc)	>OF NSTD OR BIAS	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	DHV (THETAhhv)	RESULTS: Sr	Br	xr	xr	t-	Ur	% Ur
METALS (INAA):														
Arsenic	OIL	5.50E-03	0.00E+00	NSTDV	1.9E-01	1.2E-09	-6.4E-07	1.0E-03	6.0E-04	1.00	1	13	1.3E-02	108.5%
Barium		1.53E-01	0.00E+00	NSTDV	1.9E-01	2.5E-08	-1.3E-05	2.8E-02	1.2E-02	2.00	2	4.3	1.2E-01	50.8%
Cobalt		5.36E-01	0.00E+00	NSTDV	1.9E-01	3.7E-08	-1.9E-05	1.0E-01	1.8E-02	2.00	2	4.3	4.3E-01	119.5%
Chromium		2.33E-02	0.00E+00	NSTDV	1.9E-01	4.5E-09	-2.4E-06	4.3E-03	2.2E-03	2.00	2	4.3	1.9E-02	42.7%
Manganese		2.19E-02	0.00E+00	NSTDV	1.9E-01	6.4E-09	-3.4E-06	4.1E-03	3.1E-03	2.00	2	4.3	1.8E-02	28.4%
Mercury		2.52E-03	0.00E+00	NSTDV	1.9E-01	1.1E-10	-6.0E-08	4.7E-04	5.6E-05	2.00	2	4.3	2.0E-03	179.9%
Molybdenum		8.82E-03	0.00E+00	NSTDV	1.9E-01	2.5E-09	-1.3E-06	1.6E-03	1.2E-03	2.00	2	4.3	7.2E-03	28.9%
Selenium		6.00E-03	0.00E+00	NSTDV	1.9E-01	9.5E-10	-5.0E-07	1.1E-03	4.6E-04	1.00	1	13	1.4E-02	152.6%
Vanadium		3.00E+00	0.00E+00	NSTDV	1.9E-01	5.1E-07	-2.7E-04	5.6E-01	2.5E-01	2.00	2	4.3	2.4E+00	48.1%
Chloride		2.60E+00	0.00E+00	NSTDV	1.9E-01	5.6E-07	-3.0E-04	4.8E-01	2.8E-01	2.00	2	4.3	2.1E+00	38.1%

Average: 79.8%

PRELIMINARY

METALS/ANIONS - BOTTOM ASH
UNCERTAINTY ANALYSIS
SITE 112

SPECIES	LOC	RUN #1	RUN #2 In mg/Kg	RUN #3	AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE In lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
METALS (C&TE													
ARSENIC	BOT	14			1.40E+01	NA	NA	307%	307%	2.9E-02	8.8E-02	NA	NA
BARIUM	ASH	190			1.9E+02	NA	NA	307%	307%	3.9E-01	1.2E+00	NA	NA
BERYLLIUM		57			5.7E+01	NA	NA	307%	307%	1.2E-01	3.6E-01	NA	NA
CADMIUM		5.000			5.0E+00	NA	NA	307%	307%	1.0E-02	3.2E-02	NA	NA
CHROMIUM		300			3.0E+02	NA	NA	307%	307%	6.2E-01	1.9E+00	NA	NA
COBALT		520.0			5.2E+02	NA	NA	307%	307%	1.1E+00	3.3E+00	NA	NA
COPPER		380.00			3.8E+02	NA	NA	307%	307%	7.8E-01	2.4E+00	NA	NA
LEAD		93.0			9.3E+01	NA	NA	307%	307%	1.9E-01	5.9E-01	NA	NA
MANGANESE		640.00			6.4E+02	NA	NA	307%	307%	1.3E+00	4.0E+00	NA	NA
MERCURY	ND<	0.10		ND<	1.0E-01	NA	NA	307%	307%	ND< 2.1E-04	6.3E-04	NA	NA
MOLYBDENUM		340.00			3.4E+02	NA	NA	307%	307%	7.0E-01	2.1E+00	NA	NA
NICKEL		16000			1.6E+04	NA	NA	307%	307%	3.3E+01	1.0E+02	NA	NA
SELENIUM	ND<	3		ND<	3.0E+00	NA	NA	307%	307%	ND< 6.2E-03	1.9E-02	NA	NA
PHOSPHORUS		1600			1.6E+03	NA	NA	307%	307%	3.3E+00	1.0E+01	NA	NA
VANADIUM		25000			2.5E+04	NA	NA	307%	307%	5.1E+01	1.6E+02	NA	NA
						AVERAGES:		307%	307%	6.2E+00	1.9E+01		
ANIONS:	BOT ASH												
Chlorine, as Cl-	ND<	250		ND<	2.5E+02	NA	NA	307%	307%	ND< 5.1E-01	1.6E+00	NA	NA
Fluorine, as F-	ND<	150		ND<	1.5E+02	NA	NA	307%	307%	ND< 3.1E-01	9.5E-01	NA	NA
Phosphorus, as PO4 3-		4903			4.9E+03	NA	NA	307%	307%	1.01E+01	3.1E+01	NA	NA
Sulfur, as SO4 2-		69,600			7.0E+04	NA	NA	307%	307%	1.43E+02	4.4E+02	NA	NA
						AVERAGES:		307%	307%	3.8E+01	1.2E+02		

DO NOT CITE OR QUOTE

ESP REMOVAL EFFICIENCY UNCERTAINTY

Substance	D	C	δA	δB	δC	δD
Ba	0.536	12.12	6.95	4.60	8.33	0.404
Be	0.773	1.97	0.287	0.179	0.338	0.159
Cd	0.299	0.14	0.081	0.211	0.226	0.485
Cl	—					
Cr	0.568	4.86	1.05	0.92	1.40	0.177
Co	0.747	28.91	1.66	3.21	3.61	0.099
Cu	0.792	24.31	4.02	1.62	4.33	0.175
Pb	0.527	2.9	1.00	0.276	1.04	0.211
Mn	—					
Hg	0.825	1.13	0.479	0.052	0.482	0.455
Mo	0.598	8.8	0.780	1.12	1.36	0.098
Ni	0.736	845	36.4	90.8	97.8	0.088
P	0.682	234	25.8	14.9	29.8	0.101
V	0.778	839	99.9	77.7	126.6	0.138
S (as sulfate)	0.058	90,000	62,452	23,334	66,669	0.043
F	0.053	26	132	184	226	0.461
Particulate (lb/MMBtu)	0.772	0.060	0.0051	0.0010	0.0052	0.0839

ESP inlet = $A \pm \delta A$

ESP outlet = $B \pm \delta B$

ESP inlet - ESP outlet = $C \pm \sqrt{(\delta A)^2 + (\delta B)^2}$

$$ESP\ efficiency = \frac{ESP\ inlet - ESP\ outlet}{ESP\ inlet} = D \pm \left(\sqrt{\left(\frac{(\delta A)^2 = (\delta B)^2}{C}\right) + \left(\frac{\delta A}{A}\right)^2}\right)(D)$$

All values in $lb/10^{12}$ Btu except for particulate

*Use ND values at half value for Hg

No apparent ESP removal of Cl and Mn

Arsenic and selenium not detected at ESP outlet

Material balance uncertainty worksheet

Substance	E	(A+B+C)	del A	del B	del C	del(ABC)	(del D)/D	del E
Ba	16	11	5.95	0.24	1.1973	6.071	0.12	9.0
Be	22	0.72	0.24	0.04	0.3684	0.441	0.06	13.5
Cd	50	0.35	0.27	0.02	0.0307	0.271	0.12	39.2
Cl	225	3593	548.95	0.01	0.25	548.945	0.25	65.1
Cr	35	4.48	1.95	0.32	1.9034	2.745	0.10	21.7
Co	11	11.5	4.27	1.26	3.377	5.590	0.28	6.2
Cu	23	7.65	2.18	0.94	2.3946	3.374	0.01	10.2
Pb	14	2.83	0.33	0.08	0.5833	0.675	0.04	3.4
Mn	92	16.7	5.83	1.50	3.991	7.224	0.07	40.3
Hg	73	0.24	0.07	0.00	0.0001	0.068	0.42	36.9
Mo	112	8	1.56	2.85	2.149	3.893	0.07	55.0
Ni	16	357	12.12	42.11	101.31	110.379	0.02	5.0
P	14	112	20.32	0.00	10.131	22.708	0.10	3.2
S	106	1.45E+06	2E+04	30.68	439.01	2E+04	0.01	2.3
V	22	318	103	53.53	156.57	195.091	0.11	13.7

Notes:

= For mercury data from multimetals tests, one half the non-detect value was used to calculate the mean. This is a variation of the FCEM reporting convention.

* = Fuel composition and heating value was analyzed for two replicates only.

APPENDIX G

QUALITY ASSURANCE AND QUALITY CONTROL DATA

This appendix presents detailed quality assurance and quality control (QA/QC) data for the gas, fuel oil and bottom ash samples. The QA/QC data includes results of duplicate samples, spiked samples and laboratory check standards (LCS). Additional QA/QC data such as instrument calibration data required by the sampling and analytical methodology is maintained by Carnot and the laboratory. QA/QC data is grouped by sample type and analysis. All data pertaining to an analysis is presented together. Analytical data and blank analyses are presented in Appendix H. QA/QC results are presented in the following tables.

G-1 Summary of Quality Control Results for ESP Inlet and Outlet Metals Analyses
G-2 Summary of Quality Control Results for ESP Inlet and Outlet Particulate Analyses
G-3 Summary of Quality Control Results for ESP Inlet and Outlet Anion Analyses
G-4 Summary of Quality Control Results for ESP Inlet and Outlet PAH Analyses
G-5 Summary of Quality Control Results for ESP Inlet and Outlet VOC Analyses
G-6 Summary of Quality Control Results for ESP Inlet and Outlet Formaldehyde Analyses
G-7 Summary of Quality Control Results for ESP Inlet and Outlet Total and Hexavalent Chromium Analyses
G-8 Summary of Quality Control Results for ESP Mercury Evaluation Test Analyses
G-9 Summary of Quality Control Results for Metals by ICP-AES, GFAAS and CVAAS in Fuel Oil
G-10 Summary of Quality Control Results for Metals by ICP-AES, GFAAS and CVAAS in Furnace Hopper Ash
G-11 Summary of Quality Control Results for Chloride and Fluoride, in Furnace Hopper Ash
G-12 Summary of Quality Control Results for PAH in Furnace Hopper Ash
G-13 Fuel Oil Analysis of NIST Standard Reference Material 1634b.

Table G-1
Summary of Quality Control Results
for ESP Inlet and Outlet Metals Analyses

Duplicate Sample Results
1-MTLS-OUT

Element	Method	Sample Value ug/train	Duplicate Value, ug/train	RPD	Data Quality Objective for Duplicates	Comments
Arsenic	ICP-AES	ND(14)	ND(14)	–	10	
Barium	ICP-AES	117	120	2.5	10	
Beryllium	ICP-AES	4.3	4.2	2.4	10	
Cadmium	ICP-AES	4.5	4.7	4.3	10	
Cobalt	ICP-AES	74.7	73.5	1.6	10	
Copper	ICP-AES	44.3	43.5	1.8	10	
Lead	ICP-AES	34.5	27.5	22.6	10	Does not meet DQO
Manganese	ICP-AES	37.6	36.9	1.9	10	
Mercury						
FH/BH	CVAAS	3.6	4.6	24.4	10	Does not meet DQO
KMnO4	CVAAS	1.3	1.2	8.0	10	
Molybdenum	ICP-AES	36.7	35.6	3.0	10	
Nickel	ICP-AES	2230	2190	1.8	10	
Selenium	ICP-AES	ND(29)	ND(29)	–	10	
Phosphorus	ICP-AES	696	758	8.5	10	
Vanadium	ICP-AES	1790	1700	5.2	10	

Spike Results

Element	Lab blank Pre-digestion % Recovery	1-MTLS-OUT Post-digestion % Recovery	1-MTLS-IN Post-digestion % Recovery	Data Quality Objective for Spikes	Comments
Arsenic	134	MSA	MSA	–	
Barium	96	3	14	75-125	1-MTLS-IN/OUT does not meet DQO
Beryllium	67	64	108	75-125	1-MTLS-OUT does not meet DQO
Cadmium	68	69	84	75-125	1-MTLS-OUT does not meet DQO
Chromium	84	NM	80	75-125	
Cobalt	74	41	75	75-125	1-MTLS-OUT does not meet DQO
Copper	110	49	83	75-125	1-MTLS-OUT does not meet DQO
Lead	99	NM	21	75-125	1-MTLS-IN does not meet DQO
Manganese	83	52	81	75-125	1-MTLS-OUT does not meet DQO
Mercury					
FH/BH	NP	103	NP	75-125	
KMnO4	NP	NP	94	75-125	
Molybdenum	85	48	83	75-125	1-MTLS-OUT does not meet DQO
Nickel	71	48	81	75-125	1-MTLS-OUT does not meet DQO
Selenium	39	102.4	NP	75-125	
Phosphorus	NP	114	NP	75-125	
Vanadium	80	0	101	75-125	1-MTLS-OUT does not meet DQO

Notes:
RPD= relative percent difference
MSA= method of standard additions chosen due to poor spike recovery.
NM= not measurable. Spike concentration to low to measure.
NP= not performed

Table G-1 (continued)
Summary of Quality Control Results
for ESP Inlet and Outlet Metals Analyses

Laboratory Check Standards Results

Element	*Initial* Calibration % Recovery	Continuing Calibration % Recovery		Data Quality Objective for LCS
Arsenic	MSA	MSA	MSA	–
Barium	101.9	96.2	95.5	90-110
Beryllium	101.5	95.8	94.9	90-110
Cadmium	103.3	98.0	98.0	90-110
Chromium	105.4	104.8	104.1	90-110
Cobalt	104.5	99.4	100.2	90-110
Copper	101.8	95.3	96.2	90-110
Lead	100.8	78.7	–	90-110
Manganese	104.0	98.6	97.8	90-110
Mercury				
FH/BH	89.0	96.3	–	80-120
KMnO4	100.1	92.3	–	80-120
Molybdenum	96.6	94.8	93.5	90-110
Nickel	106.6	99.3	99.1	90-110
Selenium	MSA	MSA	MSA	–
Phosphorus	97.6	109.3	109.2	90-110
Vanadium	99.7	94.4	93.8	90-110

Correlation Coefficients for MSA Data, R2

Sample ID	Arsenic, R2	Selenium, R2	Data Quality Objective for MSA
LAB BLANK	0.9990	0.9961	0.995
1-MTLS-IN	0.9981	0.8611	0.995
2-MTLS-IN	0.9992	0.6200	0.995
3-MTLS-IN	0.9985	0.4001	0.995
FB-MTLS-IN	0.9971	0.9981	0.995
RB-MTLS-IN	0.9998	0.9999	0.995
1-MTLS-OUT	1.0000	0.9333	0.995
2-MTLS-OUT	0.9997	0.7963	0.995
3-MTLS-OUT	0.9984	0.9991	0.995
FB-MTLS-OUT	0.9983	0.9541	0.995
RB-MTLS-OUT	0.9987	0.9997	0.995

Notes:
MSA= method of standard additions
The MSA data was not used where R2 <0.995.

Table G-2
Summary of Quality Control Results for
ESP Inlet and Outlet Particulate Analyses

Method	Quality Control	Data Quality Objective	Comments
Particulate EPA Method 5	Acetone Blank	<=0.008 mg/ml	meets EPA criterion of <= 0.008 mg/ml
	Balance Calibration Check	+/- 0.0003 at >20 g	NBS traceable weights
		+/- 0.0001 at <=20 g	

Table G-3
Summary of Quality Control Results for
ESP Inlet and Outlet Anion Analyses

Sample Duplicate Results

Anion	Sample value mg/l	Duplicate value mg/l	RPD	Data Quality Objectives for Duplicates
Filter:				
Chloride	0.618	0.552	11	15
Fluoride	ND(0.3)	ND(0.3)	--	15
Phosphate	ND(2)	ND(2)	--	15
Sulfate	15.593	15.901	2	15
Bicarbonate/ carbonate:				
Chloride	0.317	0.323	2	15
Fluoride	ND(0.3)	ND(0.3)	--	15
Phosphate	ND(2)	ND(2)	--	15
Sulfate	6.614	6.860	4	15
3% Peroxide				
Chloride	ND(0.5)	ND(0.5)	--	15
Fluoride	ND(0.3)	ND(0.3)	--	15
Phosphate	ND(2)	ND(2)	--	15
Sulfate	40.463	40.983	1	15

Spike Results

Anion	Matrix Spike % Recovery	Quality Control Objective for Spikes	Comments
Filter:			
Chloride	64	80-120	Does not meet DQO
Fluoride	137	80-120	Does not meet DQO
Phosphate	50	80-120	Does not meet DQO
Sulfate	124	80-120	Does not meet DQO
Bicarbonate/ carbonate:			
Chloride	91	80-120	
Fluoride	122	80-120	Does not meet DQO
Phosphate	98	80-120	
Sulfate	96	80-120	
3% Peroxide			
Chloride	98	80-120	
Fluoride	94	80-120	
Phosphate	97	80-120	
Sulfate	105	80-120	

Notes:
RPD= relative percent difference; not used for species that were not detected.

Table G-4
Summary of Quality Control Results for
ESP Inlet and Outlet PAH Analyses

Duplicate Matrix Spike Results Component	Blank Matrix Spike #1 ug	Blank Matrix Spike #2 ug	RPD	Data Quality Objective for Duplicates
Naphthalene	NA	NA	NA	50
Acenaphthylene	0.26	0.25	3.9	50
Acenaphthene	0.28	0.27	3.6	50
Fluorene	0.25	0.25	0.0	50
Phenanthrene	0.28	0.29	3.5	50
Anthracene	0.27	0.29	7.1	50
Fluoranthene	0.26	0.26	0.0	50
Pyrene	0.25	0.26	3.9	50
Benz(a)anthracene	0.25	0.26	3.9	50
Chrysene	0.27	0.28	3.6	50
Benzo(b)fluoranthene	0.24	0.24	0.0	50
Benzo(k)fluoranthene	0.28	0.33	16.4	50
Benzo(a)pyrene	0.28	0.28	0.0	50
Indeno(1,2,3-cd)pyrene	0.26	0.24	8.0	50
Dibenzo(a,h)anthracene	0.27	0.27	0.0	50
Benzo(g,h,i)perylene	0.28	0.27	3.6	50
2-Methylnaphthalene	NS	NS	NS	–
7,12-Dimethylbenz(a)anthracene	NS	NS	NS	–
3-Methylcholanthrene	NS	NS	NS	–

PAH Blank Matrix Spike Results Component	Blank Matrix Spike #1 % Recovery	Blank Matrix Spike #2 % Recovery	Average % Recovery	Data Quality Objective for Spikes
Naphthalene	NA	NA	NA	50-150
Acenaphthylene	104	100	102	50-150
Acenaphthene	112	108	110	50-150
Fluorene	100	100	100	50-150
Phenanthrene	112	116	114	50-150
Anthracene	108	116	112	50-150
Fluoranthene	104	104	104	50-150
Pyrene	100	104	102	50-150
Benz(a)anthracene	100	104	102	50-150
Chrysene	108	112	110	50-150
Benzo(b)fluoranthene	96	96	96	50-150
Benzo(k)fluoranthene	112	132	122	50-150
Benzo(a)pyrene	112	112	112	50-150
Indeno(1,2,3-cd)pyrene	104	96	100	50-150
Dibenzo(a,h)anthracene	108	108	108	50-150
Benzo(g,h,i)perylene	112	108	110	50-150
2-Methylnaphthalene	NS	NS	NS	–
7,12-Dimethylbenz(a)anthracene	NS	NS	NS	–
3-Methylcholanthrene	NS	NS	NS	–

RPD: Relative Percent Difference
NA: Not Available
NS: Not Spiked

Table G-4 (continued)
Summary of Quality Control Results for
ESP Inlet and Outlet PAH Analyses

Internal Recoveries, % (added pre-extraction)	Method Blank	Blank Resin Spike # 1	Blank Resin Spike # 2	FB-PAH-IN	12-PAH-IN	13-PAH-IN	14-PAH-IN	FB-PAH-OUT	12-PAH-OUT	13-PAH-OUT	14-PAH-OUT	Data Quality Objective for Spikes
Napthalene-2H8	71	6*	64	65	60	59	68	38**	56	49**	50	50-150
Acethenapthylene-2H8	74	20**	70	78	3*	3*	33**	55	1*	28**	18*	50-150
Acenapthene--2H10	76	22**	74	79	71	66	76	69	65	63	62	50-150
Fluorene-2H10	78	35**	79	86	82	78	87	84	79	67	73	50-150
Phenanthrene-2H10	85	62	85	96	90	88	100	98	89	83	86	50-150
Anthracene-2H10	53	44	62	76	2*	5*	17*	20*	3*	11*	7*	50-150
Fluoranthene-2H10	88	80	89	98	93	89	98	100	88	80	90	50-150
Pyrene-2H10	87	79	86	96	87	85	95	93	79	77	87	50-150
Benz(a)anthracene-2H12	98	87	90	97	51	56	79	75	35*	46*	56	50-150
Chrysene-2H12	98	86	87	68	130	77	80	79	95	52	68	50-150
Benzo(b)fluoranthene-2H12	100	86	86	98	61	89	91	96	49*	53	78	50-150
Benzo(k)fluoranthene-2H12	110	100	91	82	84	82	89	87	43*	46*	65	50-150
Benzo(a)pyrene-2H12	68	65	65	130	130	NR	140	30*	NR	4*	4*	50-150
Indeno(1,2,3-c,d)pyrene-2H12	120	81	81	130	120	110	120	110	21*	34*	55	50-150
Dibenzo(a,h)anthracene-2H14	120	87	87	120	100	96	110	110	20*	37*	50	50-150
Benzo(g,h,i)perylene-2H12	100	77	80	100	89	84	93	93	17*	32*	48*	50-150
Surrogate Recoveries, % (field spikes)												
Benzo(e)pyrene-2H12	NS	NS	NS	73	74	74	78	72	63	61	70	50-150
Terphenyl-2H14	NS	NS	NS	71	71	72	75	74	81	75	79	50-150

* Does not meet DQO; result is not recovery corrected
** Does not meet DQO; result is recovery corrected
NA: Not Applicable
NR: Not Recovered
NS: Not Spiked

Table G-5
Summary of Quality Control Results for
ESP Inlet and Outlet VOC Analyses

Sample Duplicate Results

Component	Sample ID	Run # 1 ppb	Run #2 ppb	RPD	Data Quality Objective for Duplicates	Comments
Benzene	1A-VOC-IN	0.26	0.24	8.0	20	
	1A-VOC-OUT	0.90	0.52	53.5	20	Does not meet DQO
	1C-VOC-OUT	0.78	1.07	31.4	20	Does not meet DQO
	1D-VOC-OUT	0.87	0.56	43.4	20	Does not meet DQO
Toluene	1A-VOC-IN	8.65	7.29	17.1	20	
	1A-VOC-OUT	44.2	44.8	1.3	20	
	1C-VOC-OUT	18.1	18.2	0.6	20	
	1D-VOC-OUT	6.68	6.41	4.1	20	

Matrix Spike Results

Component	Sample ID	Expected Value	Measured Value	% Recovery	Data Quality Objective for spikes
Benzene	1A-VOC-OUT	40.2	39.1	97.3	70-130
Toluene	1A-VOC-OUT	74.6	75.1	100.7	70-130

Table G-6

Summary of Quality Control Results for

ESP Inlet and Outlet Formaldehyde Analysis

Sample Duplicate Results

Sample ID	Sample ug/sample	Duplicate ug/sample	RPD	Data Quality Objective for Duplicates
2-2-FB-IN	1.30	1.35	3.8	10
2B-FORM-IN	1.20	1.20	0.0	10
2C-FORM-IN	1.17	1.12	4.4	10
2B-FORM-OUT	3.43	3.42	0.3	10

Spike Results

Field Spikes:	Expected Value	Measured Value	% Recovery	Data Quality Objective for Spikes	Comments
Inlet	5.0	10.4	208	60-140	Does not meet DQO
Outlet	5.0	8.0	160	60-140	Does not meet DQO
Trip Spike	5.0	5.9	118	60-140	

Table G-7
Summary of Quality Control Results for ESP Inlet and Outlet Total Chromium and Hexavalent Chromium Analyses

Duplicate Analysis Result

Sample ID 6-OUT-CR	Sample ug/ml	Duplicate ug/ml	RPD
Chromium (VI)	ND<0.0015	ND<0.0015	--

EPA Audit Spike Analysis Results

Sample ID Cr(VI) Spike	Expected value ug	Measured value ug	% Recovery	Data Quality Objective for Spikes
5-IN-CR	12	14.0	117	80-120
5-OUT-CR	12	12.8	107	80-120

Lab Check Standard Results

Sample ID	Expected value ug/ml	Measured value ug/ml	% Recovery	Data Quality Objective for LCS
QC 1				
Total Chromium	1.00	0.977	97.7	95-105
Chromium (VI)	0.0100	0.0100	100	95-105
QC 2				
Total Chromium	1.00	0.987	98.7	95-105
Chromium (VI)	0.0100	0.0104	104	95-105
QC 3				
Total Chromium	1.00	0.996	99.6	95-105
Chromium (VI)	--	--	--	--
SRM WP481				
Total Chromium	0.0522	0.0510	97.7	95-105
SRM WP481				
Total Chromium	0.0522	0.0520	99.6	95-105

Table G-8
Summary of Quality Control Results for
Mercury Evaluation Tests Analyses

Brooks Rand Method

	Mercury concentrations, ug/m3				
Parameter	Hg (total)	Hg (II)	Hg(0)	MMHg	Probe
Reagent Blank	--	0.022	0.052	0.002	0.0001
SD	--	0.013	0	0.001	--
N	--	3	3	3	1

Fuel oil Analysis (10/92):	replicate #1 ng/g	replicate #2 ng/g	replicate #3 ng/g	mean	SD
	1.1	1.1	0.4	0.87	0.40

Fuel Oil Spike Analysis:	Expected Value ng/g	Measured Value ng/g	% Recovery	Data Quality Objective for Spikes
	48.47	48.2	99.4	75-125

Multimetals Method

Sample ID 5-OUT-HG	Sample ug/fraction	Duplicate ug/fraction	RPD	Data Quality Objective for LCS
KMnO4 fraction	ND<0.26	ND<0.26	NC	10
front/back-half	1.1	ND< 1.1	NC	10

	Matrix Spike % Recovery	Data Quality Objective for Spikes	LCS % Recovery	Data Quality Objective for LCS
KMnO4 fraction	94	75-125	100.1	75-125
front/back-half	94	75-125	96.9	75-125

Table G-9
Summary of Quality Assurance Results for
Metals by ICP-AES, GFAAS and CVAAS in Fuel Oil

Duplicate Analysis Results
fuel oil 7/16/92

	Method	Sample Value ug/g	Duplicate Value ug/g	RPD %	Data Quality Objective for Duplicates	Comments
Arsenic	GFAAS	0.008	0.019	77.2	10	Does not meet DQO
Berium	ICP-AES	2.1	1.3	47	10	Does not meet DQO
Beryllium	ICP-AES	0.053	0.054	2.4	10	
Cadmium	ICP-AES	0.01	0.01	0.2	10	
Chromium	ICP-AES	0.22	0.2	6.2	10	
Cobalt	ICP-AES	1.2	1.2	3.2	10	
Copper	ICP-AES	0.69	0.69	0.2	10	
Lead	ICP-AES	0.37	0.39	4.2	10	
Manganese	ICP-AES	0.31	0.24	0.24	10	
Mercury	CVAAS	0.20	0.04	139	10	Does not meet DQO
Molybdenum	ICP-AES	0.24	0.24	0.9	10	
Nickel	ICP-AES	39.5	38.7	2.3	10	
Selenium	GFAAS	ND <0.005	ND <0.005	–	10	
Phosphorus	ICP-AES	16.7	12.5	28.5	10	Does not meet DQO
Vanadium	ICP-AES	22.0	22.0	0.1	10	

Spike Results
fuel oil 7/16/92

	Post-digestion % recovery	Data Quality Objective for Spikes	Comments
Arsenic	48	75-125	Does not meet DQO
Barium	85	75-125	
Beryllium	84	75-125	
Cadmium	82	75-125	
Chromium	77	75-125	
Cobalt	75	75-125	
Copper	80	75-125	
Lead	80	75-125	
Manganese	83	75-125	
Mercury	22	75-125	Does not meet DQO
Molybdenum	83	75-125	
Nickel	NM	75-125	Does not meet DQO
Selenium	0	75-125	Does not meet DQO
Phosphorus	107	75-125	
Vanadium	NM	75-125	Does not meet DQO

(continued)

NM= not meaningful. It is likely that the sample was not spiked for V or Ni.

Table G-9 (continued)
Summary of Quality Assurance Results for
Metals by ICP-AES, GFAAS and CVAAS in Fuel Oil

Laboratory Check Standards Results

Element	Initial Calibration % Recovery	Continuing Calibration % Recovery		Data Quality Objective for LCS
Arsenic	104.9	110.1	NP	90-110
Barium	101.4	102.2	101.2	90-110
Beryllium	98.3	100.1	99.5	90-110
Cadmium	101.5	--	--	90-110
Chromium	106.3	106.4	105.2	90-110
Cobalt	103.7	103.7	103.4	90-110
Copper	102.8	102.7	101.4	90-110
Lead	99.3	--	--	90-110
Manganese	104.1	--	100.2	90-110
Mercury	109.4	101.3	100.2	80-120
Molybdenum	96.1	98.8	97.4	90-110
Nickel	105.1	105.2	105.0	90-110
Selenium	102.7	92.0	NP	90-110
Phosphorus	101.8	105.7	NP	90-110
Vanadium	100.4	99.5	97.8	90-110

Sulfur	Expected Value, %	Measured Value, %	% Recovery	Data Quality Objective for LCS
	0.5	0.498	99.6	90-110
	1.48	1.470	99.3	90-110
	2.04	2.04	100.0	90-110
	3.12	3.18	101.9	90-110

Notes:
NP=not performed
Sulfur per LECO SC 132

Table G-10
Summary of Quality Assurance Results for
Metals by ICP-AES, GFAAS and CVAAS in Furnace Hopper Ash

Duplicate Analysis Results

Bottom Ash 7/21/92	Method	Sample Value ug/g	Duplicate Value ug/g	RPD %	Data Quality Objective for Duplicates	Comments
Arsenic	GFAAS	13.8	15.2	9.4	10	
Barium	ICP-AES	185	168	9.4	10	
Beryllium	ICP-AES	56.8	56.1	1.3	10	
Cadmium	ICP-AES	4.8	3.5	30.2	10	Does not meet DQO
Chromium	ICP-AES	296	214	32.1	10	Does not meet DQO
Cobalt	ICP-AES	521	441	16.7	10	Does not meet DQO
Copper	ICP-AES	378	250	40.7	10	Does not meet DQO
Lead	ICP-AES	166	137	19.5	10	Does not meet DQO
Manganese	ICP-AES	641	650	1.3	10	
Mercury	CVAAS	ND<0.1	–	–	10	
Molybdenum	ICP-AES	344	357	3.7	10	
Nickel	ICP-AES	15800	16000	1.6	10	
Selenium	GFAAS	ND<2.5	2.5	–	10	
Phosphorus	ICP-AES	1570	NP	–	10	
Vanadium	ICP-AES	24900	24200	2.9	10	

Duplicate Analysis Results

	Blank spike ppm	Blank spike Duplicate ppm	RPD	Data Quality Objective for Duplicates	Comments
Arsenic	1713	1713	0	10	
Barium	1898	1920	1.2	10	
Beryllium	54.8	55.9	2	10	
Cadmium	52.3	49.5	5.5	10	
Chromium	196.8	205	4.1	10	
Cobalt	444.8	455.9	2.5	10	
Copper	230.8	235.5	2	10	
Lead	514.8	452.6	12.9	10	Does not meet DQO
Manganese	499.6	504.2	0.9	10	
Mercury	0.428	0.419	1.9	10	
Molybdenum	382	378..6	0.9	10	
Nickel	493.4	498.6	1	10	
Selenium	181.7	181.7	0	10	
Phosphorus	8825	9163	3.8	10	
Vanadium	463.3	465.4	0.5	10	

Table G-10(continued)
Summary of Quality Assurance Results for
Metals by ICP-AES, GFAAS and CVAAS in Furnace Hopper Ash

Spike Results	Average Blank Spike % recovery	Data Quality Objective for Spikes
Arsenic	106	75-125
Barium	95.5	75-125
Beryllium	110.7	75-125
Cadmium	101.8	75-125
Chromium	100.5	75-125
Cobalt	90.1	75-125
Copper	93.3	75-125
Lead	96.8	75-125
Manganese	100.4	75-125
Mercury	106	75-125
Molybdenum	95.1	75-125
Nickel	99.2	75-125
Selenium	113	75-125
Phosphorus	90.0	75-125
Vanadium	92.9	75-125

Note: matrix spike recovery data is unavailable for ICP-AES results
due to the high levels of metals relative to the spike level.
The results of a pre-digestion laboratory method blank spike are presented here.

Table G-11
Summary of Quality Control Results for
Chloride and Fluoride in Furnace Hopper Ash

Duplicate Analysis Results				Spike Analysis Results		
Species	Sample ug/g	Duplicate ug/g	RPD	Matrix Spike % Recovery	Data Quality Objective for Spikes	Comments
Chloride	ND<250	ND<250	--	109	80-120	
Fluoride	ND<150	ND<150	--	65.1	80-120	Does not meet DQO

Table G-12
Summary of Quality Control Results for
PAH in Furnace Hopper Ash

Duplicate Analysis Results				
Component	Sample ug	Duplicate ug	RPD	Data Quality Objective for Duplicates
Naphthalene	ND <0.01	ND <0.01	--	50
Acenaphthylene	ND <0.01	ND <0.01	--	50
Acenaphthene	ND <0.01	ND <0.01	--	50
Fluorene	0.02	0.02	0.0	50
Phenanthrene	0.27	0.23	16.0	50
Anthracene	0.029	0.018	46.8	50
Fluoranthene	0.012	0.013	8.0	50
Pyrene	0.096	0.087	9.8	50
Benz(a)anthracene	ND <0.01	ND <0.01	--	50
Chrysene	ND < 0.015	ND <0.01	--	50
Benzo(b)fluoranthene	ND <0.01	ND <0.01	--	50
Benzo(k)fluoranthene	ND <0.01	ND <0.01	--	50
Benzo(a)pyrene	ND <0.01	ND <0.01	--	50
Indeno(1,2,3-cd)pyrene	ND <0.01	ND <0.01	--	50
Dibenzo(a,h)anthracene	ND <0.01	ND <0.01	--	50
Benzo(g,h,i)perylene	ND <0.01	ND <0.01	--	50
2-Methylnaphthalene	0.013	0.017	26.7	50
7,12-Dimethylbenz(a)anthracene	ND <0.005	ND <0.005	--	50
3-Methylcholanthrene	ND <0.005	ND <0.005	--	50

(continued)

Table G-12(continued)
Summary of Quality Control Results for
Analyses of PAH in Furnace Hopper Ash

Internal Recoveries, % (added pre-extraction)	Method Blank	Bottom Ash 7/21/92	Duplicate 7/21/92	Average	Data Quality Objective for Spikes
Napthalene-2H8	50	50	73	62	50-150
Acethenapthylene-2H8	80	68	76	72	50-150
Acenapthene–2H10	80	78	88	83	50-150
Fluorene-2H10	85	85	95	90	50-150
Phenanthrene-2H10	90	97	100	99	50-150
Anthracene-2H10	84	60	71	66	50-150
Fluoranthene-2H10	83	140	130	135	50-150
Pyrene-2H10	92	100	100	100	50-150
Benz(a)anthracene-2H12	83	130	120	125	50-150
Chrysene-2H12	87	120	120	120	50-150
Benzo(b)fluoranthene-2H12	94	110	99	105	50-150
Benzo(k)fluoranthene-2H12	100	110	110	110	50-150
Benzo(a)pyrene-2H12	91	92	85	89	50-150
Indeno(1,2,3-c,d)pyrene-2H12	110	110	120	115	50-150
Dibenzo(a,h)anthracene-2H14	120	120	120	120	50-150
Benzo(g,h,i)perylene-2H12	110	120	120	120	50-150

Table G-13
Fuel Oil Analysis of NIST
Standard Reference Material 1634b

Element	ICP-AES, GFAAS, CVAAS Analysis				INAA Analysis			NIST 1634b		% Difference		Conclusion
	Method	Replicate 1 ug/g	Replicate 2 ug/g	Average ug/g	Replicate 1 ug/g	Replicate 2 ug/g	Average ug/g	Certified Value ug/g	Uncertified Informational Value ug/g	ICP-AES, GFAAS, CVAAS	INAA	
Arsenic	GFAAS	ND<2.5	ND<2.5	ND<2.5	0.15	0.15	0.15	0.12			25%	GFAAS not sensitive enough, INAA used
Barium	ICP-AES	2.5	7.1	4.8	3.1	4.4	3.75		1.3	269%	188%	both are high
Beryllium	ICP-AES	ND<0.010	ND<0.025	ND<0.018								cannot do by INAA
Cadmium	ICP-AES	ND<0.025	ND<0.063	ND<0.044	ND<0.008	ND<0.005	ND<0.007					no result
Chromium	ICP-AES	0.4	0.94	0.67	0.72	0.76	0.74		0.7	-4%	6%	both acceptable
Cobalt	ICP-AES	0.14	0.37	0.26	0.36	0.36	0.36	0.32		-20%	13%	both acceptable
Copper	ICP-AES	0.29	0.29	0.42								no certified value
Lead	ICP-AES	1.4	3.7	2.6					2.8	-9%		ICP-AES acceptable, cannot do by INAA
Manganese	ICP-AES	0.34	0.36	0.35	0.18	0.18	0.18	0.23		52%	-22%	INAA closer to certified value
Mercury	CVAAS	ND<0.10	ND<0.10	ND<0.10	0.0015	0.0012	0.0014		ND<0.001		35%	CVAAS not sensitive enough, INAA used
Molybdenum	ICP-AES	0.12	0.34	0.23								no certified value
Nickel	ICP-AES	15	34	24.5				28		-13%		ICP-AES acceptable, not performed routinely by INAA
Selenium	GFAAS	ND<2.5	ND<2.5	ND<2.5	0.17	0.11	0.14	0.18			-22%	GFAAS not sensitive enough, INAA used
Phosphorus	ICP-AES	ND<5.0	ND<5.0	ND<5.0								no result
Vanadium	ICP-AES	30	66	48	47	51	49	55.4		-13%	-12%	both acceptable
Sodium					95	94	95		90		5%	INAA Acceptable
Aluminum					7.4	7.4	7.4		16		-54%	no conclusion
Iron					25	26	26	31.6			-19%	INAA Acceptable
Zinc					2.2	2.1	2.2	3			-28%	INAA Acceptable

Note: Detection limits for ICP-AES, GFAAS, and CVAAS maybe higher than those obtained for flue gas samples because of the small sample size (10g).
Replicates 1 and 2 used 10 and 5 g samples respectively.

APPENDIX H

ANALYTICAL AND BLANK CORRECTION DATA

This Appendix contains summary tables of the laboratory analysis results for the ESP inlet and outlet gas, fuel samples and bottom ash samples. These tables indicate the analytical results obtained for field blanks, reagent blanks and laboratory preparation blanks. Field blanks are a sampling train that is set-up and recovered at the test site using the same procedure as an actual sample. In general, field blanks are not used to correct the result but do indicate the level of the analyte present in the sample train introduced by the recovery procedures. Reagent blanks are collected in the field and consist of reagents and filters used for each sample train. Laboratory preparation blanks consist only of the chemicals needed to decompose and analyze the samples. All blanks are carried through the entire analytical procedure. Corrections to the data for reagent or preparation blanks are noted. The blank correction contribution is the percentage of an analyte that was subtracted from the original value. For a series of tests the blank correction contribution is calculated as

$$\frac{\sum_{n=1}^{i} \left(\frac{\textit{Amount of blank correction}}{\textit{Original sample value}} \times 100 \right)}{n}$$

For example, the ESP inlet manganese result was corrected for the reagent blank of 9.2 μg. Raw data for the test series was 120, 59 and 45 μg per train. The blank correction contribution is calculated as

$$\frac{\left(\frac{9.2}{120} \times 100\right) + \left(\frac{9.2}{59} \times 100\right) + \left(\frac{9.2}{45} \times 100\right)}{3}$$

or

$$\frac{(7.7\% + 15.6\% + 20.4\%)}{3}$$

or

$$14.6\%$$

Blank corrections in no case bring the sample value below the reporting limit. Tables in this Appendix include:

H-1 Trace Metals Analytical Results Summary

H-2 PAH Analytical Results Summary

H-3 Anion Analytical Results Summary

H-4 Particulate Analytical Results Summary

H-5 Formaldehyde Analytical Results Summary

H-6 Benzene and Toluene Analytical Results Summary

H-7 Total and Hexavalent Chromium Analytical Results Summary

H-8 Mercury Evaluation Test Analytical Results Summary

H-9 Fuel Oil Analytical Results Summary

H-10 Bottom Ash Analytical Results Summary

H-11 Summary of Blank Corrections Made to Analytical Data

TABLE H-1
TRACE METALS ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET

Trace Metals, μg/train	Reagent Blank	1-MTLS-IN	2-MTLS-IN μg/train	3-MTLS-IN	Field Blank	Prep Blank	Field Blank+ μg/Nm³	Blank Corr. Contribution, % (Average)
Arsenic	ND<0.3	16	20	26	ND<14	ND<2.5	ND<3.98	0.0%
Barium[2]	8.5	94	160	65	26	10	4.54	10.8%
Beryllium[1]	0.2	11	10	12	0.2	ND<0.1	0.06	1.8%
Cadmium	5.2	3.1	1.4	1.7	0.4	ND<0.3	0.11	0.0%
Chromium[2]	55	42	31	42	8.4	1.8	1.87	4.8%
Cobalt[1]	3.4	200	150	160	ND<1	ND<1	ND<0.28	2.0%
Copper[1]	2.9	140	110	150	15	1.6	3.81	1.2%
Lead[2]	ND<14	53	37	31	26	16	3.98	41.7%
Manganese[1]	9.2	120	59	45	12	ND<0.8	0.80	14.6%
Mercury-FH/BH	ND<0.2	3.6	8.8	2.6	0.9	ND<NR	0.26	0.0%
$KMnO_4$ Imp.[1]	0.3	1.3	1.1	1.0	ND<0.4	ND<NR	ND<0.11	26.8%
Molybdenum[1]	5.4	72	66	66	19	2	3.86	8.0%
Nickel[1]	68	5700	4600	4700	42	2.7	11.16	0.1%
Selenium	ND<2.8	ND<29	ND<29	ND<29	ND<2.8	23	ND<0.80	0.0%
Phosphorus	ND<6	1600	1300	1500	ND<56	ND<6	ND<15.90	0.0%
Vanadium[1]	21	4600	4400	4800	18	2.7	4.34	0.1%

+ - used average Vmstd from the three tests, no reagent blanks were subtracted

Notes:

[1]Carnot reagent blank subtracted from laboratory result. Carnot reagent blank consists of filter, impinger solutions and laboratory chemicals needed for the analysis.

[2]Laboratory prep blank subtracted from laboratory result.

ND<: not detected

ND<NR: Preparation blank level was not detected, however the detection limit was not stated. Because these blank analyses were performed at the same time and in the same manner as the rest of the sample set it can be inferred that the detection limit will be the sample as reported for other samples; 0.2 μg/sample for the FH/BH and 0.4 μg/sample for the $KMnO_4$ portion.

TABLE H-1 (cont'd)
TRACE METALS ANALYTICAL RESULTS SUMMARY
SITE 112 ESP OUTLET

Trace Metals, μg/train	Reagent Blank	1-MTLS-OUT	2-MTLS-OUT	3-MTLS-OUT	Field Blank	Prep Blank	Field Blank+ μg/Nm³	Blank Corr. Contribution, % (Average)
Arsenic	ND<0.6	ND<14	ND<2.8	ND<14	11	ND<2.5	2.39	0.0%
Barium[2]	8.8	120	24	75	28	10	3.91	21.1%
Beryllium	ND<0.1	4.3	1.4	4.8	0.1	ND<0.1	0.02	0.0%
Cadmium	ND<0.3	4.5	0.6	0.8	ND<0.3	ND<0.3	ND<0.07	0.0%
Chromium[2]	1.4	140	440	190	140	1.8	30.02	0.9%
Cobalt[1]	1.9	75	23	84	ND<1	ND<1	ND<0.22	4.4%
Copper[1]	1.4	44	22	54	21	1.6	4.21	4.6%
Lead[2]	ND<14	35	22	23	24	16	3.04	40.4
Manganese[1]	1.5	38	110	120	93	ND<0.8	19.88	2.2%
Mercury-FH/BH	ND<0.2	ND<1.7	ND<1.3	ND<1.5	ND<0.8	ND<NR	ND<0.17	0.0%
$KMnO_4$ Imp.[1]	ND<0.2)	0.5	1.4	ND<0.3	ND<0.4	ND<NR	ND<0.09	0.0%
Molybdenum[1]	3.5	37	29	51	25	2.0	4.67	9.5%
Nickel[1]	1.9	2200	760	2500	130	2.7	27.65	0.2%
Selenium	3.3	ND<29	ND<29	ND<14.0	ND<29	23	ND<6.30	0.0%
Phosphorus	ND<6	700	490	770	ND<6	ND<6	ND<1.30	0.0%
Vanadium[1]	ND<0.6	1800	530	2000	38	2.7	7.67	0.3%

+ - used average Vmstd from the three tests, no reagent blanks were subtracted

Notes:

[1]Carnot reagent blank subtracted from laboratory result. Carnot reagent blank consists of a filter, impinger solutions and laboratory chemicals needed for the analysis.

[2]Laboratory prep blank subtracted from laboratory result.

Lead blank on samples 2-Mtls and 3-Mtls subtracted to detection level and reported as detected.

ND<: not detected

NR: not reported

TABLE H-2
PAH ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET

Species, μg/train	Method Blank	Field Blank	12-PAH-IN	13-PAH-IN	14-PAH-IN	Field Blank* μg/Nm³
Naphthalene	1.4	0.6	1.7	1.6	1.6	0.21
Acenaphthylene	ND<0.068	ND<0.05	ND<0.07	ND<0.07	ND<0.49	ND<0.018
Acenaphthene	ND<0.05	ND<0.05	ND<0.24	ND<0.26	ND<0.22	ND<0.018
Fluorene	ND<0.011	ND<0.005	0.07	0.05	0.04	ND<0.002
Phenanthrene	ND<0.03	0.02	0.46	0.33	0.24	0.007
Anthracene	ND<0.09	ND<0.050	ND<0.06	ND<0.06	ND<0.06	ND<0.018
Fluoranthene	ND<0.058	ND<0.100	ND<0.14	0.05	0.03	ND<0.036
Pyrene	ND<0.055	ND<0.1	ND<0.14	ND<0.09	ND<0.17	ND<0.036
Benz(a)anthracene	ND<0.063	ND<0.07	ND<0.29	ND<0.13	ND<0.2	ND<0.025
Chrysene	ND<0.06	ND<0.08	ND<0.3	ND<0.1	ND<0.2	ND<0.028
Benzo(b)fluoranthene	ND<0.034	ND<0.04	ND<0.1	ND<0.1	ND<0.09	ND<0.014
Benzo(k)fluoranthene	ND<0.036	ND<0.05	ND<0.1	ND<0.11	ND<0.09	ND<0.018
Benzo(a)pyrene	ND<0.078	ND<0.050	ND<0.08	ND<0.07	ND<0.08	ND<0.018
Indeno(1,2,3-cd)pyrene	ND<0.094	ND<0.05	ND<0.01	ND<0.08	ND<0.06	ND<0.018
Dibenzo(a,h)anthracene	ND<0.11	ND<0.08	ND<0.03	ND<0.2	ND<0.1	ND<0.028
Benzo(g,h,i)perylene	ND<0.09	ND<0.07	ND<0.03	ND<0.09	ND<0.08	ND<0.025
2-Methylnaphthalene	ND<0.05	ND<0.05	ND<0.05	0.094	0.11	ND<0.018
7,12-Dimethylbenz(a)anthracene	ND<0.05	ND<0.050	ND<0.05	ND<0.05	ND<0.5	ND<0.018
3-Methylcholanthrene	ND<1.0	ND<1.000	ND<1.0	ND<1.0	ND<1.0	ND<0.356

*Used average V_{mstd}

(continued)

TABLE H-2 (continued)
PAH ANALYTICAL RESULTS SUMMARY
SITE 112 ESP OUTLET

Species, μg train	Method Blank	Field Blank	12-PAH-OUT	13-PAH-OUT	14-PAH-OUT	Field Blank* μg/Nm³
Naphthalene	1.4	0.55	2	1.7	2	0.12
Acenaphthylene	ND<0.068	ND<0.08	ND<0.07	ND<0.26	ND<0.070	ND<0.018
Acenaphthene	ND<0.05	ND<0.08	ND<0.14	ND<0.13	ND<0.32	ND<0.018
Fluorene	ND<0.011	ND<0.005	0.06	0.03	0.28	ND<0.001
Phenanthrene	ND<0.03	0.02	0.13	0.11	0.11	0.004
Anthracene	ND<0.09	ND<0.06	ND<0.06	ND<0.06	ND<0.06	ND<0.013
Fluoranthene	ND<0.058	ND<0.1	ND<0.1	ND<0.07	ND<.11	ND<0.022
Pyrene	ND<0.055	ND<0.1	ND<0.11	ND<0.06	ND<0.11	ND<0.022
Benz(a)anthracene	ND<0.063	ND<0.18	ND<0.44	ND<0.19	ND<0.200	ND<0.040
Chrysene	ND<0.06	ND<1.73	ND<0.15	ND<0.150	ND<0.150	ND<0.385
Benzo(b)fluoranthene	ND<0.034	ND<0.05	ND<0.110	ND<0.05	ND<0.05	ND<0.011
Benzo(k)fluoranthene	ND<0.036	ND<0.06	ND<0.14	ND<0.06	ND<0.06	ND<0.013
Benzo(a)pyrene	ND<0.078	ND<0.2	ND<0.07	ND<0.070	ND<.070	ND<0.044
Indeno(1,2,3-cd)pyrene	ND<0.094	ND<0.07	ND<0.39	ND<0.24	ND<0.18	ND<0.016
Dibenzo(a,h)anthracene	ND<0.11	ND<0.12	ND<0.61	ND<0.34	ND<0.3	ND<0.027
Benzo(g,h,i)perylene	ND<0.09	ND<0.08	ND<0.45	ND<0.25	ND<.2	ND<0.018
2-Methylnaphthalene	ND<0.05	ND<0.05	0.093	0.079	0.084	ND<0.011
7,12-Dimethylbenz(a)anthracene	ND<0.050	ND<0.050	ND<0.050	ND<0.500	ND<0.050	ND<0.011
3-Methylcholanthrene	ND<1.000	ND<1.000	ND<1.000	ND<1.000	ND<1.000	ND<0.222

*Used average V_{msd}

TABLE H-3
ANION ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET

Sample I.D.	9-PM/AN-IN	10-PM/AN-IN	11-PM/AN-IN	Reagent Blank	Blank Correction Contribution
Chloride Distribution in Sample Train (mg):					
front-half rinse	0.06	ND<0.06	ND<0.06	ND<0.06	0.0%
filter	0.14	0.08	0.10	ND<0.02	0.0%
bicarbonate/carbonate fraction	6.8	5.8	5.2	ND<0.18	0.0%
3% peroxide fraction	not used (16.2)	not used (ND<7.2)	not used (ND<6.2)	ND<0.16	0.0%
Fluoride Distribution in Sample Train (mg):					
front-half rinse	ND<0.04	ND<0.16	ND<0.04	ND<0.04	0.0%
filter	ND<0.08	ND<0.08	ND<0.08	ND<0.08	0.0%
bicarbonate/carbonate fraction	1.8	0.8	0.7	ND<0.1	0.0%
3% peroxide fraction	NB (ND<38)	NB (ND<4.4)	NB (ND<3.6)	ND<0.1	0.0%
Sulfate Distribution in Sample Train (mg):					
front-half rinse	10.8	8.6	6.8	ND<0.06	0.0%
filter	37	21	31	ND<0.12	0.0%
bicarbonate/carbonate fraction	260	198	200	ND<0.18	0.0%
3% peroxide fraction	3600	3400	3400	ND<0.16	0.0%
Phosphate Distribution in Sample Train (mg):					
front-half rinse	ND<0.2	ND<0.2	ND<0.2	ND<0.1	0.0%
filter	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0.0%
bicarbonate/carbonate fraction	ND<4.6	ND<4.4	ND<4.0	ND<0.8	0.0%
3% peroxide fraction	NB (ND<260)	NB (ND<28)	NB (ND<24)	ND<0.6	0.0%

NB: no breakthrough from bicarbonate/carbonate fraction to 3% peroxide fraction.

(continued)

3% peroxide fraction was analyzed for Cl^-, F^- and PO_4^{3-} for verification only. Detection limits are high in this fraction because of analytical difficulties with IC analysis in this matrix. Chloride values in this fraction were not used because of suspected analytical problems producing inconsistent results.

TABLE H-3 (cont'd)
ANION ANALYTICAL RESULTS SUMMARY
SITE 112 ESP OUTLET

Sample I.D.	9-PM/AN-OUT	10-PM/AN-OUT	11-PM/AN-OUT	Reagent Blank	Blank Correction Contribution
Chloride Distribution in Sample Train (mg):					
front-half rinse	ND<0.06	ND<0.06	ND<0.06	ND<0.06	0.0%
filter	ND<0.02	ND<0.02	ND<0.02	ND<0.02	0.0%
bicarbonate/carbonate fraction	9.4	15.4	16.0	ND<0.18	0.0%
3% peroxide fraction	not used (ND<0.14)	not used (26)	not used (20)	ND<0.16	0.0%
Fluoride Distribution in Sample Train (mg):					
front-half rinse	ND<0.04	ND<0.04	ND<0.04	ND<0.04	0.0%
filter	ND<0.08	ND<0.08	ND<0.08	ND<0.08	0.0%
bicarbonate/carbonate fraction	3.0	1.4	0.68	ND<0.1	0.0%
3% peroxide fraction	(ND<40)	(ND<46)	(ND<3.8)	ND<0.1	0.0%
Sulfate Distribution in Sample Train (mg):					
front-half rinse	0.56	78.00	1.26	ND<0.06	0.0%
filter	14.18	14.18	15.78	ND<0.12	0.0%
bicarbonate/carbonate fraction	240	192	340	ND<0.18	0.0%
3% peroxide fraction	5200	5400	5000	ND<0.16	0.0%
Phosphate Distribution in Sample Train (mg):					
front-half rinse	ND<0.2	ND<0.2	ND<0.2	ND<0.1	0.0%
filter	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0.0%
bicarbonate/carbonate fraction	ND<6	ND<1	ND<1.2	ND<0.8	0.0%
3% peroxide fraction	NB (ND<140)	NB (ND<300)	NB (ND<24)	ND<0.6	0.0%

NB: no breakthrough from bicarbonate/carbonate fraction to 3% peroxide fraction.
3% peroxide fraction was analyzed for Cl^-, F^- and PO_4^{3-} for verification only. Detection limits are high in this fraction because of analytical difficulties with IC analysis in this matrix. Chloride values in this fraction were not used because of suspected analytical problems producing inconsistent results.

TABLE H-4
PARTICULATE ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET AND OUTLET

	Inlet			Outlet		
	9-PM/AN-In	10-PM/AN-In	11-PM/AN-In	9-PM/AN-Out	9-PM/AN-Out	11-PM/AN-Out
Particulate Catch: (mg)						
Filter	137.6	109.9	122.9	56.4	64.1	68.0
Probe/nozzle wash	81.7	61.6	57.4	3.8	3.7	6.3
Acetone blank	2.1	2.0	1.3	0.3	0.2	0.2
Total	217.2	169.5	179.0	59.9	67.6	74.1
Blank Correction Contribution	1.0%	1.2%	0.7%	0.5%	0.3%	0.3%

*Acetone blank contained particulate matter at 0.008 mg/ml. The acceptable limit according to EPA guidelines is 0.008 mg/ml.

TABLE H-5
FORMALDEHYDE ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET AND OUTLET

Sample I.D.	μg/Test	Reagent Blank, μg	Blank Correction Contribution	Field Blank, μg
2A-Form-In	3.49	1.1	31.5%	4.13
2B-Form-In	3.54	1.1	31.1%	3.33
2C-Form-In	2.19	1.1	50.2%	6.62
		Average:	37.6%	
2A-Form-Out	2.19	1.1	50.2%	3.33
2B-Form-Out	6.83	1.1	16.1%	4.83
2C-Form-Out	1.53	1.1	71.9%	4.05
		Average:	46.1%	

TABLE H-6
BENZENE AND TOLUENE ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET AND OUTLET

Sample I.D.	Benzene, ppb	Toluene, ppb
1A-VOC-Inlet	0.25	7.97
1B-VOC-Inlet	0.32	3.97
1C-VOC-Inlet	0.25	4.36
1D-VOC-Inlet	ND < 0.15	3.77
1A-VOC-Outlet	0.71	44.5
1B-VOC-Outlet	1.12	30.2
1C-VOC-Outlet	0.92	18.2
1D-VOC-Outlet	0.72	6.54

Note: No blank corrections have been made to the results. No tedlar bag blanks were performed. Laboratory blanks indicated no detectable benzene or toluene.

TABLE H-7
TOTAL AND HEXAVALENT CHROMIUM ANALYTICAL RESULTS SUMMARY
SITE 112 ESP INLET AND OUTLET

Sample I.D.	Fraction	Total Chromium, μg/train	Reagent Blank, μg/train	Blank Correction Contribution
5-IN-CR	KOH Filtrate	32.4	14.2	43.8%
	HNO_3 Impinger	0.900	0.600	66.6%
	HNO_3 Rinse	1.05	0.600	57.1%
	Filtrant (filter)	27.8	0.600	2.16%
5-OUT-CR	KOH Filtrate	17.2	11.8(1)	19.6%
	HNO_3 Impinger	1.30	0.600	46.1%
	HNO_3 Rinse	1.25	0.600	48.0%
	Filtrant (filter)	24.5	0.600	2.45%
6-IN-CR	KOH Filtrate	15.9	7.99	50.2%
	HNO_3 Impinger	0.550	0.600(2)	54.5%
	HNO_3 Rinse	0.400	0.600(2)	75%
	Filtrant (filter)	16.6	0.600	3.61%
6-OUT-CR	KOH Filtrate	13.4	8.32	62.1%
	HNO_3 Impinger	0.300	0.600(2)	100%
	HNO_3 Rinse	0.300	0.600(2)	100%
	Filtrant (filter)	3.75	0.600	16.0%
8-IN-CR	KOH Filtrate	ND<2.55	–	0.0%
	HNO_3 Impinger	ND<4.92	0.600	0.0%
	HNO_3 Rinse	ND<1.77	0.600	0.0%
	Filtrant (filter)	29.3	0.600	2.05%
8-OUT-CR	KOH Filtrate	ND<1.59	–	0.0%
	HNO_3 Impinger	ND<3.24	0.600	0.0%
	HNO_3 Rinse	ND<1.50	0.600	0.0%
	Filtrant (filter)	7.30	0.600	8.22%
Field Blank Inlet/Outlet	KOH Filtrate	ND<6.90		
	HNO_3 Impinger	ND<2.01		
	HNO_3 Rinse	ND<1.50		
	Filtrant (filter)	ND<3.00		

Sample I.D.	Fraction	Hexavalent Chromium, μg/train	Reagent Blank,* μg/train	Blank Correction Contribution
5-IN-CR	KOH Filtrate	4.28	3.26	0.0%
5-OUT-CR	KOH Filtrate	ND<1.68	3.26	0.0%
6-IN-CR	KOH Filtrate	ND<0.89	3.26	0.0%
6-OUT-CR	KOH Filtrate	ND<0.83	3.26	0.0%
8-IN-CR	KOH Filtrate	ND<4.25	3.26	0.0%
8-OUT-CR	KOH Filtrate	ND<2.65	3.26	0.0%
Field Blank Inlet/Outlet	KOH Filtrate	ND<1.15		

Note: Reagent blank not subtracted. Result at same level as reagent blank. The result was reported at the reporting limit of (1) 3.37 μg/train and (2) 0.300 μg/train.

* Reagent blank not subtracted from results.

TABLE H-8
MERCURY EVALUATION TESTS ANALYTICAL RESULTS SUMMARY
SITE 112 ESP OUTLET

	Hg Total	Hg (II)	Hg(O)	MMHg	Probe
Brooks Rand Method, ng/train (with blank corrections)					
5-MIT/BR	ND<2.1	ND<0.80	ND<0.80	0.60	--
6-BR	ND<1.8	ND<0.70	ND<0.70	0.10	0.072
7A-BR	ND<1.9	ND<0.70	ND<0.70	0.50	0.072
7B-BR	ND<1.8	ND<0.70	ND<0.70	0.40	0.037
Blanks	--	0.88	2.08	0.08	0.004
SD	--	0.52	0.000	0.04	--
MIT Method, ng/train (Hg Total) (with blank corrections)					
7A-MIT		Blank[1]	17±6		
7A1	340±9				
7A2	143±6				
7B-MIT					
7B1	75±3				
7B2	315±8				

Multimetals Method, µg/train Hg Total[2]

	5-OUT-Hg	6-OUT-Hg	7-OUT-Hg	Prep Blank
$KMnO_4$	ND<0.26	ND<0.22	0.33	ND<0.22
front/back half	1.1	ND<1.1	ND<1.2	ND<1.1

Note:
(1) The blank level of Hg is determined from a series of measurements on the lot of carbon used. The average value was 17±6 ng Hg per cartridge.
(2) Multimetals results are not blank corrected.

TABLE H-9
FUEL OIL ANALYTICAL RESULTS SUMMARY
SITE 112

(ICP-AES, GFAAS, CVFAS) Trace Metals, μg/g	7/16/92	7/17/92	7/18/92	Laboratory Blank	Average Blank Correction Contribution
Arsenic	0.008	ND<0.005	ND<0.005	ND<0.005	0.0%
Barium	2.1	2.3	3.6	0.40	15.9%
Beryllium	0.053	0.066	0.062	ND<0.002	0.0%
Cadmium	0.010	0.015	0.014	ND<0.005	0.0%
Chromium (total)	0.22	0.24	0.28	0.03	12.2%
Cobalt	1.2	1.4	1.3	ND<0.02	0.0%
Copper	0.69	0.68	0.67	0.05	7.3%
Lead	0.4	0.36	0.4	ND<0.3	0.0%
Manganese	0.31	0.33	0.49	0.07	18.6%
Mercury	0.20	0.10	0.06	0.12	69.0%
Molybdenum	0.24	0.25	0.23	ND<0.01	0.0%
Nickel	40	42	40	0.08	0.2%
Phosphorus	17	16	12	ND<5	0.0%
Selenium	ND<0.005	ND<0.005	ND<0.005	ND<0.005	0.0%
Vanadium	22	26	25	0.05	0.2%

INAA Trace Metals, μg/g	7/16/92	7/17/92	7/18/92
Arsenic	0.059	0.070	NA
Barium	1.1	1.2	1.6
Cobalt	1.3	1.5	3.0
Chromium (total)	0.23	0.28	0.20
Mercury	0.0028	0.0043	0.011
Manganese	0.32	0.38	0.31
Molybdenum	0.13	0.15	0.12
Selenium	0.056	0.044	NA
Vanadium	24	33	24
Chlorine	30.0	34.0	25.0

(continued)

Note: No blank corrections for INAA results
NA - Not available

TABLE H-9 (continued)
FUEL OIL ANALYTICAL RESULTS SUMMARY
SITE 112

	7/16/92	7/17/92
% Water	0.04	0.04
% Carbon	85.87	85.85
% Hydrogen	10.03	10.06
% Nitrogen	0.50	0.43
% Sulfur	0.86	0.84
% Ash	0.01	0.05
% Oxygen (diff.)	2.69	2.73
% Chlorine	0.05	0.04
Fluorine, μg/g	<10	<10
Higher Heating Value (btu/lb)	18,620	18,544

CHROMIUM AND MERCURY EVALUATION TESTS

Composite for 7/21-7/23/92	Hg, μg/g	Cr, μg/g
Brooks Rand	0.0009	—
MIT/INAA	0.015	0.64
ICP-AES/CVAAS		
fuel sample	0.045	0.40
prep blank	0.12	0.07
Blank correction contribution	0.0%	17.5%

Note: No blank correction available for composition or heating value

Chlorine values by ASTM D 808

TABLE H-10
BOTTOM ASH ANALYTICAL RESULTS SUMMARY
SITE 112

Metals µg/g	7/21/93
Arsenic	14
Barium	190
Beryllium	57
Cadmium	5
Chromium (total)	300
Cobalt	520
Copper	380
Lead	93
Lead	170
Manganese	640
Mercury	ND<0.1
Molybdenum	340
Nickel	16,000
Phosphorus	1,600
Selenium	ND<3
Vanadium	25,000

PAH µg/g Species	7/24/93	Method Blank
Naphthalene	ND<0.01	ND<0.005
Acenaphthylene	ND<0.01	ND<0.002
Acenaphthene	ND<0.01	ND<0.005
Fluorene	0.020	ND<0.005
Phenanthrene	0.25	ND<0.005
Anthracene	0.024	ND<0.005
Fluoranthene	0.013	ND<0.005
Pyrene	0.092	ND<0.005
Benz(a)anthracene	ND<0.01	ND<0.005
Chrysene	ND<0.015	ND<0.005
Benzo(b)fluoranthene	ND<0.01	ND<0.005
Benzo(k)fluoranthene	ND<0.01	ND<0.005
Benzo(a)pyrene	ND<0.01	ND<0.005
Indeno(1,2,3-cd)pyrene	ND<0.01	ND<0.01
Dibenzo(a,h)anthracene	ND<0.01	ND<0.01
Benzo(g,h,i)perylene	ND<0.01	ND<0.01
2-Methylnaphthalene	0.013	ND<0.005
3-Methylcholanthrene	ND<0.005	ND<0.005
7,12-Dimethylbenz(a)anthracene	ND<0.005	ND<0.005

Anions µg/g	7/24/93
Chloride	ND<250
Fluoride	ND<150
Phosphate	ND<1000
Sulfate	4,900

% Sulfur	2.32%
Loss on Ignition	4.58%

NOTES: Metals results are not blank corrected.
PAH results are not blank corrected.
Anion results are not blank corrected.
Phosphate and sulfate results not used in report.
Phosphorus results were used from metals analysis.
Sulfur results from the LECO analysis were used to calculate sulfate.

TABLE H-11
SUMMARY OF BLANK CORRECTIONS
MADE TO ANALYTICAL DATA
SITE 112

Sample Type	Parameter	Type of Blank Correction	Blank Correction Contribution
Exhaust Gas, ESP Inlet	Arsenic	None	0.0%
	Barium	Laboratory Blank	10.8%
	Beryllium	Reagent Blank	1.8%
	Cadmium	None	0.0%
	Chromium	Laboratory Blank	4.8%
	Cobalt	Reagent Blank	2.0%
	Copper	Reagent Blank	1.2%
	Lead	Laboratory Blank	41.7%
	Manganese	Reagent Blank	14.6%
	Mercury - FH/BH	None	0.0%
	$KMnO_4$ Impinger	Reagent Blank	26.8%
	Molybdenum	Reagent Blank	8.0%
	Nickel	Reagent Blank	0.1%
	Selenium	None	0.0%
	Phosphorus	None	0.0%
	Vanadium	Reagent Blank	0.1%
Exhaust Gas, ESP Outlet	Arsenic	None	0.0%
	Barium	Laboratory Blank	21.1%
	Beryllium	None	0.0%
	Cadmium	None	0.0%
	Chromium	Laboratory Blank	0.9%
	Cobalt	Reagent Blank	4.4%
	Copper	Laboratory Blank	4.6%
	Lead	Laboratory Blank	40.4%
	Manganese	Reagent Blank	2.2%
	Mercury - FH/BH	None	0.0%
	$KMnO_4$ Impinger	None	0.0%
	Molybdenum	Reagent Blank	9.5%
	Nickel	Laboratory Blank	0.0%
	Selenium	None	0.0%
	Phosphorus	None	0.0%
	Vanadium	Laboratory Blank	0.3%
Exhaust Gas, ESP Inlet	PAH (all species)	None	0.0%
Exhaust Gas, ESP Outlet	PAH (all species)	None	0.0%

(continued)

TABLE H-11
SUMMARY OF BLANK CORRECTIONS MADE TO ANALYTICAL DATA
SITE 112

Sample Type	Parameter	Type of Blank Correction	Blank Correction Contribution
Exhaust Gas, ESP Inlet	Chloride (all sample train fractions)	None	0.0%
	Fluoride (all sample train fractions)	None	0.0%
	Sulfate (all sample train fractions)	None	0.0%
	Phosphate (all sample train fractions)	None	0.0%
Exhaust Gas, ESP Outlet	Chloride (all sample train fractions)	None	0.0%
	Fluoride (all sample train fractions)	None	0.0%
	Sulfate (all sample train fractions)	None	0.0%
	Phosphate (all sample train fractions)	None	0.0%
Exhaust Gas, ESP Inlet	Particulate	Acetone reagent blank	1.0%
Exhaust Gas, ESP Outlet	Particulate	Acetone reagent blank	0.4%
Exhaust Gas, ESP Inlet	Formaldehyde	Reagent blank	37.6%
Exhaust Gas, ESP Outlet	Formaldehyde	Reagent blank	46.1%
Exhaust Gas, ESP Inlet	Benzene and Toluene	None	0.0%
Exhaust Gas, ESP Outlet	Benzene and Toluene	None	0.0%
Exhaust Gas, ESP Inlet	Total Chromium		
	KOH Filtrate	Reagent blank	31.3%
	HNO_3 impinger	Reagent blank	40.4%
	HNO_3 rinse	Reagent blank	44.0%
	Filter	Reagent blank	2.61%
Exhaust Gas, ESP Outlet	Total Chromium		
	KOH Filtrate	Reagent blank	27.2%
	HNO_3 impinger	Reagent blank	48.7%
	HNO_3 rinse	Reagent blank	49.3%
	Filter	Reagent blank	8.89%
Exhaust Gas, ESP Inlet	Hexavalent Chromium	None	0.0%
Exhaust Gas, ESP Outlet	Hexavalent Chromium	None	0.0%

(continued)

TABLE H-11
SUMMARY OF BLANK CORRECTIONS
MADE TO ANALYTICAL DATA
SITE 112

Sample Type	Parameter	Type of Blank Correction	Blank Correction Contribution
Exhaust Gas, ESP Outlet	Mercury Evaluation		
	1. Brooks Rand	Reagent blank	Data received was blank corrected
	2. MIT	Reagent blank	Data received was blank corrected
	3. Multimetals	None	0.0%
Fuel Oil (ICP, GFAAS, CVAAS)	Arsenic	None	0.0%
	Barium	Laboratory blank	15.0%
	Beryllium	None	0.0%
	Cadmium	None	0.0%
	Chromium	Laboratory blank	12.2%
	Cobalt	None	0.0%
	Copper	Laboratory blank	7.30%
	Lead	None	0.0%
	Manganese	Laboratory blank	18.6%
	Mercury	Laboratory blank	69.0%
	Molybdenum	None	0.0%
	Nickel	None	0.0%
	Selenium	Laboratory blank	0.2%
	Phosphorus	None	0.0%
	Vanadium	None	0.2%
Fuel Oil (INAA)	Arsenic	None	0.0%
	Barium	None	0.0%
	Cobalt	None	0.0%
	Chromium	None	0.0%
	Mercury	None	0.0%
	Manganese	None	0.0%
	Molybdenum	None	0.0%
	Selenium	None	0.0%
	Vanadium	None	0.0%
Bottom Ash	Metals	None	0.0%
Bottom Ash	PAH	None	0.0%
Bottom Ash	Anions	None	0.0%
Bottom Ash	LOI	None	0.0%